TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA,

FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XV.—NEW SERIES.

PART I.

Philadelphia:
PUBLISHED BY THE SOCIETY,

AND FOR SALE BY

HENRY C. LEA, PHILADELPHIA;

N. TRÜBNER & CO., 60 PATERNOSTER ROW, LONDON.

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1873.

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JANUARY 1,
1881.

EXTRACT

FROM THE LAWS OF THE SOCIETY RELATING TO THE TRANSACTIONS.

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1. Every communication to the Society which may be considered as intended for a place in the Transactions, shall immediately be referred to a committee to consider and report thereon.

2. If the committee shall report in favor of publishing the communication, they shall make such corrections therein as they may judge necessary to fit it for the press; or, if they shall judge the publication of an abstract or extracts from the paper to be more eligible, they shall accompany their report with such abstract or extracts. But if the author do not approve of the corrections, abstract, or extracts reported by the committee, he shall be at liberty to withdraw his paper.

3. Communications not intended by their authors for publication in the Transactions, will be received by the Society, and the title or subject of them recorded ; and, if they be in writing, they shall be filed by the secretaries.

4. The Transactions shall be published in numbers, at as short intervals as practicable, under the direction of the Committee of Publication, and in such a form as the Society shall from time to time direct; and every communication ordered to be published in the Transactions shall be immediately sent to the printer, and fifty copies thereof be given to the author as soon as printed.

5. The order in which papers are read shall determine their places in the Transactions, unless otherwise ordered by the Society; priority of date giving priority of location.

6. The expenses of publishing the Transactions shall be defrayed by subscriptions and sales, aided by such funds as the Society shall from time to time appropriate for that purpose.

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OF THE

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1689. Wm. C. Kerr, Raleigh, N. C.
1690. LaMotte Dupont, Wilmington, Delaware.
1691. Wm. P. Trowbridge, New Haven, Conn.
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1696. George W. Hough, Albany, N. Y.
1697. Wm. A. Stokes, Philadelphia. Died May, 1877.
1698. Edwin J. Houston, Philadelphia.

Elected April 19, 1872.

1699. Jean Baptiste Léon Say, Paris, France.
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1701. D. Hayes Agnew, M.D., Philadelphia.
1702. Adolph E Borie, Philadelphia. Died February 5, 1880, æt. 70.

Elected July 19, 1872.

1703. Starr Hoyt Nichols, Philadelphia.
1704. Coleman Sellers, Philadelphia.
1705. Robert Peter, M.D., Lexington, Kentucky.
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Elected October 18, 1872.

1707. Alexander Johnston Cassatt, Philadelphia.
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1710. Dr. Paul Broca, Paris, France. Died July 10, 1880.
1711. Franz Joseph Lauth, Munich, Bavaria.
1712. Isaac Norris, Jr., M.D., Philadelphia.

Elected January 17, 1873.

1713. Henry W. Acland, M.D., Oxford, England.
1714. George Borrows, M.D., London, England.
1715. James E. Oliver, Ithaca, N. Y.
1716. Robert P. Frazer, Philadelphia. Died May 1878, æt. 59.
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1719. Joseph Zentmeyer, Philadelphia.
1720. A. H. Spofford, Washington, D. C.
1721. C. Percy LaRoche, M.D., Philadelphia.
1722. Henry Pemberton, Philadelphia.

Elected April 18, 1873.

1723. Sir William Thomson, F.R.S., London. (Present address Glasgow.)
1724. Alfred R. Wallace, Croydon, England.
1725. Philip Lutley Sclater, London.
1726. Sir Henry Thompson, M.B., London.
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1735. Theodor Mommsen, Berlin, Germany.
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1737. Joseph LeConte, Oakland, Cal. (Present address Berkeley, Cal.)
1738. John LeConte, Oakland, Cal. (Present address Berkeley, Cal.)
1739. John Fulton, Johnstown, Pa.
1740. Lloyd P. Smith, Philadelphia. Resigned Jan. 25, 1875.
1741. George F. Barker, Philadelphia.

Elected October 17, 1873.

1742. A. Loudon Snowden, Philadelphia.
1743. John S. Haines, Germantown, Pa.
1744. Matthew Huizinga Messchert, Douglassville, Pa.
1745. J. Blodget Britton, Philadelphia.
1746. John Walter Harden, Philadelphia. Died Nov. 8, 1870, æt. 63.

Elected January 16, 1874.

1747. Joseph Miller Wilson, Philadelphia.
1748. William H. Wahl, M.D., Philadelphia.
1749. Increase Allen Lapham, Milwaukee, Wis. Died September 14, 1875, æt. 65.
1750. Dr. Hermann Kolbe, Leipsig, Saxony.
1751. J. E. Wootten, Reading, Pa.

Elected April 17, 1874.

1752. William Camac, Philadelphia.
1753.
1754. Frank Thomson, Altoona, Pa. (Present address Philadelphia.)
1755. Rev. Robert Ellis Thompson, Philadelphia.
1756. Joseph Norman Lockyer, London.
1757. Richard A. Proctor, England.
1758. Raphael Pumpelly, Newburgh, N. Y. (Present address Newport, R. I.)
1759. Charles Augustus Young, Princeton, N. J.

Elected July 17, 1874.

1760. Franklin Platt, Philadelphia, Pa.
1761. Sir William George Armstrong, Newcastle-on-Tyne, England.
1762. Henry Woodward, London, England.

Elected October 16, 1874.

1763. Rev. James Freeman Clarke, Boston, Mass.
1764. Franz Ritter Von Hauer, Vienna, Austria.
1765. Rawson W. Rawson, Barbadoes.
1766. Samuel Philip Sadtler, Philadelphia.
1767. George A. König, Philadelphia.
1768. Charles Francis Himes, Carlisle, Pa.
1769. Robert Stockton Kenderdine, M.D., Philadelphia.
1770. Alfred R. C. Selwyn, Montreal, Canada.

Elected January 15, 1875.

1771. Jared P. Kirtland, M.D., East Rockport P. O., Ohio. Died December 10, 1877, æt. 84.
1772. John B. Pearse, Philadelphia. (Present address Boston.

Elected April 16, 1875.

1773. William A. Ingham, Philadelphia.
1774. Viollet le Duc, France. Died.
1775. John McArthur, Jr., Philadelphia.
1776. Joseph Allison, Philadelphia.
1777. Edward Penington, Philadelphia.
1778. Henry Cadwalader Chapman, M.D., Philadelphia.
1779. Alexander Agassiz, Cambridge, Mass.
1780. Frederick Prime, Jr., Easton, Pa. (Present address Baltimore, Md.)
1781. Samuel P. Langley, Allegheny City, Pa.
1782. Henry S. Hagert, Philadelphia.
1783. C. F. Chandler, New York City.
1784. Rossiter W. Raymond, New York City.
1785. Leonard G. Frank, Philadelphia. Died May (?), 1876.
1786. William P. Tatham, Philadelphia.

Elected July 16, 1875.

1787. Thomas Messinger Drown, M.D., Easton, Pa.
1788. John Lyle Campbell, Crawfordsville, Indiana.

Elected October 15, 1875.

1789. Stephen Smith, M.D., New York City.
1790. William Blasius, Philadelphia.
1791. Gideon E. Moore, Jersey City, N. J.
1792. Furman Sheppard, Philadelphia.
1793. Russell Thayer, Philadelphia.
1794. James Clerk Maxwell, Cambridge, England. Died November 4, 1879, æt. 47.
1795. Charles Edward Hall, Philadelphia.
1796. John Franklin Carll, Pleasantville, Pa.
1797. Andrew Sherwood, Mansfield, Pa.

Elected January 21, 1876.

1798. J. Gibbons Hunt, Philadelphia. Resigned November 17, 1876.

Elected April 21, 1876.

1799. Frank M. Etting, Philadelphia.
1800. Daniel C. Gilman, Baltimore, Md.
1801. P. Cunliff Owen, London, England.
1802. I. Lowthian Bell, Newcastle-on-Tyne, England.
1803. James Geikie, Edinburgh, Scotland.
1804. Thomas C. Archer, Edinburgh, Scotland.
1805. Adolf Eric Nordenskiold, Stockholm, Sweden.
1806. C. Juhlin Dannefeld, Stockholm, Sweden.

1807. Elihu Thompson, Philadelphia.
1808. Charles V. Riley, St. Louis, Mo.

Elected July 21, 1876.

1809. Richard Åkerman, Stockholm.
1810. John Johnson, Middletown, Conn.

Elected October 20, 1876.

1811. Samuel Davenport, Adelaide, S. Australia.
1812. Dom Pedro D'Alcantara, Emperor of Brazil, Rio da Janeiro.
1813. John F. Hartranft, Philadelphia.
1814. W. Milnor Roberts, New York City.
1815. Augustus Radcliffe Grote, Buffalo, N. Y.

Elected February 2, 1877.

1816. F. Reuleaux, Berlin, Germany.
1817. Rudolf Von Wagner, Würtzburg, Germany.
1818. Mariano Barcena, Mexico.
1819. E. H. Von Baumhauer, Harlem, Holland.
1820. George Stuart, Philadelphia.
1821. William V. McKean, Philadelphia.
1822. Charles W. Shields, Princeton, N. J.
1823. Franklin B. Gowan, Philadelphia.
1824. Henry Phillips, Jr., Philadelphia.
1825. Henry Turner Eddy, Cincinnati, Ohio.
1826. Cyrus Fogg Brackett, M.D., Princeton, N. J.
1827. James Morgan Hart, Cincinnati, Ohio.
1828. Henry Armitt Brown, Philadelphia. Died August 24, 1878, æt. 33.
1829. Charles William Siemens, London, England.
1830. M. Russell Thayer, Philadelphia.
1831. Craig Biddle, Philadelphia.
1832. Thomas Hewson Bache, M.D., Philadelphia.
1833. John Hugh McQuilian, M.D., Philadelphia. Died March 3, 1879, æt. 53.
1834. George Strawbridge, M.D., Philadelphia.
1835. William Goodell, M.D., Philadelphia.
1836. Thomas Frederick Crane, Ithaca, N. Y.

Elected April 20, 1877.

1837. Henry Draper, M.D., New York City.
1838. J. T. Rothrock, M.D., Philadelphia.
1839. James Douglas, Phœnixville, Pa.
1840. John James Stevenson, New York City.
1841. George R. Moorehouse, M.D., Philadelphia.
1842. T. B. Reed, M.D., Philadelphia.

Elected July 20, 1877.

1843. H. C. Humphreys, Philadelphia.
1844. J. J. Sylvester, Baltimore, Md.
1845. John Ericsson, New York City.

Elected October 19, 1877.

1846. William B. Taylor, Washington.

Elected January 18, 1878.

1847. Ira Franklin Mansfield, Cannelton, Pa.
1848. I. C. White, Morgantown, W. Va.
1849. F. A. Randall, M.D., Warren, Pa.
1850. John Price Wetherill, Philadelphia.
1851. Elisha Gray, Chicago, Ill.
1852. Simon Newcomb, Washington, D. C.
1853. Asaph Hall, Washington, D. C.
1854. Theodore G. Wormley, M.D., Philadelphia.
1855. Christian Henry Frederick Peters, Clinton, N. Y.
1856. James F. Watson, Ann Arbor, Mich. Died Nov. 23, 1880, æt. 41.
1857. Francis Andrew March, Easton, Pa.
1858. Burnet Landreth, Bristol, Pa.

Elected May 3, 1878.

1859. C. Newlin Pierce, DDS., Philadelphia.
1860. Robert Henry Alison, M.D., Philadelphia.
1861. William D. Marks, Philadelphia.
1862. Lewis M. Haupt, Philadelphia.
1863. Burt Green Wilder, M.D., Ithaca, N. Y.

Elected September 20, 1878.

1864. Carl Schurz, Washington, D. C.
1865. Jacob B. Knight, Philadelphia. Died March 10, 1879, æt. 48.
1866. Rev. Fred. Augustus Muhlenberg, Philadelphia.
1867. Elliott Coues, M.D., U.S.A., Washington, D. C.
1868. Alpheus Spring Packard, Jr., M.D., Salem, Mass. (Present address Providence, R. I.)
1869. Joel Asaph Allen, Cambridge, Mass.
1870. Samuel Hubbard Scudder, Cambridge, Mass.
1871. Rev. William Rudder, Philadelphia. Died Jan. 29, 1880.
1872. Morris Longstreth, M.D., Philadelphia.

Elected October 18, 1878.

1873. Albert H. Smith, M.D., Philadelphia.
1874. Rev. Samuel Longfellow, Germantown (Phila).
1875. Rev. Edward Abraham Foggo, Philadelphia.
1876. M. A. Descloizeaux, Paris, France.
1877. C. Schorlemmer, Manchester, England.

Elected January 17, 1879.

1878. Charles Benjamin Dudley, Altoona, Pa.
1879. Philip Howard Law, Philadelphia.

Elected April 18, 1879.

1880. William H. Greene, M.D., Philadelphia.
1881. Arthur Erwin Brown, Philadelphia.
1882. Middleton Goldsmith, M.D., Rutland, Vt.

1883. Carl Seiler, M.D., Philadelphia.
1884. Richard Wood, Philadelphia.

Elected July 18, 1879.

1885. Charles Martins, Montpellier, France.
1886. Sir George Biddle Airy, Greenwich, England.
1887. Charles M. Wheatley, Phœnixville, Pa.
1888. Andrew S. McCreath, Harrisburg, Pa.
1889. Ira Remsen, Baltimore, Md.
1890. E. Reneviers, Lausanne, Switzerland.
1891. Benjamin B. Comegys, Philadelphia.

Elected January 16, 1880.

1892. Damiano Muoni, Milan, Italy.
1893. Charles Francis Adams, Boston, Mass.
1894. Henry Wharton, Philadelphia.
1895. Charles A. Ashburner, Philadelphia.
1896. Robert C. Winthrop, Boston, Mass.
1897. Archibald Geikie, Edinburgh, Scotland.
1898. Oliver Wendell Holmes, M.D., Boston, Mass.
1899. George Whitney, Philadelphia.

Elected April 16, 1880.

1900. Austin Flint, M.D., New York.
1901. Austin Flint, Jr., M.D., New York.
1902. Robert Bartholow, M.D., Philadelphia.
1903. John Vaughan Merrick, Philadelphia.
1904. Ellis Yarnall, of Philadelphia.
1905. George Dana Boardman, D.D., Philadelphia.
1906. Wm. B. Rogers, Sr., Philadelphia.
1907. Ogden N. Road, New York.
1908. Henry Martin Chance, Philadelphia.
1909. Wm. Thomson, M.D., Philadelphia.
1910. Carlisle P. Patterson, Supt. U. S. C. Survey.
1911. Hampton L. Carson, Philadelphia.
1912. Joseph C. Fraley, Philadelphia.
1913. Joseph A. Murray, D.D., Carlisle, Pa.
1914. Horace Howard Furness, Philadelphia.

Elected October 15, 1880.

1915. Alvan Clark, Cambridgeport, Mass.
1916. Alex. C. Outerbridge, U. S. Mint.
1917. Jacob B. Eckfeldt, U. S. Mint.
1918. Patterson Dubois, U. S. Mint.
1919. Lewis A. Scott, Philadelphia.
1920. Cadwalader Biddle, Philadelphia.
1921. Thomas H. Dudley, Camden, N. J.
1922. Isaac C. Martindale, Camden, N. J.
1923. Wm. Boyd Dawkins, Manchester, England.
1924. Daniel Draper, Ph.D., New York.

TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

ARTICLE I.

TOPOGRAPHY OF THE PUNJAB OIL REGION

BY BENJAMIN SMITH LYMAN.

Read January 19, 1872.

I.—SITUATION.

The Punjab oil region is in the corner between Cashmere and Cabul, and lies wholly between north latitude 32° 31′, and 33° 47′, and east longitude (from Greenwich) 71° 18′, and 73° 5′; a nearly square space about a hundred miles long east and west by ninety miles wide, north and south.

Just inside the northeast corner of this square is Rawul Pindee, the largest town of the region, with about twenty thousand inhabitants; just inside the southeast corner is Pind Dadun Khan, a town of about twelve thousand inhabitants; and just inside the southwest corner is the ancient uninhabited ruin of a walled town, now called Kafir Kot. Just within the northwest edge of the region, and less than twenty miles from its eastern edge, stands the little village of Shah kee Dheree, on the site of the ancient capital Taxila, where the king Taxiles hospitably entertained

Alexander the Great. The small town of Attok, where Alexander crossed the Indus into India, is only ten miles north of the middle of the northern edge of the square. The famous Muneekyala Tope, built by king Kanishka, about the Christian Era, to mark the spot where Booddha in compassion gave his own flesh to satisfy the hunger of a starving tiger, stands a little outside the square, fifteen miles southeast of Rawul Pindee.

The river Indus enters the square about the middle of the northern edge, and leaves it at the southwest corner. The Jhelum River (the "fabulosus Hydaspes" of the ancients), one of the five rivers that gives its name to the Punjab, flows across the southeast corner, past Pind Dadun Khan, southwesterly towards the Indus. The centre of the region is drained by the Sohan, which rises near Rawul Pindee, and flows west southwest to the Indus.

The region lies, then, mostly between the Indus and Jhelum, in what is called the Sind Sagur Doab (two rivers), and it is mainly in the mountainous or hilly part (Kohistan) of the Doab.

II.—General Lay of the Land.

The wide, flat plain of the lower Indus skirts the southern edge of the region, but the rest (within the Doab) is filled by a somewhat uneven table land, about 750 feet higher than that plain, with the Salt Range on the south in a very open vee, pointing southwesterly, and long armed on the east, and with the Choor Hills and a spur of the Himalayas on the north, nearly parallel to the Salt Range, but in a still more open curve, and with two or three much shorter parallel mountains between those two main ranges.

This spur of the Himalayas (4,000 feet high above the sea) just enters the northeast corner of the region, dies down into the plains (about 1,900 feet above the sea) for a dozen miles, and is continued westerly in the Choor Hills (up to 3,500 feet in height) as far as to the Indus, followed by a little studied region of higher mountains, west of the river. The Salt Range, with two ridges 3,000, or even at one point 5,000 feet high and a valley between of half a dozen miles wide and some 2,500 feet high, passes just north of Pind Dadun Khan, west and southwesterly, to the southern edge of the region, and then turns northwest with a single ridge, and afterwards with several ridges, to the Indus, followed by high mountains west of the river.

The country between the Choor Hills and the Salt Range is a comparatively level one, about fifteen hundred feet above the sea. A dozen miles southwest of Rawul Pindee, the mountain called Khairee Moorut rises above the plain, and runs southwest for fifteen or twenty miles, reaching a height of over 3,000 feet. There are also, here and there, a few lower hills in the plains.

On the south the Salt Range falls abruptly to a very level plain that spreads far and wide at about 750 feet above the sea. In the very southwesternmost corner of the region the mountains west of the Indus come close to it at Kafir Kot, and run southerly with a double ridge, and rise to a height of more than 2,000 feet above the sea.

The Indus flows with a swift current through a narrow, rocky channel (100 to 500 yards wide) with high banks in the country above the Salt Range, but on reaching the plain below (at Kalabagh) spreads out into many wide channels, with low banks and irregular islands, and changes its course from time to time. The river falls between Attok and Kalabagh (110 miles) about two feet a mile; for 350 miles below Kalabagh about eight inches a mile. The Jhelum likewise spreads out into many channels in the low country.

As the climate affects the topography, it must be remarked that almost all the rain of the year takes place, in this region, within two or three months of the summer, which are preceded by two or three months of very hot, dry weather, with the thermometer sometimes at 120° F. in the shade. Owing to the summer rains and the melting of snow in the Himalayas, and other very high mountains, there are great floods, and the Indus rises about fifty feet in the narrow channel above Kalabagh; but in the wide channels below, about eight or nine feet, spreading out into broad lakes. The stream of the Sohan, and other smaller rivers is, in the dry season, a mere thread in the midst of a waste of sand sometimes a mile or more wide, which it wholly covers in the rainy season. Of course many of the smallest rivers are quite dry before the rains begin. The streams that flow down the southern face of the Salt Range almost all dry up in the great heat of the low country, and are lost in the sand before reaching the great rivers.

In the valley on top of the Salt Range is a lake, Son Sukesur Kuhar, that has no outlet and is salt. On the northern side is another salt lake, Kullur Kuhar, which has, however, an outlet in high water, and is less salt than the other.

III.—SPECIAL FEATURES.

In looking into the topography of parts of the region, the chief things to notice will be (1) their general height, (2) the character of the hills as affected by the steepness of dip of the rocks, (3) the modification of this character with time, and (4) the mode of cutting out the valleys.

1. The most striking feature in the topography of any region is the general difference of height of the different districts. We have, for example, in the region in question, mountain lands, such as the Salt Range, the Choor Hills, the Himalaya Spur and Khairee Moorut; table land, such as the central part of the region; and low land, such as the plain south of the Salt Range.

The causes of such present differences of height are: the height to which the rocks have been raised to begin with; the length of time that they have been wearing away, and the general ease with which they wear away, which depends on their general hardness, firmness, solubility and permeability. The final result of the wearing away that is going on all over the land is, of course, to bring everything to a dead level, and that the level of the sea. It might, therefore, be that land as high as the Kohistan once stood south of the Salt Range, and has, in the course of many ages, been worn down to a low, flat plain; as in the course of time the Kohistan must be, if it should never be pushed upward again. But the low land south of the Salt Range, is still high enough above the sea to show by unequal wearing away, harder ribs of rock, if it had them; and it would seem to be pretty uniformly soft to some depth, as if not long enough deposited to become very hard. It is probable, therefore, that since the deposit of its present upper surface, it has never been raised so high as the Kohistan, though this surface may rest upon a floor of much older rocks below, that may be the remnant of land as high as the Kohistan.

The whole of the Kohistan, however, seems to have been raised about the same time and to about the same height; and its differences of level come in a great measure from the relative ease with which its rocks have been worn away, chiefly from their relative hardness. But the table land has been in general wearing away for a much less time than the mountain land, because it is made up of newer rocks that were formed in the bed of what was perhaps a great lake in the older rocks that make up the mountains. The newer rocks, then, take the place of a great hollow in softer rocks of the older formation, a hollow that would have been worn still deeper but for the protection that has been afforded by the covering.

This consideration enables some conclusions to be drawn as to the geology from the mere topography. The Salt Range is formed chiefly of a thick lime rock (the nummulitic) and the softer rocks that it covers; and the Choor Hill Range consists of a similar probably the same lime rock; and Khairee Moorut most likely of the same; in short, all the high mountain land of the region seems to be caused by the presence of this thick lime rock, and it is probable that wherever it once rose above the present level of the country it has left hills or mountains to mark its place. Now, the dip on the northern side of the Salt Range is northerly, and it is pretty certain therefore that the southern dip of the Choor Hills must be southerly; for, if this were northerly, the lime rock must have risen to the surface somewhere between the two ranges, and have left a ridge of rocks dipping southerly. Khairee Moorut is too short to represent so long a ridge as this must have been, and is probably a small saddle of the lime rock rising above the table land. The rocks, then, south of the Choor Hills as at Gunda, must rest upon the lime rock of those hills, however much steep and even somewhat reversed dips may make the contrary seem probable. The apparent dips did, indeed, mislead me at first. But if the Choor Hill lime rock lies really above the Gunda rocks, then both must be above the Salt Range nummulitic lime rock; and this is possibly so.

2. Looking closer than at the mere height of the land, the forms of its surface have three different characters according as the rocks (*a*) lie level, or (*b*) dip steeply, or (*c*) gently.

a. The central table land of the region is mainly made up of rocks of quite late age, perhaps old alluvium, possibly passing without break into Siwalik (Miocene) rocks below. These rocks lie nearly or quite level, and this fact here, as in other regions, gives rise to characteristic forms. The general slope of the country is comparatively level, and the ground is generally flat; but near the streams, high vertical cliffs are common, connecting the flat tables above with the flat valleys below. This might be called square-edged topography. The rocks are generally pretty soft or tender, some of them especially so; and the growth of a narrow gully into a good sized valley is quite rapid.

b. The surface of this part of the region is not, however, exclusively of this square-edged character, for it is somewhat affected by the older rocks below, which rise to to the light in many places both in the valleys and on the higher lands. These rocks are of nummulitic age, and are generally harder and firmer than those above, and often remain standing where they may have once been covered by them. In the northern part of the region the lower rocks generally have also a steep dip, and are folded into numerous sharp saddles and basins. This makes it not uncommon here for harder layers of rock to stand up like a knife-edge, so sharp, in fact, that some of the Cheerpar hills, 150 feet or more in height above the plains, are so thin as to have holes and long horizontal slits quite through them at some distance from the top. Such topography might be called sharp-edged. Owing to the great exposure of the softer layers to the falling rain, they have been much worn away, so as to leave the harder ribs standing out, and the topography has a skeleton-like, bony look. This fact often enables the geological structure to be seen very easily from the mere topography, and the basins and saddles to be made out from the map. The topography has this sharp-edged character, in places where the streams have cut down to the lower rocks, as far south at least as the Sohan River. It is shown by the little, sharp, narrow, parallel valleys of the small streams that empty into the Sohan on the north. It is probable that the same sharp folding of the lower rocks continues for some distance south of the Sohan; but the map shows no such sharp-edged topography, owing no doubt to the thick covering of the newer rocks above, as far as to the Salt Range.

c. In the Salt Range part of the region, the nummulitic rocks rise very high, generally in a double saddle with a small basin between, but have commonly pretty gentle dips especially towards the north. Sometimes the dip is so gentle as to give rise to something like the square-edged topography already noticed; for example, at Chinnoor, Hungooch and Dooma. But the dip is often too steep for this, and the topography is then blunt-edged in character, as in the hills northeast of the Salt Range at Jaba near Kalabagh and many parts of the Salt Range itself. There are even in this case often short vertical cliffs, but the shape of the land above them is steeper than where the rocks lie level, though less steep than where the rocks dip very steeply. At Aluggud there is a very uniform dip of about 25°, and a nearly corresponding steepness to the hill on one side; but certain soft thick layers of clay or shales are so protected by harder layers of sand rock or lime rock as to form vertical walls on the other side of the hills. Had the dip been much steeper, the clay and shales would doubtless have been wholly washed away to water level leaving the harder sand rock and lime rock layers standing, if these were thick enough to hold themselves up.

3. The progress of the wearing away with time gives rise to varieties of these main topographical characters. The tendency is to bring the whole country finally to the level of the sea; but progress towards this end is, of course, more rapid in the water courses than elsewhere. Little elevation above neighboring drainage levels by lessening the force of the streams makes the progress slower.

We have, therefore, in a square-edged district, first, flat land with crooked, meandering, almost aimless streams, as shown in the low country south of the Salt Range and perhaps in some patches north of Nummul and elsewhere, as well as along some large streams. Next the country becomes uneven; and if the surface to some depth is uniformly soft, the land becomes rolling, as perhaps in some large patches north of the Salt Range; if the surface is somewhat harder, it will so last and shelter the rocks below, as to give rise to long cliffs and gorges, as near Chinnoor, Hungooch and Dooma and elsewhere along the northern side of the Salt Range, and at Nursingpuhar and other places on the southern side. In the course of time, however, after the streams have cut down to their lowest level, these cliffs must recede farther and farther from the streams, though at length with great slowness, and finally the whole country becomes again a dead level, if it remain undisturbed long enough.

But where the rivers, as in the higher country, flow among rocks that have a decided dip, their direction is of course much influenced by the strike of the rocks. It is very plain, for example, that the Sohan follows in general the strike of the lower (nummulitic) rocks; and the same may be said of many of the smaller streams, especially of the very striking series of small side streams of the northern feeders of the Sohan.

In a district where the rocks dip gently, their basins, as they are wider than in one of steep dips, are likely to be longer also and less decidedly broken up by subordinate folds, and the saddles between less broken up and crushed together. The valleys are therefore more likely to be long and the ridges unbroken; and in the course of time, after the first irregularity caused by the comparatively quick wearing down of the main channels to their lowest level, there becomes great uniformity in the shape of the valleys, long, narrow, and parallel, and in the crests of the mountains long and level. The valleys form ravines rather than gorges; for they are not extremely steep on both sides for any great distance. The mountains about Aluggud show these features well. Such mountains in wearing away to the final dead level will become more and more gently rounded ridges, the country will become more and more open, and at length quite flat.

Where the rocks, however, dip very steeply and have been much crushed together and overturned, the small basins are more likely to vary the drainage of the large ones, there are more chances of cross breaks and numerous cleavage planes; so that the valleys are shorter and more irregular, and the mountains rise in peaks rather than in long crests. So it is in the spur of the Himalayas, in the Choor Hills and in the western end of the Salt Range about Jaba near the Indus. In wearing away, such peaks may become more and more rounded, until they sink to the level of the valleys and the country becomes flat.

4. The topography is somewhat affected by the nature of the wearing agent, whether this be the wind, (*a*) the rain, (*b*) rivers, (*c*) the sea, (*d*) frost, or (*e*) ice. But no part of this region would seem to be affected materially by the wearing or carrying power of the wind, unless it be some light, sandy portions of the low country south of the Salt Range.

a. The rain of course falls equally on the hilltops and on the plains, and loosens more or less of the rocks or earth it falls on, according to their hardness, and carries the loosened particles with it to the streams and towards the sea, more or less according to the steepness of the surface. Where a harder bed covers a soft one, this will be, as already remarked at Aluggud and elsewhere, cut to an upright wall around the edges of its shelter. The action of the rain is, then, that of washing. Its effect can be seen everywhere through the region.

b. The action of rivers on the other hand is not merely that of washing, in the same way as rain, but of undermining; for a stream often washes away the bottom of a cliff, and lets the upper part fall by its own weight. It may then wash away the rubbish formed by the fall and continue its attack on the cliff. Such undermining may be seen in progress a quarter of a mile below the Burra Kutta Oil Springs, where the brook has formed at the bottom of the cliff a low cavern not yet deep enough to make the rocks above fall down. A stream that falls over a bed of rock will often, as is well known, undermine it especially if there be a softer layer of rock at the bottom of the fall. The undermined edge of the fall at length comes down, the rubbish is washed away, the undermining goes on again, and so a gorge is gradually formed below the fall. A gorge or pair of cliffs facing each other is, then, a mark of river action; and this is generally combined with the action of rain. Such a gorge is to be seen still forming on a small scale at the Chhota Kutta Oil Springs and a few hundred yards above them, although the greater part of the work was done long ago. Gorges formed in the same way are to be seen at Nursingpuhar and elsewhere along the southern face of the Salt Range; they have apparently been made by much larger streams than now flow through them.

The Salt Range has in the western arm of its vee, near its point, at the village of Nummul, a right angled bay in its southwestern face; and it looks as if this had once been the outlet of all the waters north of the range, and as if there had been an enormous Niagara here that had begun to cut a gorge below for itself, before the present gorge of the Indus at Kalabagh was cut. Perhaps the great amount of salt in the thick layers in the mountain near Kalabagh by its readily dissolving and possibly letting the rocks above become undermined, hastened the completion of the gorge and gave it the start of the one at Nummul.

c. The wearing action of the sea is almost wholly by undermining the headland of a coast. The waves dash against the shore and wear it into a cliff, undermine the cliff, the tidal currents carry off the rubbish that falls, the undermining goes on again, and the sea at last cuts the land down to its own level. But in bays the force of the waves is lessened, the water is quieter, the earthy matters in the water drop more readily to the bottom, the rivers bring in such matter from the valley at the head of the bay, and this becomes silted up. A single long cliff or line of cliffs looking down on a wide plain is then, the mark of sea cutting. The southern escarpment of the Salt Range, so abrupt and striking, gives the impression of a coast line formed by the sea; and really seems to have been so formed when the low land to the south was under water either salt or fresh, though perhaps a little rounded by the rains since then.

d. The frost, as everybody knows, acts by freezing the water in the small cracks or pores of the rock, and so by expansion loosening particles or masses of rock or breaking them apart, and letting them fall, as soon, at least, as the ice that may still unite them melts away. Such loosened masses could only fall down a pretty steep slope. It may be that this action of the frost takes place sometimes, though rarely, in this region; but it cannot happen often in so hot a climate.

e. For the same reason, there is no sign whatever of the action of ice or glaciers, with their grooving and polishing of the rocks by the pebbles and mud they push along, and with the heaps of rubbish that they leave behind them melted.

It is plain from what has been said that, as the topography is so far from being accidental and is so thoroughly modified by the nature and position of the rocks according to simple laws, its careful study is of the greatest importance in making the geology clear; even if not quite so indispensable for the general geology of a large region as for the geological details of a small tract. A merely shaded or hachured map shows some of the geological facts along with a part of the topography, but is very indefinite and imperfect and insufficient for both, as compared with a contour line map. Such work may sometimes seem too laborious and time-taking, but is after all so necessary as to be worth the trouble.

IV. ROCK GROUPS.

The geology of the region or of large parts of it has been treated of by Dr. W. Jameson (Journal of the Asiatic Society of Bengal, 1843), Dr. A. Fleming (Jour. As. Soc. Beng., 1848 and 1853), Mr. W. Theobald, Jr., (J. A. S. B., 1854), Mr. A. M. Verchère (J. A. S. B., 1866–67; and as far as it relates to the oil has been discussed in my own "General Report on the Punjab Oil Lands, Lahore, 1870." Mr. A. B. Wynne, of the Geological Survey of India, has spent the two last winters in exploring the Salt Range and mapping its geology, but beyond a paper or two on special places in the "Records of the Geological Survey of India," his observations have not yet been made public. To save the trouble of turning to those works it may be worth while to give here a short sketch of the geology, so far as known, aside from the structure, which has been already described.

The old alluvial rocks that have been mentioned, as covering much of the table land are of unknown thickness (more than fifty yards at any rate), and perhaps pass upward in some places without interruption into the newest alluvium or wash. It is also possible that in places they pass downward without interruption into the rocks that have been called Sivalik.

We have then this general section of the rocks of the region:

	Thickness
New, little disturbed rocks:	
Alluvium, or wash, - - - - - - - -	unknown.

Old Alluvium? perhaps much more than		150 feet.
Older rocks, with more or less steep dips:		
Miocene?	Greenish grey sand rock, shales and pebble rock and red and green clays (Sivalik? Aluggud and table land north of Salt Range); by some called 10,000 feet, perhaps not more than	3,000 "
Eocene.	Gunda rocks; light brown and red sand rocks and shales with some grey lime rock and shales (south of Choor Hills) with *oil*,	850 "
	Nummulitic lime rock (Jaba and Salt Range generally) with *oil*.	1,100 "
Mesozoic.	Green sand rocks and shales, cherry lime rocks, and iron stained sand rocks with bituminous shales; perhaps	700 "
Carboniferous.	Lime rock, grey sand rock and shales, calcareous sand rock and shales, about	1,800 "
Devonian.	Red variegated grits and clays with copper; greenish sand rocks and shales with grey dilomitic sand-rock; red sand and pebble rock; and red marl with rock salt and plaster, say	2,850 "
		10,450 feet.

The three lower formations are in this region found only in the southern part of the Salt Range and about Kafir Kot; and this account of them is gathered from the older writers. But their statements disagree very much; and the age of different beds often seems to have been determined from quite a small number of their fossils. Mr. Wynne's study of these formations has no doubt added much to what was learned about them nearly twenty years ago, and his report will perhaps change some of the estimates of thickness or of age. There would seem to be a good deal of variation in the beds from place to place within short distances.

V. USEFUL MINERALS.

The following useful minerals are found in the region in greater or less quantity: —(1) oil, (2) salt, (3) plaster, (4) sulphur, (5) alum, (6) saltpetre, (7) coal, (8) gold; and in minute quantity ores of (9) copper, (10) iron, (11) lead.

1. *Oil.*—The oil has been bored upon at Gunda, and at first fifty gallons of it a day were pumped from the well; but the yield of course, grew quickly less (like the ordinates of a parabola), and after the whole amount had reached two thousand gallons (about five months) the daily yield was less than ten gallons. In the region, oil flows also at five other places from natural springs, from a gill to three quarts a day,

and there are traces of it at yet two other places, making eight in all. Asphalt, or dried oil, is found in small quantities at four of these places, and at four other places, at two in notable quantities. At most of the asphalt places there are traces of rock tar or asphalt melted in the heat of the sun; and at one of them (Aluggud) as much as 100 gallons. Besides these dozen places where oil or asphalt is found there are half a dozen places where there are small traces of one or the other, enough to attract notice in the minute examination of the country by its inhabitants. About half of all the places are in the north-eastern corner of the region; about half towards the south-western corner; and one or two in the north-western corner towards the middle.

The Aluggud oil (now dried to asphalt) seems to have come from rocks of carboniferous age, to judge by their fossils, though other things would rather show that they were of later age. If they are carboniferous, then the nummulitic rocks are wanting above them, and have thinned completely away from a thickness of 2,000 feet only thirty miles distant. This oil is also the only case of oil outside of the older tertiary rocks anywhere in the whole region.

All the other oil springs or shows of oil in the southern part of the region are on the northern side of the Salt Range and in the nummulitic lime rock or close above it. The northern ones are either in the nummulitic lime rock, of the Choor Hills, the same probably as that of the Salt Range; or in the Gunda rocks (chiefly sand rocks) that lie south of them, also accompanied by nummulites.

In every case the oil seems to come from a deposit of very small horizontal extent, sometimes only a few feet, seldom as much as a few hundred yards; only in one case, that of the Chhota Kutta and Burra Kutta oil springs, near Jaba does the deposit seem to extend as much as half a mile. Here, too, the oil comes from a thickness of about a hundred feet, and the natural springs yield at one place as much as three quarts a day. At all the other places the oil comes from a much smaller thickness of of rock, from forty feet at Aluggud and twenty at Gunda and Punnoba downwards. Scarcely do any two oil springs come from the same bed of rock.

The oil is dark green in color, and so heavy as to mark 25° of Beaume's scale, or even less. The Gunda oil has been burned a little by the natives with a simple wick resting on the side of an open dish; but the Punnoba oil is more inflammable, and needs a special tube for the wick, though the main opening of the dish or lamp may stay uncovered. The oil generally, however, has been little used for burning except at Punnoba; but has been sought for as a cure for the sore backs of camels. The asphalt was also highly prized forty years ago by the natives as medicine, taken in pills, especially for broken bones. It was carried far and wide, and was called "negro's fat," because it was generally believed to have dripped from the brains of a negro that had been hung up by the heels before a slow fire. It is perhaps needless to say that there is nothing whatever in the mode of occurrence of the Punjab oil, to uphold the chimerical belief that rock oil ever passes by distillation, emanation, or otherwise, from one set of rocks to another, that it originates in any different rocks from those in which it is found; and nothing to show that it has been formed by any other method than the very natural and sufficient one of the low decomposition of organic matter, deposited along with the other materials of the rock. Neither is there anything to show that the oil has been driven by the upward pressure of water, from the lower parts of a bed of rock through its pores to a higher part of the same bed; on the contrary, as the rocks near most of the oil springs dip pretty steeply, if such an action of water were possible, all the oil would long ago have been altogether forced out of the rock at the outcrop. Indeed, such an idea is quite inconsistent with the fact that even a slight amount of oiliness in the pores of a body is a complete bar to the entrance of water; much less could water (without soap) scour the oil from one mass of rock and make it flow into another mass filled with moisture. If oil wells are more numerous in some regions along the tops of rock saddles, the reason is clear, that the oil-bearing bed lies too deep for boring conveniently elsewhere.

Wild hopes have sometimes been entertained that a large amount of oil might by boring near the oil springs be struck in some cavity below the oil-bearing bed; but it is safe to say that they are not justified by anything whatever, either in the Punjab or in any other part of the world, either in the practical experience of oil boring or in the general laws of physics.

2. *Salt.*—In the lower part of the Devonian rocks there are large deposits of salt from white to brick red in color, in layers of about two feet thick, separated by thin (half-inch) layers of red marl, amounting in all to a hundred feet or more. It is mined especially at Keora (in one place in a chamber thirty or forty feet wide and high,) and at other places near Pind Dadun Khan, and on both sides of the Indus near Kalabagh. There are other like deposits of salt, perhaps of the same age, west of the Indus, twenty-five miles north of Kalabagh.

3. *Plaster.*—Gypsum is found in beds as much as thirteen feet thick or more, and in thin seams in the Devonian salt marl in the Salt Range, especially near the salt mines; and is commonly light gray and mottled in color, sometimes pure white, pink, brown or greenish, sometimes crystalline. It is also found in a mass of perhaps 20,000 tons at the Chhota Kutta oil springs, and in one of perhaps 200,000 tons near the Punnoba oil springs, and in some quantity at Loone kee Kussee sulphur pits opposite Dundee on the Indus; in each of these cases apparently altered from line

rock by sulphur springs; and there may be other similar deposits in the region.

4. *Sulphur.*—In each of these cases the gypsum is associated with sulphur, which was dug in some quantities twenty years or more ago, from small open pits, and afterwards separated from earthy impurities by sublimation. It is said to have been visible in small yellow particles in the earth, but cannot now be seen in the rubbish of the old pits. There are other sulphur pits near Nakbund west of the Indus, and perhaps elsewhere in the region.

5. *Alum.*—Alum shales, which are also bituminous and pyritous, are found in the Eocene rocks of the mountains near Kalabagh, and are largely mined. They are burned six or eight months in kilns thirty or forty feet high, and leached in vats of baked clay; the liquor is boiled in iron pans and mixed with "jumsan" (a mixture of sulphate of soda and salt, an efflorescence of the soil in many parts of the low lands), and left to settle and crystalize in vats; the crystals are washed with cold water, and melted in an iron pan in their own water of crystallization; the liquid is poured into earthen jars where it crystallizes, and finally the uncrystallized portion is poured off, the jar is broken apart, and the alum is ready for sale. About twenty years ago its manufacture amounted to more than 400 tons a year; and it had been carried on by one family for eight generations.

6. *Saltpetre.*—Saltpetre is said to be leached from black soil at several places a dozen or twenty miles south-west of Kalabagh on the west side of the Indus.

7. *Coal.*—Thin beds of brown coal, with the look sometimes of good bituminous coal, are found in the Eocene rocks of the Salt Range, especially near Pind Dadun Khan; and in the alum shales of Kalabagh. These last beds of coal are very thin and irregular; but the others sometimes reach a thickness of two feet towards the east, and one of them becomes even three feet thick with good coal at one point fifteen miles northeast of Pind Dadun Khan. The beds, however, would not seem to keep of one thickness for any distance, and are on the whole of little value.

8. *Gold.*—Gold has been washed from the miocene sands along the Indus, near Mukhud and elsewhere; and is found in almost invisible scales. Towards the head-waters of the Indus the scales are said to be much larger. Thirty years ago there were about 300 gold washers between Attok and Kalabagh, and each one earned about ten cents a day. They used a pick, shovel, sieve, cradle, wooden platter (for panning out) and quicksilver. The gold on the Indus is said to be somewhat whiter than that found further east. The washings are richest after heavy rains, that bring down fresh sand from the neighboring rocks to the brooks.

9. *Copper.*—Small concretionary balls of copper ore, chiefly sulphuret of copper

(copper glance), commonly covered with green carbonate of copper, from the size of a walnut down, are found in the upper part of the Devonian rocks of the Salt Range; but no vein of the ore has been discovered. The ore is thought to contain from twelve to twenty per cent. of copper; but to be insignificant in amount.

10. *Iron.*—The ores of iron seem to be almost as small in amount at any one place as the copper ore just mentioned. Small balls or crystals of magnetic iron ore from the size of a walnut down, are found in a pebble rock at Aluggud through a small space; and similar bits of iron are found on the surface of the ground at Gunda, and doubtless in many other places. But no place has been found to yield enough to work.

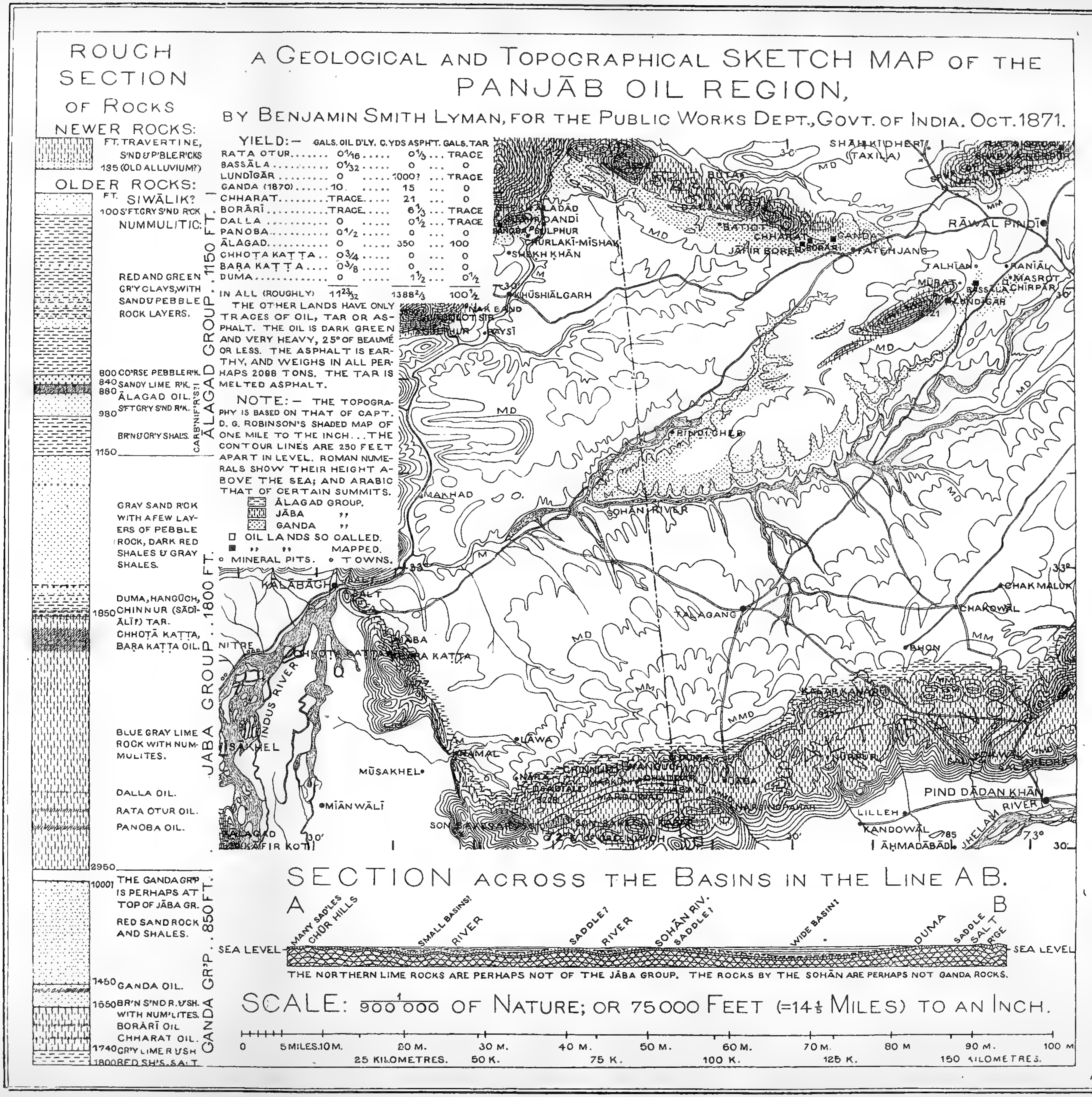
11. *Lead.*—Galena is found in small crystals in a limestone near the Keora salt mines; but is in such small quantity as to be worthless.

VI. MAP.

The Topography of the map that goes with this paper is based on that of Captain (now Colonel) D. G. Robinson's admirable map of the Kohistan of the Sind Sagur Doab, a map on a scale of one mile to the inch with the steepness of the slopes shown merely by depth of shading, and with numerous levels marked in feet.

As a difference will be noticed in the spelling of the same names in the paper and on its map, it may be said that the spelling of the map is according to the rules of romanized Hindoostanee (or for reducing Hindoostanee to Roman characters), a system very convenient for maps, as comparatively brief, and showing the native pronunciation very perfectly, while the diacritical marks can be made in the manuscript without trouble. On the other hand the spelling of the names in the paper is according to the rules for anglicising Indian names, and is more convenient to print, from the absence of diacritical marks, and is more consistent with the rest of the text, and at the same time shows passably the common English pronunciation of native words.

The map is printed from a plate electrotyped direct from a photograph of the manuscript by the process of Mr. Julius Bien, Superintendent of the New York Lithographing, Engraving and Printing Company.


ROUCH SECTION OF ROCKS
NEWER ROCKS:
FT. TRAVERTINE, S'ND & P'BLE R'CKS
135 (OLD ALLUVIUM?)
OLDER ROCKS:
FT. SIWĀLIK?
100 S'FT GRY S'ND R'CK
NUMMULITIC.
RED AND GREEN GR'Y CLAYS, WITH SAND & PEBBLE ROCK LAYERS.
800 CO'RSE PEBBLE R'K.
840 SANDY LIME R'K.
880 ĀLAGAD OIL.
980 S'FT GR'Y S'ND R'K.
BR'N & GR'Y SHALS.
1150
CARB'NIF'R'S?
ĀLAGAD GROUP. 1150 FT.
GRAY SAND R'CK WITH A FEW LAYERS OF PEBBLE ROCK, DARK RED SHALES & GRAY SHALES.
DUMA, HANGŪCH, CHINNUR (SĀDĪ-ĀLĪ?) TAR.
1850
CHHOṬĀ KATTA, BARA KATTA OIL.
BLUE GRAY LIME ROCK WITH NUMMULITES.
DALLA OIL.
RATA OTUR OIL.
PANOBA OIL.
2950
JABA GROUP. 1800 FT.
1000? THE GANDA GR'P IS PERHAPS AT TOP OF JĀBA GR.
RED SAND ROCK AND SHALES.
1450 GANDA OIL.
1650 BR'N S'ND R. & SH. WITH NUM'LITES. BORĀRĪ OIL CHHARAT OIL.
1740 GR'Y LIME R & SH
1800 RED SH'S. SALT
GANDA GR'P. 850 FT.
A GEOLOGICAL AND TOPOGRAPHICAL SKETCH MAP OF THE PANJĀB OIL REGION,
BY BENJAMIN SMITH LYMAN, FOR THE PUBLIC WORKS DEPT., GOVT. OF INDIA. OCT. 1871.
YIELD:— GALS. OIL D'LY. C. YDS ASPH'T. GALS. TAR
RATA OTUR .... 0 1/16 ..... 0 1/3 ... TRACE
BASSĀLA .... 0 1/32 ..... 0 ... 0
LUNDĪGĀR .... 0 ..... 1000? ... TRACE
GANDA (1870) ...... 10 ..... 15 ... 0
CHHARAT .... TRACE ..... 21 ... 0
BORĀRĪ .... TRACE ..... 6 1/3 ... TRACE
DALLA .... 0 ..... 0 1/2 ... TRACE
PANOBA .... 0 1/2 ..... 0 ... 0
ĀLAGAD .... 0 ..... 350 ... 100
CHHOṬA KAṬṬA ... 0 3/4 ..... 0 ... 0
BAṚA KAṬṬA ... 0 3/8 ..... 0 ... 0
DUMA .... 0 ..... 1 1/2 ... 0 1/2
IN ALL (ROUGHLY) 11 23/32 1388 2/3 100 1/2
THE OTHER LANDS HAVE ONLY TRACES OF OIL, TAR OR ASPHALT. THE OIL IS DARK GREEN AND VERY HEAVY, 25° OF BEAUMÉ OR LESS. THE ASPHALT IS EARTHY, AND WEIGHS IN ALL PERHAPS 2098 TONS. THE TAR IS MELTED ASPHALT.
NOTE:— THE TOPOGRAPHY IS BASED ON THAT OF CAPT. D. G. ROBINSON'S SHADED MAP OF ONE MILE TO THE INCH... THE CONTOUR LINES ARE 250 FEET APART IN LEVEL. ROMAN NUMERALS SHOW THEIR HEIGHT ABOVE THE SEA; AND ARABIC THAT OF CERTAIN SUMMITS.
ĀLAGAD GROUP.
JĀBA ,,
GANDA ,,
OIL LANDS SO CALLED.
,, ,, MAPPED.
MINERAL PITS. TOWNS.
SHĀH KĪ DHERĪ (TAXILA)
RĀWAL PINDĪ
BŪTAR
ĀLAGAD
DANDĪ
SULPHUR
HURLAKĪ-MĪSHAK
SHEKH KHĀN
KHŪSHIĀLGARH
JĀHIR BORĀRĪ
GANDA
FATEHJANG
TALHIAN
RANIĀL
MASROT
MŪRAT
BASSĀLA
CHIRPAR
LUNDĪGĀR
RAYSĪ
RINDĪGHEB
MAKHAD
SOHĀN RIVER
KĀLĀBĀGH
SALT
NITRE
CHHOTA KATTA
BARA KATTA
JABA
INDUS RIVER
TALAGANG
CHAKMALUK
CHAKOWĀL
BHON
LĀWA
ISĀKHEL
MŪSAKHEL
MĪĀN WĀLĪ
NAMAL
KAFIR KOT
PIND DĀDAN KHĀN
JHELAM RIVER
LILLEH
KANDOWĀL
ĀHMADĀBĀD
NŪRPUR
MD
MM
MMD
SECTION ACROSS THE BASINS IN THE LINE AB.
A
B
MANY SAD'LES CHŪR HILLS
SMALL BASINS?
RIVER
SADDLE?
RIVER
SOHĀN RIV. SADDLE?
WIDE BASIN?
DUMA
SADDLE SALT R'GE
SEA LEVEL
SEA LEVEL
THE NORTHERN LIME ROCKS ARE PERHAPS NOT OF THE JĀBA GROUP. THE ROCKS BY THE SOHĀN ARE PERHAPS NOT GANDA ROCKS.
SCALE: 1/900 000 OF NATURE; OR 75000 FEET (=14 1/5 MILES) TO AN INCH.
0 5 MILES. 10 M. 20 M. 30 M. 40 M. 50 M. 60 M. 70 M. 80 M 90 M. 100 M
25 KILOMETRES. 50 K. 75 K. 100 K. 125 K. 150 KILOMETRES.

ARTICLE II.

NOTES ON THE GEOLOGY OF WEST VIRGINIA.

BY JOHN J. STEVENSON,

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In this paper I propose to describe the carboniferous series as displayed in a portion of Monongalia and Marion counties, West Virginia, the extension of that part of Pennsylvania described in the reports as the Third Great Basin south of the Ohio, first subdivision.

Laurel Hill, the eastern boundary, appears to attain its greatest importance in the neighborhood of Uniontown, Pa., from which point it gradually diminishes southward, until at the Valley Falls of the Monongahela River, about thirty miles south from the State line, it becomes so insignificant that the Mahoning sandstone passes over it, unbroken. The western boundary is the first sub-axis of the third great basin of Pennsylvania, and was termed Brush Ridge in the report. It is almost parallel with Laurel Hill in Pennsylvania, but near the line it turns towards the southwest, and very soon ceases to affect the dip. The breadth of the sub-basin in its northern part varies little from eight miles. I have chosen to regard this as the average width of the section to be examined, although the western boundary soon disappears and the sub-basin as such no longer exists.

Through the whole district the Monongahela river runs with a course irregularly north and south, cutting through Laurel Hill near Valley Falls. Its numerous tributaries from the east afford excellent natural sections of the lower groups, while those from the west afford equally satisfactory illustrations of the upper coals. Cheat River runs through the northeastern corner. The village of Morgantown is on the bank of the Monongahela, about six miles south from the State line; and Fairmount, on the same river, is twenty miles south from Morgantown. I shall make no reference to the portion lying north from Cheat river, as that has been fully discussed by Prof. W. B. Rogers, in his report on property connected with the Pridevale Iron Works.

The superficial deposits here are very thin. Along the Monongahela, terraces of limited extent are occasionally seen, but along the smaller streams they are not readily distinguishable.

The rock deposits belong to the carboniferous age exclusively. In the gaps made by the Cheat river and Decker's creek near Morgantown, we find the sandstone, limestone and shales of the Lower Carboniferous, Umbral of Rogers. On these rests the great conglomerate, which forms the saddle of the mountain, and which may be seen beautifully curving in the gap of Decker's creek. On the flank of Laurel Hill the coal measures begin, from which line they continue without serious interruption to the western limit of the coalfield in Ohio. The district under consideration shows a small anticlinal axis, parallel to Laurel Hill, which crosses the Monongahela just at Morgantown, and has a marked effect on the dip, reducing it from nearly two hundred feet per mile, near the mountain, to little more than thirty feet per mile west of the axis. As already stated, Brush Ridge, or the first sub-axis of the third basin of Rogers, has little effect on the dip.

THE COAL MEASURES.

In describing the coal measures, I have thought it best to adopt the terms used in the Geology of Pennsylvania and the Virginia Reports, for, though they may not have been based on scientific grounds, they are most convenient for description, as the rocks are here developed.

The Lower Coal Group extending from the conglomerate to the Mahoning sandstone is found on the sides of the mountain, and disappears not far from its foot. It contains one, or in some localities two workable seams of coal and some valuable deposits of iron ore. The Lower Barren Group rests on the Mahoning sandstone and reaches to the base of the Pittsburgh coal. It contains a seam of coal, sometimes workable, several deposits of ore, and some limestone. The Upper Coal Group begins with the Pittsburgh coal, and includes the Waynesburg coal, with its overlying sandstone. It contains four beds of coal, all of large size, and an immense deposit of limestone. Its eastern limit is within two miles of Laurel Hill, and it disappears from four to five miles west from the mountain. The Upper Barren Group includes all above the Waynesburg Sandstone, if I may so term it. Only a small portion is seen in this district, and that only near the western limit. It is developed chiefly in the second subdivision. It contains four beds of coal, two of workable thickness, but all of rather poor quality.

UPPER BARREN GROUP.

This is composed chiefly of shales and sandstones. No satisfactory sections have been obtained, as the hills are usually rounded by erosion and covered with soil. On the Aiken tract, near Dankard creek, thirty-five miles northwest from Morgantown, the blossoms of several small beds are seen; but of these only one has been examined. This is eighteen or twenty inches thick. About fifteen miles east of this, at Price's, is a four feet seam of moderately good quality, from which coal is obtained for smiths' use. Above this, perhaps fifty feet, is another seam of nearly the same thickness, which is opened at Brown's Mills. It is slaty and of very poor quality. Five or six miles east of Price's, there is said to be a five feet coal worked near the hill-top. Of this I know nothing, not having seen it. On Scott's Run, a small seam, one foot thick, and perhaps eighty feet above the Waynesburg, was struck by Mr. Lumley in boring a well at the head of Ramp's Hollow. Exposures are so rare that it is impossible to determine the dip with any degree of accuracy. Otherwise the distance between these coals might be calculated. The intervals, as already stated, are filled with shales and sandstones, limestones being almost wholly absent until the Aiken tract is reached.

UPPER COAL GROUP.—MONONGAHELA RIVER SERIES.

The approximate section of this group is as follows:

1.	Sandstone, "Waynesburg,"	30—40 feet.	
2.	Shale,	1—15 "	
3.	*Coal*, "Waynesburg,"	6—9 "	
4.	Sandstone,	15 "	Interval rocks 183 to 207 feet.
5.	Shale,	8 "	
6.	Limestone,	5 "	
7.	Shales and sandstone,	20 "	
8.	Limestone and shale,	30 "	
9.	Sandstone and shale,	35 "	
10.	Limestone,	6 "	
11.	Sandstone,	15 "	
12.	Limestone,	7 "	
13.	Sandstone,	10 "	
14.	Limestone,	8 "	
15.	Sandstone and shales,	23 "	
16.	Shale,	1—25 "	
17.	*Coal*, "Sewickly,"	4½—6 "	
18.	Shale,	5—8 "	Interval rocks 40 to 49 feet.
19.	Limestone,	9 "	
20.	Sandstone,	4—10 "	
21.	Limestone,	22 "	
22.	*Coal*, "Redstone,"	4—5 "	
23.	Fireclay,	1 "	Interval rocks 18 to 60 feet.
24.	Limestone,	12 "	
25.	Shale,	5—12 "	
26.	Sandstone,	0—35 "	
27.	*Coal* "Pittsburgh,"	7—14 "	
28.	Fireclay,	3	

Waynesburg Coal. The eastern outcrop of this bed is about four or five miles northwest from Laurel Hill. There it caps the highest hills and dips gently to the northwest. This dip is retained until the coal approaches the axis or western limit of our sub-basin, where it is slightly reversed. The bed is everywhere double, which, as well as the heavy overlying sandstone, has led some local geologists to identify it with the "Pittsburgh," which, they believe, runs out in the hills south from Brownville, and does not re-appear to the south again until it reaches the neighborhood under consideration.

On Scott's Run, the first openings are seen high up in the hills about two and one half miles from the river, where the coal is worked by Core, Aiken and Ira Ramsay. Mr. Aiken's bank furnishes the following section; sandstone, very coarse, 30 feet; shale, 1 ft. 2 in.; *coal*, 1 ft. 9 in.; bituminous shale, 1 in.; *coal*, 4 ft. 10 in. At Cassville, one mile and one half higher up the run, the intervening shale disappears and the whole bed increases in thickness, so that, at Tucker's bank, it shows full nine feet of coal. Numerous openings in this neighborhood show no material difference, and the seam is generally known as the "eleven foot vein."

On Robinson's Run this coal is worked near Bowlesby's Mills, where it shows the following section:—Shales with some iron, not measured; Shale, very bituminous, and with thin laminæ of *coal*, 2 feet; *Coal*, 1 ft. 6 in.; Clay 7 in.; *Coal*, 4 ft. 8 in. At this point, five miles from the river, the bed approaches closely to the axis and dips very slightly south-east. No other openings were seen. The coal is locally known as the "Cassville Coal."

The development of this bed here is remarkable, and appears to be limited to our sub-basin. At no point observed does it show less than six and one-half feet of coal, and at Cassville it reaches nine feet. I have not been able to find it in the adjoining county of Marion, and so cannot tell how it may hold out to the south. To the north-west it shows a diminution in size, giving the following section at Waynesburg, Penn.: *Coal*, 1 ft. 8 in.; Clay, 1 ft. 2 in.; *Coal*, 3 ft. 2 in. At Wheeling, W. Va., the thickness is only two feet six inches, and it is single.

In the coal, as seen on Scott's and Robinson's Runs, the laminæ are coarse and irregularly prominent, often one-third of an inch thick, giving a ligneous appearance. Laminæ of mineral charcoal are found at irregular distances and of varying thickness, but preserving the vegetable structure, and looking much like crushed cane. In some of these fragments of a *Cordaites* can be recognized. When rudely broken, it frequently resembles an impure cannel. It burns with great readiness, and for the most part has no considerable tendency to cake upon the fire. As seen on Scott's Run, the lower bed is a good coal, very compact, and in high repute. The upper bed shows numerous thin seams of pyrites, and at times is very slaty. At some points it is a very bad coal. On Robinson's Run, the lower bench, if one may judge from the outcrop, contains a good deal of pyrites, not readily distinguishable, however, in the sound coal, within the opening. The upper bed tends to run into bituminous shale, and is not of very good quality.

Sewickly Coal. In the neighborhood of its eastern outcrop, near Stewartstown, this coal seems to have suffered so much from aboriginal erosion, during the deposition of the overlying stratum, as to have lost all economical value, rarely exceeding one foot in thickness. At that point, one of the highest in the county, it is well exposed; but it does not show itself again, as far as observed, east of the Monongahela River. West of the river, we find it nearly six feet thick, on Mr. Boyer's property, at the mouth of Scott's Run. At Mr. Newkirk's, one mile up the run, it is four feet six inches. At Ira Ramsay's, one mile further, it is five feet, and a short distance beyond, where it sinks under the run, is five feet eight inches. It has been opened at many points along Scott's Run, and, at all these openings, it is divided near the middle by a layer of cannel coal varying from two to six inches in thickness. The lower portion is compact, and contains but little pyrites, while the upper part is softer, and apparently altogether free from pyrites.

On Robinson's Run only one opening was observed—about three miles from the river, a short distance above the school-house. There the bed is four feet six inches thick, and has a thin clay parting near the middle. The cannel coal is about one foot from the bottom, and is not so well marked as in the Scott's Run openings. The coal is very free from pyrites, but is rather friable. At this opening the dip is southerly.

At Laurel Point, on the road to Fairmount, the coal is six feet thick, and the cannel does not appear.

In this coal the laminæ of mineral charcoal, though thin, are at short distances apart. Along the planes of vertical cleavage it shows a neat, clean surface, brightly polished, and none of the ligneous structure belonging to the Waynesburg bed. The fracture is irregular. The coal is remarkably pure. Fifty bushels, which had lain on the dump for a year, exposed to sun and rain, were still brilliant and compact, showing no disposition to slack. On the fire it is almost open-burning, having a very slight tendency to cake. The upper or softer portion on Scott's Run, is in great favor among blacksmiths, owing to its purity, while coal from any part of the bed is highly regarded for domestic purposes. It is undeniably a coal of singular excellence in every respect.

Redstone Coal. This coal is seen at many points along the road leading from the Ice's Ferry pike to Stewartstown. At the latter place it is well exposed on many farms, and shows a thickness of about four feet at its outcrop. The Pittsburgh coal, below, is so accessible there, and is so much thicker, that no openings have been made in the Redstone bed, so far as I could ascertain. The coal along the road, referred to, lies very near the hill-tops, so that the area is quite circumscribed and the quality rather poor.

West of the river it is seen near the mouth of Scott's Run, on Mr. Boyer's property. It is there about four and one-half feet thick, and was worked somewhat, many years ago, for blacksmiths' use, the coal being very pure. A mile and a half up the run, a little stream comes in, on which this bed is exposed, showing a thickness of four feet. The next exposure is by the side of the road at the "fill." The coal disappears under the run at Stumptown, opposite Ira Ramsay's house, a little more than two miles from the river. There is now no opening on Scott's Run, and it is almost impossible to speak positively respecting its character there.

On Robinson's Run, a short distance above Mr. Murphy's house, perhaps two and one-half miles from the river, several rude openings have been made. Here the coal is four feet nine inches thickness, showing a clear bright wall at the end of the drift. The coal is very brilliant and compact, coming out in large blocks, two feet from the outcrop, and showing little disposition to disintegrate upon exposure. At these openings the fireclay varies in thickness at the expense of the coal, sometimes cutting out a foot. The bed disappears a short distance beyond this locality.

Wherever seen, this is the clearest and purest coal in the basin. It seems to contain a very inconsiderable proportion of pyrites, and it has always been in great favor among the blacksmiths. Openings in this as well as the Sewickly are not numerous except in short distances. The people evidently regard a four or five feet seam too thin to pay, and the inclination is to depend on the Pittsburgh coal. Along Scott's Run there are, however, some who appreciate the excellence of these coals, and use them in preference to those of the Pittsburgh bed, even abandoning openings into the latter bed on their own property.

The Sewickly and Redstone coals diminish in thickness toward the south and west. At Fairmount, twenty miles south from Morgantown, the Redstone is three to three and one-half feet thick, with a slaty parting. The Sewickly reaches four feet and has a parting of bituminous shale. They appear to be represented at Wheeling by two seams, twenty feet apart, and each five inches thick.

Pittsburgh Limestone. Under this term I include all the limestone below the Waynesburg coal, although I am aware, that it does not rightly cover so much. The total thickness is about one hundred feet in three hundred and fifty feet of strata. The color varies from light blue to almost black, while most of the strata are quite compact. The layers in each stratum are separated by thin calcareous shale. No 12 of our section yields a good hydraulic lime, which, however, has sufficient tendency to slack to prevent its being a cement of high grade. No fossils have been found in any part of the deposit here; but at Wheeling, a layer of bituminous shale, about two inches thick, occurs thirty-five feet above the coal, and contains a great number of minute fossils. These are very indistinct. The bivalves resemble *Cardiomorpha*, and the univalves, *Spirorbis*. Mr. Meek has informed me that he found a little shell, resembling *Pupa*, in that locality.

Pittsburgh Sandstone. This rock accompanies the Pittsburgh coal at its easterly outcrop along the line of strike from the Pennsylvania line to Pruntytown, thirty miles south from Morgantown, and doubtless further, but my observations terminated there. At a distance of about three miles from the eastern outcrop, it has entirely disappeared. To determine the line upon which it disappears is impossible, as the coal itself has been removed by denudation to a distance of more than a mile, east of the Monongahela, and to almost as great a distance west of the river opposite Morgantown. After crossing the river below Morgantown, one finds no vestige of the rock, nor does it re-appear at any point west on the Ohio side of the great basin.

This sandstone is usually coarse-grained, with feldspathic sand, and some pebbles of quartz, often numerous enough to render it conglomerate, a character which it shares with the sandstone overlying the Waynesburg coal. Its stratification is very irregular, and the material is so uneven in compactness that, in weathering, its surface becomes honeycombed. The thickness varies little from thirty-five feet.

Pittsburgh Coal. Along its eastern outcrop, as already stated, this coal is overlaid by the Pittsburgh sandstone, and where so accompanied the lower bench only is present. The upper bench was doubtless removed by denudation during the deposition of the overlying sandstone. A local geologist, residing not long since at Morgantown, erroneously identified this coal with the Upper Freeport, alleging that it disappears under the Monongahela, about fifteen or twenty miles south from Brownsville, and does not rise again until it passes some distance north from Pittsburgh, where it is supposed to lie one hundred and fifty feet under the river. This locally prevalent mistake has doubtless arisen from the confusion produced by the frequent and extensive curves in the Monongahela river.

The most easterly outcrop is on the property of Mr. House, near the Ice's Ferry Pike, about a mile west from Cheat River. Not far from this point, it is worked by Mr. Anderson, and is eight feet thick. At Anderson's Store, four miles east from Morgantown, it is worked by M. Koontz, and is about the same thickness. Turning north at Anderson's Store and following the road to Stewartstown, the first opening is Smith's bank. Here a black shale lies between the sandstone and coal. The coal is *eight* feet *two* inches thick, with numerous thin partings of highly bituminous clay, quite distinct near the outcrop, but not readily traceable in the solid coal. Some thin seams and occasional nodules of pyrites are seen, but the quantity does not appear to be sufficient to injure the coal. Two other openings in the vicinity show the same characteristics.

In the neighborhood of Stewartstown, seven miles from Morgantown, this coal is finely exposed in ravines upon the farms of Major Johns and Henry Coombs, two hundred and fifty feet below the village church. Several openings have been made, in all of which the bed shows a thickness averaging about *eight* feet. It is quite hard, usually somewhat dull in color, showing little pyrites, but evidently containing some sulphur, as appears from analyses of coal from this locality recently made by Dr. Newberry. About a mile north from Stewartstown, on a farm belonging to the Misses Lewellyn, this coal is said to be eleven feet thick.

Returning to the Ice's Ferry Pike we find, one mile from Morgantown, a number of openings to supply the village. In these the coal varies from six to eight feet in thickness. At two of the openings, the sandstone rests directly on the coal, forming a very irregular surface. To the northwest from these, perhaps, half a mile or a mile, are several other openings. In the former the coal is very black, of dull lustre, and of very variable quality. In the latter it is chiefly irised, quite soft, and contains much less pyrites than the others.

Two miles south from Morgantown, on the west side of the river, Capt. Sears has opened this coal and finds it about nine feet thick and of excellent quality. No further exposure known to me occurs to the south until reaching Smithstown, twelve miles from Morgantown, where it is found in the hills between the village and the river. From that point it is readily traceable to where it crosses the Kanawha river. I have observed the sandstone as far south as the Falls of the Valley river. All along the line the upper layers are wanting, and the average thickness of the bed varies little from nine feet.

Descending the Monongahela from Morgantown, we first find the coal back of Granville, west of the river, where it is worked by Dr. Dent. Two miles below, near the mouth of Scott's run, Boyer's old opening gives the following section: Bituminous shale 1 ft.; *coal* 3 in.; shale 1 ft. 8 in.; *coal* 1 ft.; bituminous shale 1 ft.; *coal* 9 ft. 6 in. About a mile further up the run, near Haigh's Mill, the seam is thicker and shows as follows: Shale 5 ft.; *coal* 3 in.; shale 1 ft. 9 in; *coal* 1 ft. 3 in.; shale 1 ft. 5 in.; *coal* 10 ft. The coal here is of good quality, with some iron pyrites, and is rather soft. The shale above the main coal contains numerous vegetable remains, but they are for the most part indistinct. A *neuropteris* and a *cordaites* are the only ones that can be determined. The upper coal is said to be remarkably pure. The seam disappears under the run, about two miles from the river. North from Scott's run, the bed shows some interesting variations. On a little stream one mile below, we find: Limestone 14 ft.; shale 3 ft. 8 in.; *coal* $4\frac{1}{2}$ in.; shale 1 ft. 10 in.; *coal* 1 ft.; shale 10 in.; *coal* 8 ft. 3 in. Not far from this on Courtney's run, a tributary of Robinson's run, we find the following section on Mr. Davis' property: Shale; *coal*, slaty, 1 ft. 9 in.; shale 3 ft. 5 in.; *coal* $4\frac{1}{2}$ in.; shale 1 ft. 10 in.; *coal* 1 ft. 4 in.; shale 10 in.; *coal* 8 ft. 8 in. On Robinson's run, nearly three miles from the river there are several deserted openings which give a section very nearly like the last: Limestone 14 ft.; shale, dark, 2 ft.; *coal*, slaty, 2 ft.; black shale 3 ft. 6 in.; shale very bituminous, 10 in.; coal 1 ft. 3 in.; shale, very bituminous, 1 ft.; *coal* 8 ft., exposed.

The variations of this bed are better marked in this district than in any other known to me. Along the eastern outcrop it has but one layer of coal and one of shale, the latter being occasionally absent. On Scott's run we find two additional layers of coal, with intervening shale; on Courtney's run a third layer is added, with shale; while on Robinson's run the two upper layers of Scott's run are together, the thin 4 in. lying directly upon the lower one, but distinct from it, the two amounting to 1 ft. 3 in., as above given.

The quality of the coal from this seam varies so much at different banks that no positive general statement respecting it can be made with safety. The coal is usually soft, very bituminous, and cakes readily upon the fire. Where not too pyritous, it is an excellent gas coal, for which purpose it is extensively mined at Fairmont. From that point Pierpoint & Watson have shipped to the east about 40,000 tons per annum. Were proper means of transportation afforded, this firm could do three times as much; but the Baltimore & Ohio R. R. Co. evidently seeks to discourage coal mining west of Cumberland, as it neglects or refuses to provide enough cars to accommodate the business. The coal shipped from Fairmont rates hardly so high in the eastern markets as that from Connellsville in Pennsylvania.

North from Fairmont to the Pennsylvania line the coal has been worked only for domestic use. No railroad opens up the country, and the Monongahela as a navigable stream is too uncertain an outlet. One is surprised to learn that this whole section is an unknown land to capitalists, that coal adds no value to property, and that farms with twenty-seven feet of coal, have been offered for sale at twenty dollars per acre, within a year, without finding a purchaser. Under such circumstances there has been no inducement to experiment. There can be no doubt, however, that at two or three banks, near Morgantown, as well as at other localities, the Pittsburgh seam yields a very superior coal for gas and coke. This will soon be of considerable value, as two railroads connecting with the Pennsylvania Central are in course of construction toward Morgantown, and preliminary surveys have been made by U. S. engineers, with a view to the immediate slacking of the Monongahela.

LOWER BARREN GROUP. [BARREN MEASURES.]

An approximate section of this group is as follows:

1.	Shale with iron,	14 feet.	Interval rocks 16—18 feet.
2.	Limestone,	2—4 "	
3.	*Coal,*	$1\frac{1}{2}$–2	
4.	Shale,	3 feet.	
5.	Sandstone,	25 "	
6.	Shales,	8 "	
7.	Limestone,	3 "	
8.	Shale with iron,	$4\frac{1}{2}$ "	Interval rocks $86\frac{1}{2}$ feet.
9.	Limestone,	$1\frac{1}{2}$ "	
10.	Shales and shaly sandstone,	22 "	
11.	Limestone,	$1\frac{1}{2}$ "	
12.	Shale,	18 "	
13.	*Coal,*	$1\frac{1}{4}$–2 "	
14.	Sandstone,	10–25 "	Interval rocks 10—25 feet.
15.	*Coal,*	8 in.–$1\frac{1}{4}$ "	
16.	Limestone,	8 "	
17.	Shales olive,	10 "	
18.	Limestone,	3 "	
19.	Shale olive,	12 "	Interval rocks 88—94 feet.
20.	Sandstone,	40 "	
21.	Conglomerate,	0—6 "	
22.	Sandstone,	15 "	
23.	*Coal,*	$3\frac{1}{2}$–4 "	
24.	Shales variegated with some shaly sandstone,	$33\frac{1}{2}$ "	
25.	Sandstone,	1—4 "	Interval rocks $60\frac{1}{2}$ to $65\frac{1}{2}$ feet.
26.	Shale, calcareous and fossiliferous.	2—4 "	
27.	Shale, variegated, fossiliferous,	24 "	
28.	*Coal,*	4 in.–$1\frac{1}{2}$ "	
29.	Limestone,	5 "	
30.	Shales, variegated with iron,	20 "	
31.	Sandstone,	10–20 "	Interval rocks 45—60 feet.
32	Shales with iron,	10–15 "	

Coals. The coals of this group are, for the most part, of little interest, and none appear to be of economical importance. No 3 is seen on Robinson's and Scott's runs, reaching occasionally a thickness of two feet, and yielding a coal of excellent quality. It has been worked in one or two instances where the owner was ignorant of the proximity of the Pittsburgh coal. Nos. 13 and 15 are never of available thickness; though I have been informed that, at one point below the mouth of Scott's run, along the river, No 13 expands to twenty inches. No 15 is about as bad a coal as one often sees, its outcrop, where protected by projecting rock, being coated with crystals of copperas.

No 28, which may be the equivalent of the Elk Lick coal, is exceedingly variable in size and appearance. At the "Hog Back" on Decker's creek, one mile from Morgantown, it varies from *four* to *twelve inches* in thickness within one hundred feet. It breaks into small blocks, an inch or two each way, and bears much resemblance to an imperfectly formed cannel. At some points it is slaty, at others entirely free from any such structure. Many years ago it was opened two miles south from Morgantown, near the poor-house. There it is nearly *twenty inches* thick and of very poor quality—a richly bituminous shale, of the kind usually termed "cannel coal," by courtesy.

No. 23 in its local development is of some importance. I have seen it only east of the Monongahela, but it exists on the west side. Thirty years ago it was opened near Decker's creek, three miles from Morgantown. At the same time it was opened in the hill opposite the University, near the village. Two or three years ago it was opened in a ravine east from the village, with a view to supply the village. The work was abandoned owing to the thinness of the bed, which made the cost of extraction too great to admit of competition with the openings into the Pittsburgh. During the present year it has been opened by Mr. Millar, opposite the University, and also by Mr. Fordyce, a short distance to the north, merely to supply the owners.

At Mr. Millar's opening, the seam shows: Bituminous shale six to eight inches; *coal* three to three and one-half feet. The general structure of the coal is slaty, and in some portions its fracture resembles that of impure cannel. In others it is distinctly conchoidal and of the color of lignite; while again it resembles the Grahamite of Ritchie County, or the Albertite of New Brunswick, to a wonderful degree. Near the bottom, the coal is very hard and brilliant, apparently only semi-bituminous. It does not ignite as readily as the other coals of this region, but lasts longer on the fire, and produces an intense heat. In burning, it gives off little soot, not enough to coat the pipe, "being almost as clean as wood," as Mr. Millar expressed it. It, however, contains a considerable amount of free sulphur, which renders it very hard upon stoves. The ashes are bulky but light, and contain no cinders, as the coal burns up clean. It is unfortunate that this coal has so much sulphur, as otherwise its very large proportion of fixed carbon would render it very valuable for manufacturing purposes here where the available coals contain so much volatile matter. This bed is frequently cut up by "horsebacks" and "mudseams."

Iron. In the shale No. 1. there is usually found a highly valuable deposit of protocarbonate of iron, rich and pure, locally known as the "Olyphant blue lump." Near Uniontown, Pennsylvania, it is well developed, and Mr. Olyphant has worked it successfully there for many years, in Fairchance furnace. On Scott's run, near Haigh's mill, the quantity is considerable, and one may work out half a ton of nodules in a short time with but little labor. According to the Pennsylvania surveyors this deposit is not found to the north from Redstone Creek; and I have been informed by Hon. F. H. Pierpoint, who is engaged in mining the Pittsburgh coal at Fairmont, that it does not appear under the coal bed there. It is said to be found south from Fairmont, near the Monongahela river. The distribution of this ore is of much economical importance, as it is the most extensive deposit in this region. In No. 10, nodules of large size are common; but the character of the rock is such as to render profitable mining impossible. No. 30 contains two seams of ore. The lower is irregular in thickness, averaging about six inches, of moderately good quality, and occasionally calcareous. The upper is nodular, but seldom of sufficient thickness to prove of value. Both seams sometimes disappear altogether. The seam of ore in No. 32 is near the bottom of the stratum—an irregular band of nodules, of low grade. Many years ago it was extensively taken out to supply the old furnace on Decker's creek, where, in combination with other and better ores, it was successfully worked. No. 24 contains an irregular band about a foot thick which has never been tested.

The *Conglomerate*, No. 21, is a curious stratum varying in thickness from a few inches to several feet. It is made up of fragments of limestone, sandstone, and iron ore, in size from fine sand to that of a man's head. These fragments are usually rounded, as if by currents existing before or during the time of deposition. Thin layers of homogeneous sandstone or shale may be traced to a considerable distance; and at one point there is a layer of iron ore one foot thick. The extent of this stratum is not known, and I doubt whether it exists west of the river.

The *Sandstone*, No. 20, appears to be equivalent to the one described at Pittsburgh in the Pennsylvania Report. The lower portion is usually compact, affording a handsome and durable building stone. The lines of deposition are often well marked, and not unfrequently the iron there deposited gives the rock a yellowish tint. The upper portion presents a curiously shattered appearance where exposed, due evidently to the decomposition of nodules of impure iron ore.

Shales, Fossiliferous, Nos. 26 and 27, form an interesting little group with the following section: Shale, calcareous, blue, gray or black, 3 ft.; dark shale, with many small ferruginous nodules 12 ft.; calcareous nodules 1 ft.; olive shale 4 ft.; brown shale 6 ft. Excepting the brown shale at the bottom, which does not appear to be persistent, all the layers are richly fossiliferous. The following species have been obtained from this series: *Hemipronites crassus, Chonetes Smithii, C. granulifera, Productus Nebrascensis, P. Prattenanus, P. semi-reticulatus, Orthis carbonaria, Athyris subtilita, Spirifer planoconvexus, S. cameratus, Lima retifera, Aviculopecten carbonarius, A. occidentalis, Nucula parva, N. ventricosa*, N. (?) *anodontoides, Nuculana bellistriata, Yoldia carbonaria, Y. Stevensoni, Edmondia Aspenwalensis, Astartella concentrica, Macrodon obsoletus, Solenomya radiata, Macrocheilus primigenius, M. ventricosus, Euomphalus rugosus, Bellerophon Montfortianus, B. percarinatus, B. carbonarius, B. Stevensanus, B. Meekianus, Pleurotomaria Grayvilliensis, Orthoceras cribrosum, Nautilus occidentalis Petalodus Alleghaniensis*, and undetermined species of *Myalina, Pleurophorus, Edmondia, Deltodus, Lophodus* and *Ctenoptychius*. Fish teeth are very rare; a few crinoidal stems and bryozoans have been found near the top. This series is well exposed at several points on Decker's creek, but the fossils are not usually in very good condition. At another exposure, in a ravine on Mr. Williams' property, five miles north from Morgantown, specimens of nearly all the species named above can be obtained, in excellent preservation. It is a little curious that not a single specimen of *Chonetes mesoloba* occurs in any stratum here, its place being taken by a small variety of *C. granulifera.* The *Productus semi-reticulatus* of this region is very closely allied to *P. costatus*, and I am inclined to regard it as identical with the American variety of the latter species. For the most part the specimens of the species above given are much smaller than similar specimens from the west, and some are almost dwarfed. Mr. F. B. Meek described four new species of shells from this series in Report of the Regents of W. Virginia University for 1870.

LOWER GROUP. [ALLEGHANY RIVER SERIES.]

The section is as follows:

1.	Sandstone, "Mahoning,"	75 feet.	Interval rocks 87 feet.
2.	Shale,	12 "	
3.	*Coal,*	$1\frac{1}{3}$ "	
4.	Shales,	1–25 "	Interval rocks 1—25 feet,
5.	*Coal,*	4—5 "	
6.	Shale,	10 "	Interval rocks 10 feet.
7.	*Coal.*	1 "	
8,	Sandstone,	5 "	
9.	Shale,	10 "	
10.	Limestone. "Ferriferous,"	4—5 "	Interval rocks 50 feet.
11.	Shale,	30 "	
12.	*Coal,*	$3\frac{1}{2}$ " (?)	
13.	Sandstone and Shale,	20–30 "	Interval rocks 20—30 feet.
14.	*Coal,*	2—3 "	
15.	Shale,	15–20 "	
16.	Sandstone, "Tionesta,"	25–30 "	Interval rocks 65—75 feet.
17.	Shale,	25 "	
18.	*Coal,*	$1\frac{3}{4}$ "	
19.	Sandstone,	4 "	Interval rocks 4 feet.
20.	*Coal.*	1 "	
21.	Shale.	10 "	

Mahoning Sandstone. For the most part this is a massive rock, with alternating coarse and fine layers. The former are sometimes conglomerate, and the soft layers above them are pitted on the other side, so as to appear covered with rain markings. In some portions it is flaggy, while in others it is compact and very suitable for building purposes, as blocks six to eight feet thick can be quarried without difficulty. Rude vegetable impressions are not unfrequent, but are invariably too indistinct for identification. This stratum comes down to the level of Decker's creek about four miles from Morgantown. The dip at that point is so diminished as to be almost imperceptible, but is soon reversed and becomes slightly southeast. At the mouth of Decker's creek about forty feet are visible. Here it regains its northwesterly dip and disappears under the river near Granville, two miles below Morgantown. To the south it rises quite rapidly, and at Booth's creek, four miles south from Morgantown, it is nearly forty feet above the river. There it shows a bluff of about seventy-five feet, weathered into large rounded cavities, in some portions, and in others showing a strangely honeycombed surface.

Iron Ore (Fossiliferous). On Decker's creek there rests under the sandstone a dark shale, twelve feet thick, and containing near the middle a band of nodular iron, about two feet thick. It contains an interesting assemblage of fossils, of which the following are the most numerous: *Lophophyllum proliferum, Zeacrinus mucrospinus, Ersocrinus, Cyathocrinus,(?) Hemipronitus crassus, Productus Nebracensis, Productus Prattenanus, Athyris subtilita, Aviculopecten carbonarius, Aviculopecten Hertzeri, Nucula ventricosa, Nuculana arata, Yoldia carbonaria, Astartella concentrica, Macrocheilus primigenius, M. Ventricosus, Polyphemopsis peracutus, Euomphalus rugosus, Bellerophon Montfortianus, B. carbonarius, B. percarinatus, Pleurotemaria Greyvilliensis, P. speciosa, P. carbonaria, P.(?) tumida, Orthoceras cribrosum, Phillipsia Sangamonensis,* together with numerous undetermined species of *Myalina, Schizodus, Allorisma, Pleurotomaria, Nautilus* and *Deltodus.* On Booth's and Coburn's creeks this shale is not present, or, if present, is represented only by a black band four inches thick, which rests on a thinly laminated shale twenty feet thick, containing numerous fragments of *Nevropteris, Sphenopteris, Annularia* and *Sphenophyllum.* It seems to be present on White Day Creek, twelve miles south from Morgantown. It is not persistent in Ohio or Pennsylvania.

Coal No. 3 of Section. On Decker's creek, a small seam of coal, fifteen inches thick, underlies this shale. Some years ago it was worked near the Point House, on that stream. The coal is said to have been of excellent quality. This seam does not appear on Booth's creek, nor do I know of its existence on White Day. A coal bed occupying the same position has been slightly worked at Nuzum's Mills, seven miles south from Fairmont, on the Baltimore & Ohio Railroad. It is nearly three feet thick.

Coal No. 5 of Section is the important and persistent seam of this group. It appears on Cheat river, near Ice's Ferry, and is there worked on the north side of the river. It has been worked on Tibb's run, a tributary of Decker's creek, on the creek, and in some of the ravines opening upon it. In these localities it is four feet thick, divided near the bottom by a thin clay parting. The shale above for several feet is very bituminous, with a conchoidal fracture, and is sometimes irised. It is undoubtedly a cannel coal of inferior quality, and in some places has been worked with the coal below. The coal is very friable and breaks into rhombic pieces. Traced southwesterly this bed crosses Aaron's creek near the Kingwood road, about four miles from Morgantown, and is worked by Mr. Bell. It also appears at several points along Coburn's creek.

On the Evansville road, about seven miles from Morgantown, it is opened by Mr. William Howell. Here it lies directly under the Mahoning sandstone, and gives the following section: *Coal* 3 ft. 1 in.; clay shale 2—4 in.; *coal* 1 ft. 3 in.; shale 2 in.; *coal* 3 in. Evidently the whole bed is not worked here, for on the other side of the hill there appears to be a foot or more of coal above. It is not well exposed, but I was informed that it did not pay to work more than the lower four feet.

Coal (local). Ten to fifteen feet below this coal, on a tributary of Decker's creek, there is a small seam about one foot thick. It appears to be exceedingly local, as it has not been found on Decker's creek, or to the south.

The Ferriferous Limestone (No. 10) is frequently double, with intervening shale sometimes several feet thick. Toward the top it contains cavities with ochre, is very ferruginous, and at one or two localities it has been worked as a calcareous ore. It is quite persistent for twenty miles south of the Pennsylvania line, but does not appear in the section at Nuzum's mill. The rock was used as a flux at the old furnace on Decker's creek and at Clinton Furnace on Booth's creek. It affords a good strong lime, well fitted for agricultural purposes and for rough work. Little use has been made of it. One cannot fail to wonder at the lack of enterprise among farmers here, when he learns that, in a country where limestone shows itself in almost every hill, lime commands fifteen cents per bushel at the kiln.

Coal, No. 12, (of the main section) I have not seen. It was worked many years ago on Decker's creek, a little below the old furnace, but the openings and exposures have been so concealed by heavy slides that direct information can be obtained only with great difficulty. It is said by old miners to be from three and one-half to four feet thick, and to resemble cannel. The shales above it are laminated and highly bituminous. They burn readily and have been mistaken for cannel coal.

Coal, No. 14, was identified with the Brookville, by Prof. H. D. Rogers. It has been opened at several points along Decker's creek and its tributaries, and is in high repute for domestic use. It is friable, free from pyrites and has been termed locally, the "Blacksmith's Vein." At an opening near the furnace the coal is beautifully irised. It was formerly worked near Clinton Furnace; but, after the discovery of the larger seam above, the workings were abandoned. The openings are now filled up and no satisfactory information can be obtained. So far as known to me it has not been worked at Nuzum's mill.

The Tionesta Sandstone (No. 16), varies in texture from moderately coarse conglomerate to fine-grained sandstone. Compact and flaggy layers alternate on Decker's creek. On Booth's creek, it is mostly compact. At Nuzum's mill the texture is uneven, and it has weathered so as to leave huge chambers. The compact layers are very refractory, and some of them have been employed as furnace-hearths. On Decker's creek a small seam of coal, three or four inches thick, has been found in this rock.

Coals, No 18 and 20, seem to represent the Tionesta group of Pennsylvania. As exposed on Decker's creek, they are of no importance. No. 18 gives the following: *coal* 8 in.; shale 4 in.; *coal* $1\frac{1}{2}$ in.; shale 2 in; *coal* 1 in.; shale 1 in.; *coal* 4 in. A very hard, refractory sandstone lies between the coals, and contains numerous indistinct vegetable impressions. No. 20 is one foot thick, and of good quality. On Decker's creek these may be seen near the bridge, below Hagidore's mill. On Booth's creek only one of the seams was seen. Its thickness is 18 inches. At Nuzum's mill it is as irregular as the Briar Hill coal of Ohio. Along the railroad cutting, for some distance, it shows itself about three feet thick, but as it approaches the station, the underlying fire-clay increases in thickness, while the coal diminishes, until at length the coal entirely disappears. At this locality the bed has been worked to a slight extent, and has yielded a coal of excellent quality. The fireclay seems not to be inferior to that of Dover, Ohio, which it resembles greatly.

The *Iron Ores* of this group are of some importance.—In No. 6, the ore is a rich hematite, in nodules which frequently contain sharp vegetable impressions. This ore was extensively used at the old furnace on Decker's creek, as well as at Clinton Furnace.—In No. 21, there are two bands, quite persistent. The ore is quite impure, but works well when mixed with better ore. At Nuzum's mill, a very extensive deposit rests on this shale. The ore is very good, but is in immediate connection with the fire-clay, upon which it sometimes encroaches. The nodules are frequently encrusted with the clay, which may, perhaps, prove a hindrance to successful working. These ores have been thoroughly discussed by Prof. W. B. Rogers in his report on property connected with the Pridevale Iron Works, on Cheat River.

THE GREAT CONGLOMERATE.

This formation varies considerably in character, some of the strata being very coarse, with quartz pebbles, three-quarters of an inch thick, while others are fine-grained, and resemble quartz, etc. It disappears on Cheat River, near Ice's Ferry, on Decker's creek, near Hagidore's mill, and on the Monongahela, near Nuzum's mill. In the gaps made by these streams the channels are obstructed by huge masses of the rock, some of them as large as an ordinary log house, and weighing not less than one thousand tons. At no point is it well enough disclosed to afford satisfactory measurement or a knowledge of the succession of strata, so that our information is derived chiefly from borings.

A section thus obtained on Decker's creek, is as follows:

		FT.	IN.			FT.	IN.
1.	Hard sandstone, with seams of iron ore,	22	4	9.	Conglomerate, white, with quartz pebbles,	13	0
2.	Shales,	2	8	10.	Shales, red and blue,	10	10
3.	Sandstone, with carbonaceous matter,	12	8	11.	Sandstone, blue, fine,	23	6
4.	Shales,	1	8	12.	Sandstone, white, fine,	25	6
5.	Sandstone, white,	9	0	13.	Shales, dark with iron,	6	0
6.	Sandstone, black,	18	0	14.	Sandstone, blue, fine, very hard,	18	0
7.	Sandstone, gray, coarse,	14	0	15.	Sandstone, gray, very hard,	15	0
8.	Shales, black,	16	6				
						208	08

The record of the boring beyond this point is lost.

Another boring was made west of the Monongahela, four miles below Morgantown. The record was not carefully kept, so that it is impossible to determine the thickness of individual strata. Yet the section is of interest as showing a marked change in constitution within a few miles.

It is as follows:

1.	Sandstone, white, very hard,	8.	Sandstone, white, coarse,
2.	Sandstone, blue,	9.	Sandstone, black, very coarse,
3.	Sandstone, white,	10.	Sandstone, white, very hard,
4.	Sandstone, blue, softer,	11.	Sandstone, white, coarse,
5.	Sandstone, white, fine,	12.	Sandstone, white,
6.	Sandstone, white, coarse, depth 218 feet,	13.	Sandstone, blue, fine and hard,
7	Sandstone, blue, very hard,	14.	Sandstone, white,
		15.	Sandstone, dark, very coarse.

The shales thus appear to be local.

Thin seams of ore occur at various points; but they are unavailable, as the surrounding rock is so hard that mining would be unprofitable. The thickness of the formation does not vary much from three hundred and fifty feet.

LOWER CARBONIFEROUS.

This period is represented by the Umbral of Rogers, which here shows a division of shales, limestone and sandstone.

The *Shales* are not well defined at any point known to me, on the south side of Cheat river, though, as the land is cleared, and the mountain localities become accessible, they will doubtless be found as readily on this as on that side of the river.

The *Limestone*, as ascertained by borings, is one hundred and seven feet thick, and is well exposed in the gaps of Cheat river and Decker's creek. At the limekiln, on the latter stream, ten miles from Morgantown, where both the top and bottom of the rock are concealed, the following section was obtained:

1.	Concealed,	
2.	Limestone, weathering, yellowish white, flaggy, with fossils,	8 ft.
3.	Concealed,	12 "
3.	Limestone, dove-colored, compact, non-fossiliferous,	14 "
4.	Limestone, dull, dark gray, weathering light gray, and breaking readily after exposure—with numerous fossils,	6 "
5.	Limestone, very coarse, gray, compact, fossils numerous, and indistinct,	6 "
6.	Limestone, dark, impure, upper layers badly shattered at outcrop; lower layers more compact, but breaking readily after exposure, fossils very numerous,	10 ft.
7.	Shale, calcareous, lead-colored,	$2\frac{1}{3}$ "
8.	Limestone, weathering and plastic,	$1\frac{1}{2}$ "
9.	Shales, very calcareous, brown and weathering into mud,	$2\frac{1}{3}$ "
10.	Limestone, gray, compact, non-fossiliferous. Exposed,	8 "

On Cheat river two miles above Ice's Ferry, about twenty feet of the rock equivaalent to No. 1 of this section may be seen.

A list of the fossils obtained from the upper strata on Cheat river was made out by Meek. The following species are determined; *Monticulipora*, n. s.; *Hemipronites crassus; Productus fasciculatus; Productus pileiformis; Athyris subquadrata; Spirifer Keokuk* var.?; *Pinna Missouriensis?; Aviculopecten occidentalis; Allorisma clavata; Bellerophon crassus?; Straparollus planidorsatus; Phillipsia Stevensoni;* besides undermined species of *Allorisma, Macrocheilus, Naticopsis, Bellerophon, Pleurotomaria* and *Cyrtoceras*. This grouping of species shows unmistakably that the upper portion of this limestone belongs to the horizon of the Chester group. It is interesting to observe how closely it is related to the coal measures of the West. *Hemipronites crassus* is a characteristic form in the Western coal measures, and never before was found below them. The *Spirifer* hesitatingly identified with *S. Keokuk* var. (=*? S. Leidyi*) is very closely allied to *S. opimus* of the coal measures. An imperfect specimen of *Bellerophon* obtained here cannot easily be distinguished from *B. carbonarius*, while the *Cytoceras* is closely related to *C. curtum* of the Illinois coal measures.

As these fossils were obtained from the upper strata of the limestone, I did not deem it unreasonable to suppose that, lower down, the equivalents of the St. Louis and Keokuk group might be found; and especially because in Randolph County, West Virginia, specimens of *Lithostrotion* occur quite plentifully. Recent examinations have not justified these expectations; for although in No. 6 of the section, the grouping of species is different from the above, yet the whole has such a Chester aspect that I am compelled to regard the limestone throughout as of Chester age. Further study, however, is desirable, as one or two forms closely related to St. Louis species, occur in No. 6.

The Sandstone is not well exposed, and no satisfactory information respecting it can be given. It varies in color from light gray to brownish, and is moderately fine in texture. The thickness cannot be determined.

ARTICLE III.

THE STALEY'S CREEK AND NICK'S CREEK IRON ORE REGION.

BY BENJAMIN SMITH LYMAN.

WITH A MAP.

(Read before the American Philosophical Society, Oct. 4, 1872.)

The Staley's Creek and Nick's Creek Iron Region, near Marion, Smyth County, Virginia; according to a Rough Survey made in 1866 *by Benjamin Smith Lyman.*

SITUATION.

The Staley's Creek and Nick's Creek Iron Region (counting in it the whole of the Thomas 5,000 acre tract and the Campbell Main Tract, parts of which are strictly not upon the waters of those creeks) lies in the form nearly of a parallelogram about two miles and a-half wide from north-northwest to south-southeast and about nine miles long from east-northeast to west-southwest, containing about twenty-two square miles and a-half, or 14,300 acres; with the northwestern corner of the parallelogram about two miles south of the village of Marion, Smyth County, southwestern Virginia. Marion is on the Virginia and Tennessee Railroad, 160 miles from Lynchburg and 174 miles from Knoxville. The region contains, besides the Thomas tract of 5,000 acres at the western end: east of that, the G. H. Williams (400 acre) tract and a ninety acre tract claimed by A. H. Campbell to lie north of G. H. William's tract between it and the eastern part of the Thomas tract; still east of these tracts the Crochett 1141 acre tract on the north, the S. M. Williams 400 acre tract and the

Marchant 725 acre tract on the south; east of these, the Campbell 147 acre tract on the north, the Campbell 4 acre tract in the middle and the Henderlite 1200 acre tract on the south; east of this last, the Wright 600 acre tract; and eastermost of all, the Campbell main tract of 3550 acres. There are besides within the region a part or the whole of a Nichols tract south of G. H. Williams and some land northeast of the Campbell 147 acre tract.

LAY OF THE LAND.

The southern boundary of the parallelogram would be at the top of Brushy Mountain, for the most part about a thousand feet high above the lowest level (in this region) of the waters of Staley's Creek. About a mile and a quarter north of this mountain runs parallel to it through the whole length of the region a range of nearly the same height cut into three parts by the cross gaps of Staley's and Nick's Creeks; the western part is called Pond Mountain, from a pond somewhere upon it, and the two other parts are called Chestnut Mountain; but as this last name is also sometimes given to the western part of Brushy Mountain and gives rise to confusion, it would be convenient to drop it altogether. The Staley's Creek gap is at about the middle of the range, and the Nick's Creek gap at about the middle of the eastern half. Both creeks fork near the upper (southeast) end of the gaps, and their forks extend in either direction east and west on the north side of Brushy Mountain. The West Fork of Staley's Creek is something over three miles long, heads near the western limits of the region, and has to the south of its head a small mountain called Minton's Ridge between it and Brushy Mountain. The East Fork of Staley's Creek is a little over two miles long; and one of its branches is separated only by a low divide from the West Fork of Nick's Creek, which is but about half a mile long. The East Fork of Nick's Creek is perhaps something more than a mile long. Nick's Creek flows northerly through the gap towards the Middle Fork of Holston River, and Staley's Creek flows into the same river at Marion by a northwesterly course after leaving its gap in Pond Mountain. North of the Pond Mountain Range are smaller parallel hills or mountains, amongst which on the north some of the waters of Staley's Creek take their rise; while in the northeast they are drained by two small streams that run northerly across the northern boundary of the Campbell main tract. The South Fork of the Holston River flows westerly past the southwestern corner of the parallelogram; and between it and Minton's Ridge is another small parallel ridge called Cave Ridge separated from Brushy Mountain by a small valley called Rocky Hollow. South of the river, at the southwestern corner of the Thomas' tract, is still another small parallel mountain called Stone House

Mountain. Staley's Creek where it enters Marion is about two thousand feet above the sea.

GEOLOGY—STRUCTURE.

The rocks of the Pond Mountain Range lie in saddle form, and the saddle appears to sink towards the east from the highest part of the mountain, near the western end of the Iron Region. At the Nick's Creek Gap a small basin may be perceived upon the top of the saddle, and the small southern saddle of the basin may rise eastward so as to replace the other that is sinking; or on the other hand this southern saddle may be only a small roll that soon dies out eastward as well as westward. The rocks of Brushy Mountain form in like manner a saddle, but it appears to have at the westernmost end of the region a double crest, the northern part being the larger; but the southern part seems to rise eastward and to unite with the northern before reaching the eastern end of the region; that is, the small basin at the top of the saddle disappears eastward. There are probably more saddles than one just north of Pond Mountain. Between the Pond Mountain and Brushy Mountain saddles the rocks lie in basin form of course; and there is another basin just north of Pond Mountain.

The dips of the Brushy Mountain saddle are, in the western half of the region, forty-five degrees southerly on the south, and sixty to eighty or even ninety degrees northerly on the north; and appear to grow rather less steep towards the east on the north side, and to steepen in that direction on the south side. The dips of the Pond Mountain saddle are forty-five degrees on either side at Nick's Creek, but steeper westward, especially on the northern side, so as to become in the Thomas tract seventy degrees southerly, reversed.

ROCKS.

The rocks of the region are almost wholly sandrocks and shales; and seem to belong wholly or chiefly to the Formation called in Pennsylvania and Virginia No. I, corresponding to the lower part of the Lower Silurian System. They are grey at the bottom, brown in the middle and red at the top. On the top of Brushy Mountain, near the southwest corner of the Henderlite tract, near the middle of the saddle and consequently among the lowest rocks exposed in the region, are cliffs of a pudding rock made up of rounded pebbles as large as peas and smaller, of white and rosy translucent quartz, apparently in part if not wholly water-worn crystals. Just north of the region and just south of it the blue lime rock of Formation II (also Lower Silurian) appears; and it is likewise found in smaller patches within the region in the middle of some of the basins, probably in all the deep portions of the basins. Between the layers of the lime rock, at least near the bottom, appear to be layers of brown sand rock.

There seem to be outcropping in the region at least 3,000 feet, and perhaps 4,500 feet in thickness of the sandrocks and shales, and in the third basin north of Pond Mountain some fifty feet of the lime rock No. II. There are numerous openings and natural exposures of the outcrops of iron ores, but they seem all to belong to four beds.

The Day Ore Bed appears to lie about 600 feet below the lowest lime rock.

The Thomas Ore Bed lies about 700 feet below the Day Ore Bed.

The Cole Ore Bed is about 1300 feet below the Thomas Ore Bed.

The Old Mountain Ore Bed is about 400 feet below the Cole Ore Bed.

From that to the lowest rocks cropping out where the top of the Pond Mountain crosses the west line of the Thomas tract is perhaps 1500 feet.

The ore of all the beds is brown hematite.

OLD MOUNTAIN ORE BED.

The Old Mountain Ore Bed seems not to be opened anywhere strictly within the region, but is opened at the Old Mountain Ore Bank, close to the southeast corner of the Wright tract, but on the south side of Brushy Mountain, at the top of its southern saddle, at the divide between Slemp's Creek on the east and George's Creek on the West. At this bank there are two large openings, one, the old one, long since abandoned, and the other still in use and the larger; and besides them there are three smaller ones. The thickness of the bed is not apparent, but it must be several feet, perhaps ten feet, possibly more. It furnishes the favorite ore for bloomary forge use of all the region round, and is said to make a very tough iron of the best quality, neither too hard nor too soft, barshire. The ore is a very beautiful, pure looking, honey-combed but pretty compact brown hematite. At one of the smaller openings, the ore is of a dark bluish color and is more compact, but looks pure; it is said to make "exceedingly tough iron in the bloomary, but to free itself less easily than the other one from cinder. It works finely when mixed with the other ore, but as it was a little difficult to hit just the right proportion in mixing, the blue ore was wholly abandoned." The main opening is some twenty yards across and is fifteen to twenty-five feet deep according to the slope of the ground.

The same bed, apparently, is opened at the Barton Ore Bank, about a mile further west on the same outcrop, and about a quarter of a mile east of the southwest corner of the Henderlite tract. The opening is on the south side of a small hollow near the top of Brushy Mountain, and is some forty yards wide and ten yards deep at the western end. The bed seems to dip forty-five degrees northwesterly and is said to have shown that dip much more plainly before the sides of the hole had fallen in so much as they had in 1866 after having been abandoned five or six years. The ore is stated to have been "a bed about four feet thick, of very good quality in the bloomary forge, very easily melted and making very excellent tough substantial iron; but not always perfect, probably red-short, for wagon tires were sometimes ruined while making." The good ore is a beautiful compact brown hematite that looks very pure; but the rock left unmined just below the ore bed is a pudding rock of white crystaline rounded quartz pebbles smaller than peas, united by a brown hematite cement, making also an iron ore but of inferior quality.

The outcrop of the bed is shown also at several places in the region by beds of ore; on the road across Brushy Mountain at the west end of the Henderlite tract, near the top of the mountain, and on the bridle path across Pond Mountain on both sides of the mountain near the top; so that the bed seems to be persistent over a wide space, although the thickness is not known.

The bed seems either to crop out or to come very near the surface all along the top of Brushy Mountain, and to have in all seven miles in length of outcrop in this part of the region. On the south side of the Pond Mountain saddle its outcrop runs from the western edge of the Thomas tract three miles and a quarter nearly across the tract; and then the same outcrop returns westward, on the north side of the saddle, about three miles to the western boundary again, making for the whole Pond Mountain outcrop six miles and a quarter, everywhere near the top of the mountain. North of that the bed seems not to come to the surface again anywhere. The whole length of the outcrop of the bed in the whole region seems then to be about thirteen miles and a quarter.

The amount of ore in tons above the lowest water level of the region has been calculated for one foot of average thickness of pure ore. The lowest water level of the region is taken to be at about a hundred feet above the level of the Staley's Creek where it enters Marion, and is about the lowest level of the waters of that creek where they leave the Thomas tract. These numbers of tons will have to be multiplied of course by the number of feet that the bed averages in thickness, whatever that may hereafter prove to be. In the Brushy Mountain part of the bed there seem then to be above this water level for each foot of average thickness of the bed 7,110,000 tons; in the Pond Mountain part of the bed in like manner 2,380,000 tons; in all therefore 9,490,000 tons for each foot of average thickness of the bed.

As for the average thickness of pure ore in the bed in feet (the multiplier of this number for the full amount of ore) the imperfect information as to the thickness of the bed at the Old Mountain Ore Bank and at the Barton Ore Bank would go to show an average thickness of something like seven feet. The outcrop lumps scattered on Brushy Mountain and on Pond Mountain show the persistence of the bed but give no clue to its thickness.

COLE ORE BED.

The Cole Ore Bed has been opened apparently at two places in the region, both on the Thomas tract, and very insufficiently at both, at least for present observation (1866). The oldest opening on the bed, the Cole Ore Bank, on Rocky Branch, near the head of the hollow, was made about the year 1820, and afterwards its ore was used at Nichols' Forge; but the bank was abandoned some sixteen or eighteen years later, and there is no longer even any hole there, and it must have been but a small hole at any time. It is no longer known whether the solid bed was opened or only the loose lumps at the outcrop. Judging by a few small lumps of ore that still lie about the old opening the ore (brown hematite) was very rich.

At the other opening on the bed, the Pine Spur Ore Bank, on the eastern side of Pine Spur, near the northwest corner of the Thomas tract, a small hole now all fallen in was once dug, and lumps of the ore were found, but not the solid bed. To judge by the little left exposed there the ore is a good deal mixed with angular bits of compact brown sandstone. It is barely possible that, in consequence of a sinking westward (as well as eastward) of the Pond Mountain saddle from a high point near the middle of the Thomas tract, the ore of the Pine spur bank may belong to the Thomas Ore Bed.

Bits of the Cole ore are also found on the hillsides about a quarter of a mile east of Pine Spur opening; and on the bridle path already mentioned near the top of Pond Mountain, on both sides of the summit; on the northern side only a few small bits, but on the southern side (where the water gullies have exposed it better) the blocks are abundant and the quality of some of them pretty good, although another portion of them are merely brown sandstone sprinkled with the ore. It would be easy and well worth while to make an opening here that would thoroughly test the value of the bed at this point; a self-draining drift or open cut could be made northwestward so as to lay bare the whole thickness of the bed. The blocks here are washed for some little distance down the mountain along the path. Outcrop lumps apparently from this bed are found also even so far away as on the road across Brushy Mountain, near the southwestern corner of the Henderlite tracts three miles and a quarter east of the Cole ore bank.

The outcrop of the bed within the region seems to run for four miles and a-half on the south side of the Brushy Mountain saddle and for nine miles and a quarter on the north side, making fourteen miles and a quarter in all for the Brushy Mountain outcrop. The outcrop south of the Pond Mountain Saddle seems to run from the western edge of the Thomas tract four miles and a quarter easterly; then to return westerly four miles; making for the whole length of the Pond Mountain outcrop a length of eight miles and a quarter. North of that the bed appears not to rise anywhere to the surface; so that the whole length of its outcrop within the region is twenty-two miles and a half. It may seem useless perhaps to reckon the outcrop so long when the bed has not been opened nor even its outcrop observed through a great part of it, especially at its eastern end; but the measurement serves to show at least through what space it is worth while to search for the outcrop, although it is possible that the bed may have thinned out and disappeared in some parts. On the other hand it may have become enough thicker in the other parts to make up for any such thinning out.

The amount of ore in tons above the lowest water level of the region has been calculated for one foot of average thickness of pure ore in the same manner as for the Old Mountain Ore bed, and gives: in the Brushy Mountain part of the bed, on the south side 4,150,000 tons; in all 5,710,000 tons. In the Pond Mountain part of the bed is found in like manner 2,660,000 tons. The whole amount of both parts of the bed is then 8,370,000 tons per foot of average thickness.

The average thickness of the bed in feet (the multiplier of these numbers of tons to get the full amount of ore in the bed in this region above water level) is quite unknown; but from the appearance of the outcrop on the bridle path, as the southern side of the Pond Mountain, the bed would seem to have at least a couple of feet in thickness of good, rich ore.

THOMAS ORE BED.

The Thomas ore bed has apparently been opened at several points in the region. The largest and best opening of all is the Thomas ore bank on the Thomas tract, on the Ore Knob, a small spur of the north side of Pond Mountain, about a mile and a quarter east of the northwestern corner of the tract and of the region. The opening is an open cut some ten feet wide running southeasterly about thirty yards, apparently almost at right angles with the strike; and there is from the northern end of the cutting a similar cutting about as long running a little west of south. The ore is exposed in the sides of these cuttings some ten feet in thickness in two or three solid layers, and lies nearly flat, with the appearance of being at the gently rounded top of a saddle; but it is probably only a small saddle or roll upon the northern side of the great saddle of Pond Mountain. The ore is also said to extend below the bottom of the cutting and to be covered up there with rubbish, but it looks in the centre of the saddle as if the ten feet were the full thickness of the ore, and as if there were clay or something soft below it. The ore is very compact brown hematite, full of angular grains of white translucent quartz of the size of peas and smaller, so numerous as to reduce the iron contained in the unwashed ore, perhaps to thirty-five per cent or thereabouts.

About 350 yards east of the Thomas bank is the Hardbarger ore bank on the same bed apparently. It is a hole about fifteen feet deep and thirty feet wide, east and west, on the side of a hill, exposing a large surface of the ore at the northern end of the hole; but the dip cannot be easily made out. The ledge of ore (brown hematite) is broken by cracks in every direction into lumps that are often as much as two or three feet thick, and all the ore is full of angular bits of fine grained buff sandstone, making a breccia of it. It is said that some of it was used for making iron in the blast furnace, and after washing made as good iron as the ore from any of the other banks of the Thomas tract, contrary to expectation. It is quite likely that the ore taken from here came only from the top of the bed, or from the bottom of it, and that a more thorough exploration by digging across the whole thickness of it, would bring to light ore more like that of the Thomas ore bank. The surface of the ore now exposed is about parallel to the course of the bed, so that nothing can be determined from it as to the real thickness of the bed.

This bed apparently is opened also at the Roan ore bank at the roan tree corner of G. H. Williams' land, only about a quarter of a mile east of the eastern boundary of the Thomas tract, on the northern slope of the Wolf Pen Ridge (a spur on the north side of Brushy Mountain), and opposite the eastern end of Minton's Ridge. The opening is but a small hole, a yard or two across and about a yard deep, opened long ago and long since abandoned and fallen in; and there is no evidence whether the solid ore bed was struck, but it is likely that only the loose lumps near the outcrop were found. They are still to be seen scattered about on the hillside around the opening, and show that the ore is a compact brown hematite; but some of it (perhaps all) is filled with small white translucent quartz grains like the ore of the Thomas bank, except that the grains here seem to be all nearly as small as a pin's head; and the richness of the ore seems to be about the same as at the Thomas bank. There is of course no clue to the thickness of the bed.

The same bed too seems to be opened imperfectly on the Henderlite tract by three small holes about forty yards apart, from which only loose, outcrop lumps were taken, at the north side of Brushy Mountain, a hundred yards east of the road at the western boundary of the tract, and three quarters of a mile south southeast of the forks of Staley's Creek. At the two lower openings the ore is a fine honeycombed brown hematite, apparently very pure; but at the upper hole corresponding to the bottom of the bed, the ore is more silicious from the prtsence in it of small, round grains of crystalline quartz a little bigger than a large pin's head.

The bed seems to be opened also on the Wright tract at the Key's ore bank; likewise on the north side of the Brushy Mountain Saddle, nearly half a mile north northwest of the southwestern corner of the tract, near the burnt ruins of an old cabin called Key's Cabin. It is but a very small trial opening, and the ore, found only in loose lumps, is brown hematite in seams running through a brown, fine grained sandrock making a breccia of it; and it was found too sandy for use in the bloomary. But it is quite likely that a more thorough digging would bring better ore to light here, as at the other openinof thebedalready mentioned.

The presence of the bed is also shown by lumps of ore on the ground for more than a hundred yards, at least, west of the Thomas ore bank (the largest lump must weigh at least 300 tons); and again at a point a quarter of a mile west southwest of that bank; and at the bridle path across Pond Mountain, about half way down the northern slope of the mountain and near the foot of the southern slope. At this last place the ore lumps are very numerous, and a little piie of them has been gathered together from a small space; and the ore seems to be of a very good quality. At the outcrop in the bridle path on the north side of the mountaln the lumps are also very numerous and those on the downhill side of the outcrop, corresponding to the upper side of the bed (here reversed) arc mere lumps of sandstone with veins of hematite running through them, something like the Hardbarger orc, but poorer. At all these natural exposures of lumps from the outerops, of course, the lumps roll and slide and get washed to a greater or less distanee down the hill; but the position of the outcrop can be told more or less exactly by the upper llmit of the ore lumps, since they are not carried up hill.

The outcrop of the bed along the southern side of the Brushy Mountain Saddle seems to run for about a mile, across the southeastern corner of the Thomas Tract close by the southern boundary; and on the northern side of the saddle for nine miles and a quarter; making ten miles and a quarter in all. The outcrop south of the Pond Mountain Saddle seems to run from the western line of the Thomas tract five miles and three-quarters easterly, then to return westerly on the north side of the saddle five miles to the same line; making ten miles and three-quarters for the whole Pond Mountain outcrop. The bed seems to come to the surface again nowhere north of that in the region; so that its whole length of outcrop here amounts then to twenty-one miles.

Calculations of the amount of ore in tons above the lowest water level of the region for one foot of average thickness of the bed, like these made for the preceding beds, give: for the Brushy Mountain part of the bed 3,330,000 tons; for the Pond Mountain part, 1,590,000 tons; in all, then, 8,020,000 tons per foot of bed.

The Thomas Bank would indicate a thickness of ten feet at least for the bed (requiring these numbers of tons to be multiplied all by ten to get the full amount of ore in the bed above water level, with a deduction on account of the quartz in the ore); and it is the only point where anything like the full thickness of the bed can be seen. At the other points mentioned where the loose lumps of the outcrop have been found on the ground or dug up, the abundance of the lumps is quite consistent with such a thickness of the bed; but in the absence of any thorough trial pits it is impossible to tell what the thickness may be at those points. In order to form an idea of the average thickness of the bed throughout the region, a number of trial pits should, of course, be sunk along the different outcrops so as to expose the full thickness of the solid bed.

DAY ORE BED.

The Day Ore Bed also seems to have been opened at several points within the region. The largest opening is the Day Ore Bank on the Thomas Tract about a mile northeast of the Thomas Tract. That bank supplied Day's Forge, it is said, on the South Fork of Holston River, between the years 1790 and 1824, and after that Nichols' Forge, further up the same river. The ore has been dug from the outcrop up along the side of the hill by an open cut a hundred yards long and about twenty feet wide and fifteen feet deep. At the lower end of the cutting the lumps of ore, from three feet in diameter down, form a layer about a foot and a half thick, some three feet below the grass on the northwest (up hill) side of the cutting, and are still more abundant on the lower side. At the upper end of the cutting the solid, nearly vertical bed of ore is exposed in part, and measures ten feet in thickness, but the southeastern surface is indistinct from its being broken up into lumps. The ore is a beautiful brown hematite, very compact, yet containing many very small cavities; but it appears silicious, and in the cavities are small quartz crystals or chalcedony, and many parts of the ore seem to have fine sand intimately mixed with it; and it is said that on first working the bank there was a good deal of quartz in the shape of small round pebbles mixed with the ore.

This seems also to be the bed opened at the ore bank in the Flat, on the Thomas Tract, about two-thirds of a mile southwest of the Day Ore Bank. The opening is a hole about fifty yards long, northeast and southwest, and fifteen yards wide and perhaps six yards deep, in a flat piece of ground, and was in 1866 so full of water as to hide the ore. The solid ore bed is said to have been worked here and to have been followed as it dipped southwards, and to have been ten or twelve feet thick. This is reckoned the best of the ore banks on the Thomas Tract, at least for the quality of the ore; and judging from a few lumps lying about the bank it is really a very beautiful honeycombed brown hematite, not entirely free however from silicious matter in the form of chalcedony.

The same bed, as it seems, is opened at the Williams Ore Bank on the G. H. Williams Tract, on the other (southern) side of the Pond Mountain Saddle, about 600 yards east of the Thomas Tract, and near the northern side of the West Fork of Staley's Creek, at the foot of the Pond Mountain. The bank consists of two old holes a couple of yards in diameter and about as deep in the side of the hill; and it would seem that the solid bed was not found here, but only the loose lumps near the outcrop. Judging by the lumps still lying about the bank the ore is a very compact brown hematite, inferior to the ore of the ore bank in the Flat, but still quite good.

The same bed apparently is opened 350 yards southeast of the Williams Bank on the other side of the basin and of the valley, near the foot of the northern slope of the Wolf Pen Ridge, at the Nichols Ore Bank. This is likewise only a small hole in the ground, where probably only the loose lumps of the outcrop were found, and it has been abandoned for fifteen or sixteen years. The lumps still lying about it show the ore to have been a very beautiful compact brown hematite, apparently of the greatest purity.

A quarter of a mile northwest of this on the same hillside is a large opening, long since abandoned, that seems to be on the same bed, and is called the Old Staley's Creek Ore Bank. Only lumps of ore appear to have been found here, and the real outcrop of the bed is probably a little higher up hill. The lumps of ore still lying about show that it is a very fine compact brown hematite, apparently of excellent quality.

A quarter of a mile still further west along the same hillside is the Main Staley's Creek Ore Bank, on the same bed, a large opening fifty yards long, east and west, and thirty yards wide and ten yards deep on the deepest side towards the south. It is said that the solid ore bed was worked here, but the digging has been abandoned for some time, and is so fallen in as to hide the ledge. There are, however, two large six foot blocks together here and a third partially uncovered in another part of the hole, and some of them may be still in place. The ore is a very good brown hematite, but not perfectly free from silicious matter.

This bed seems also to be the one opened at the Nick's Ore Bank on the Campbell Main Tract, on the steep hillside about three hundred yards southeast of the forks of Nick's Creek, and about a hundred yards southwest of the East Fork of that Creek. The loose lumps that had slid down the hill from the outcrop of the bed were traced by small holes until the bed itself (it was thought) was opened by a small digging high up the hill; but the bed does not seem to have been explored thoroughly as to thickness, and the hole is now fallen in. The ore is brown hematite of very fine quality, and is so pure in parts as to have the fibrous form, and other parts are compact.

This seems to be also the bed that is opened at the West Ore Bank on the south side of Store House Mountain, about a quarter of a mile south of the southern line of the Thomas Tract and three-quarters of a mile southwest of the point where the South Fork of Holston River crosses that line. The solid bed seems not to have been opened here, but only the loose lumps of the outcrop, and the small hole that was dug is fallen in. The ore lumps still scattered about the hole are of beautiful finely honeycombed brown hematite, apparently of the best quality.

Besides all these openings, the bed shows itself by bits of ore on the ground in the bridle-path across Pond Mountain, near the northern foot of the mountain; and also in the old road across Brushy Mountain, some five hundred yards due south of the forks of Staley's Creek; and loose lumps of ore apparently from the outcrop of this bed are to be seen on the hillside west of Nick's Creek, some six hundred yards southeast of the northwest corner of the Campbell Main Tract.

The outcrop of the bed, on the north side of the Brushy Mountain Saddle, seems to run from the east side of the Campbell Main Tract westerly eight miles and three quarters; then to return eastward along the south side of the Pond Mountain Saddle seven miles and a quarter; then to run westward again on the north side of the Pond Mountain Saddle seven miles and a quarter; also on the south side of the next saddle to the north it seems to run for two miles and a half, and as much more on the north side; making in all twenty-six miles and a half for the length of the theoretical outcrop. As the ore has not been found east or west of the Thomas Tract along the last mentioned small saddle, it is quite likely that the saddle so sinks eastward, and rises so slowly towards the high ground westward that the ore does not come to the surface outside of the tract, except for a short distance on the west. It should also be mentioned that, although a former owner of the Crockett Tract made diligent search for iron ore (without any system to be sure), none of any persistence or on any of these outcrops was found; so that these beds of ore may, in that portion of them, have thinned out possibly to insignificance.

The amount in tons for one foot of average thickness of the ore of the bed above the lowest water level of the region, has been calculated as for the aforementioned beds, and is: On the north side of the Brushy Mountain Saddle 2,840,000 tons; on the south side of the Pond Mountain Saddle 3,990,000 tons; on the north side of the same 3,050,000 tons; on the little saddle next to the north 930,000 tons; making in all, 10,810,000 tons for every average foot of bed.

The bed may be taken, from the exposures of it that have been described, to be pretty uniformly of good thickness and of fine quality throughout the region. It is impossible to state, however, without more thorough trial pits, what that thickness is in feet on the average, and what consequently should be the multiplier of the number of tons just given, to get the full amount of ore in the bed above water level; but it would seem to be perhaps ten feet, to judge by the best exposures alone.

ALL FOUR ORE BEDS.—*Mode of Occurrence.*

The mode of occurrence of these ores has already been discussed in a paper read at the Burlington meeting of the American Association for the Advancement of Science, 1867, vol. xvi., p. 114. Three parallel cross-sections show that the thirty or more ore banks and natural exposures occur at corresponding distances on the opposite sides of the Pond Mountain Saddle and of the basin south of it, as if they were the outcrops of four beds of ore conformable to the other rocks. At three or four of the ore banks the solid beds are to be seen, but at the other exposures the ore is in solid lumps of irregular shape and of every weight up to three hundred tons or more, scattered irregularly through brown gravelly loam. The ore (all brown hematite) is sometimes very pure, but often has in it rounded or angular grains or pebbles of white quartz, and sometimes is merely a cement that binds together angular pieces of light brown sandstone.

The deposits of loose lumps in this region seem to resemble in every respect those that are so common throughout the Great Valley of Virginia, and its prolongation northeastward as well as southwestward. They seem beyond a doubt to be the broken pieces from the outcrops of solid beds of ore and of the same character as accumulations of outcrop blocks of any bed of rock or the black dirt of a coal outcrop, or alluvial deposits of gold or tin ore, due regard had to the effect of the special hardness, bulk and weight of the iron ore. They do not by any means seem to come, as has been maintained, from the mere percolation of water through slates impregnated with iron, which is dissolved and carried into the loam and afterwards segregated in a remarkably perfect way.

Of course, the strength of the argument furnished by the ores of the region, depends partly on the exactness of the survey; but although this was only rough, the limits of error in each cross-section are so small, compared with the distances apart of the different beds, that in a similar case the identity of coal beds exposed at different points would be quite undoubted; and the uniformity of those distances over a space of several miles is even surprising. The correspondence of the beds in the different cross-sections is, however, in some parts a little less certain. In a section across Pond Mountain and Brushy Mountain near the road the outcrop of the four beds are exposed on each side of the northern saddle, and probably the three upper ones are exposed on the north side of the southern saddle. In a section past the forks of Staley's Creek, the three lower beds seem to be exposed on the north side of the southern saddle; and in a section past the forks of Nick's Creek the upper and lower beds seem to be exposed also on the north side of the southern saddle. The exposures marked in the sections are almost all very near to the section lines, so that there can be no appreciable error from any possible slight mistake in the direction of the strike in projecting the exposures upon the section lines; and with a very few small allowances for slipping of the observed ore lumps down hill from the true outcrop of the beds all the known exposures correspond well with the theoretical outcrops of the four beds.

YIELD.—Taking the outcrops of all four beds together, there seem to be eighty-three miles of outcrop in the region.

In like manner the foregoing estimates give, for all four beds for the amount of ore in tons above the lowest water level of the region for one foot of average thickness of each bed, 36,690,000 tons.

The average thickness in feet of each of the four beds, taking them all together (the multiplier of that number of tons to get the full amount of iron ore in the region above water level), it is, of course, quite as impossible to state, as it is that of the least explored of the beds. Yet the exposures that have been described would go to show an average thickness of each bed of something like seven feet. That thickness would give according to the foregoing calculations over 250,000,000 tons of iron ore in the region above water level.

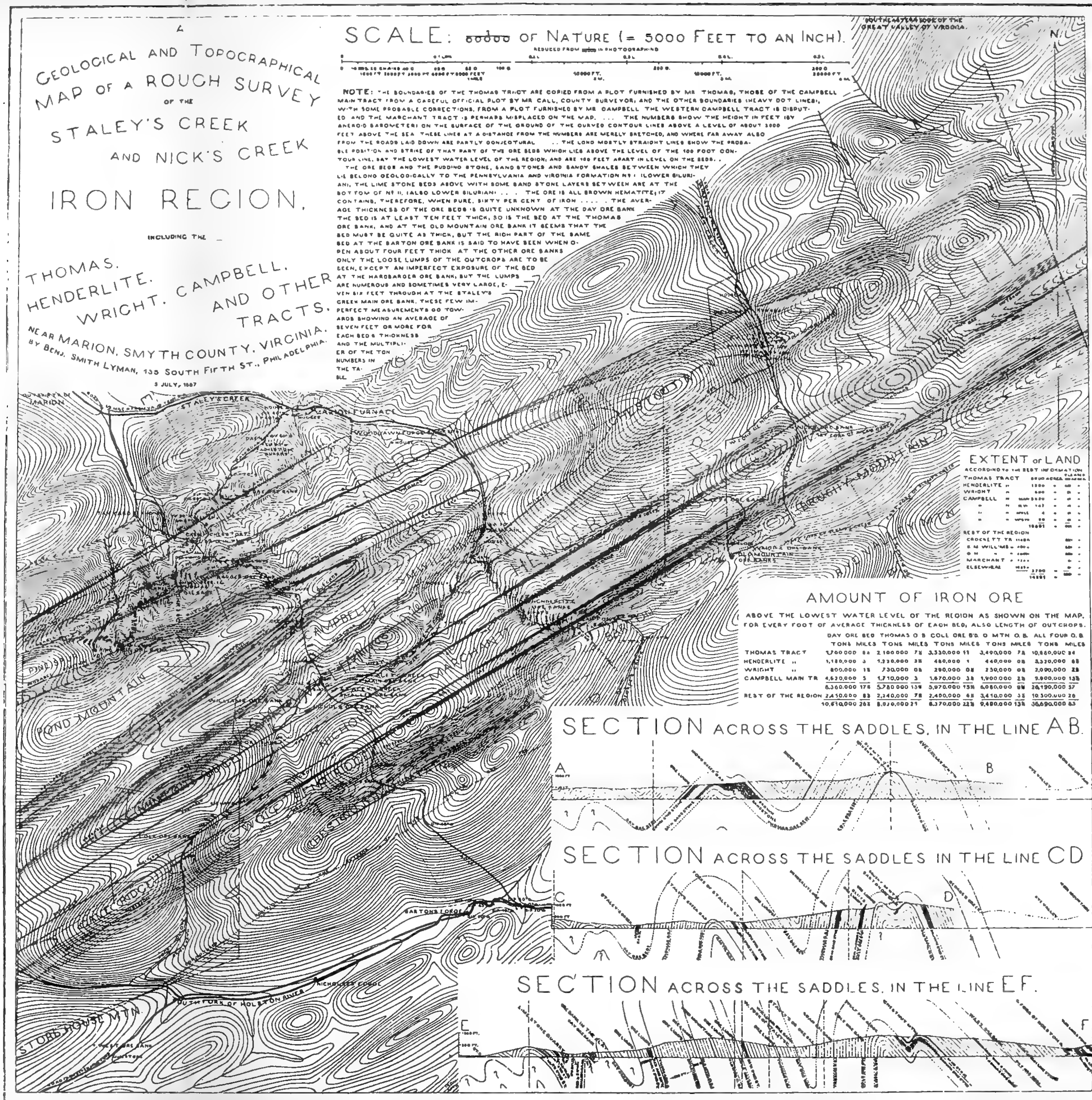
WOOD.—Within the region there seemed to be in 1866 about 260 acres of cleared land and 14,040 acres of woodland. The woodland of the Thomas Tract was estimated to bear on the average forty cords of wood to the acre, almost all hard wood; and the rest of the woodland of the region would probably yield as much.

A charcoal pit of twenty-five cords of wood, there, is reckoned to yield, when green, 800 bushels of charcoal; when dry, 1000 bushels. Charcoal at Marion cost in 1866 (it is said) from seven to eight cents a bushel. Just south of the region on Iron Mountain and southeast of that, are many thousand acres of woodland, and so there are on the south side of Brushy Mountain, or Rye Valley Mountain, south of the region, and so also east of the region; so that the surrounding country could yield an immense supply of charcoal.

Iron Works.—The Marion Furnace was, in 1866, the only blast furnace in the region, and stood at the northern corner of the Thomas Tract, on Staley's Creek. It was begun in 1860, and first blew in near the end of 1862. It was run by the rebel government, and made about five tons of iron in 1862, perhaps 300 tons in 1863 and 275 tons in 1864; or about 600 tons in all. On the 16th December, 1864, it was burned by Gen. Stoneman's raiders and the wood-work mostly destroyed, but the stack seemed in 1866 to be still in pretty good condition. It was about forty feet high, three feet across the tunnel head and ten feet across the boshes, with two engines, and furnished with hot-air pipes, though only cold-blast was used. There was also a cupola furnace alongside.

The Woodlawn Forge, on Staley's Creek near the middle of the Crockett Tract, was built in 1857 by Mr. John P. Wright, and is a bloomery just like the others so common southwestward in these mountains, with one fire and one hammer and water blast; and run like them, by fits and starts, with a very small yearly yield. Its ore came chiefly from the Old Mountain Ore Bank. Just south of the region, on the South Fork of Holston River, are two other such bloomeries, Nichols' and Barton's Forges.

Map.—A photograph of the map was shown at the Burlington meeting, in 1867, in illustration of the paper already mentioned. Not only is the shape of the ground shown by twenty foot contour lines, but the position of the four ore beds is given by contour lines upon each of them 100 feet apart in level from the lowest water level upwards. The ore bed contour lines show at the same time the structure of the other beds of rock, the saddles and basins, the strike and the steepness of the dip.


A
GEOLOGICAL AND TOPOGRAPHICAL
MAP OF A ROUGH SURVEY
OF THE
STALEY'S CREEK
AND NICK'S CREEK
IRON REGION,
INCLUDING THE
THOMAS. HENDERLITE. WRIGHT. CAMPBELL. AND OTHER TRACTS,
NEAR MARION, SMYTH COUNTY, VIRGINIA.
BY BENJ. SMITH LYMAN, 135 SOUTH FIFTH ST., PHILADELPHIA.
3 JULY, 1887
SCALE: 1/60000 OF NATURE (= 5000 FEET TO AN INCH).
REDUCED FROM … IN PHOTOGRAPHING
NOTE: THE BOUNDARIES OF THE THOMAS TRACT ARE COPIED FROM A PLOT FURNISHED BY MR. THOMAS, THOSE OF THE CAMPBELL MAIN TRACT FROM A CAREFUL OFFICIAL PLOT BY MR CALL, COUNTY SURVEYOR, AND THE OTHER BOUNDARIES (HEAVY DOT LINES), WITH SOME PROBABLE CORRECTIONS, FROM A PLOT FURNISHED BY MR CAMPBELL. THE WESTERN CAMPBELL TRACT IS DISPUTED AND THE MARCHANT TRACT IS PERHAPS MISPLACED ON THE MAP. . . . THE NUMBERS SHOW THE HEIGHT IN FEET (BY ANEROID BAROMETER) ON THE SURFACE OF THE GROUND OF THE CURVED CONTOUR LINES ABOVE A LEVEL OF ABOUT 2000 FEET ABOVE THE SEA. THESE LINES AT A DISTANCE FROM THE NUMBERS ARE MERELY SKETCHED, AND WHERE FAR AWAY ALSO FROM THE ROADS LAID DOWN ARE PARTLY CONJECTURAL. . . . THE LONG MOSTLY STRAIGHT LINES SHOW THE PROBABLE POSITION AND STRIKE OF THAT PART OF THE ORE BEDS WHICH LIES ABOVE THE LEVEL OF THE 100 FOOT CONTOUR LINE, SAY THE LOWEST WATER LEVEL OF THE REGION; AND ARE 100 FEET APART IN LEVEL ON THE BEDS. .
THE ORE BEDS AND THE PUDDING STONE, SAND STONES AND SANDY SHALES BETWEEN WHICH THEY LIE BELONG GEOLOGICALLY TO THE PENNSYLVANIA AND VIRGINIA FORMATION Nº I (LOWER SILURIAN); THE LIME STONE BEDS ABOVE WITH SOME SAND STONE LAYERS BETWEEN ARE AT THE BOTTOM OF Nº II, (ALSO LOWER SILURIAN) . . . THE ORE IS ALL BROWN HEMATITE; IT CONTAINS, THEREFORE, WHEN PURE, SIXTY PER CENT OF IRON . . . . . THE AVERAGE THICKNESS OF THE ORE BEDS IS QUITE UNKNOWN. AT THE DAY ORE BANK THE BED IS AT LEAST TEN FEET THICK, SO IS THE BED AT THE THOMAS ORE BANK, AND AT THE OLD MOUNTAIN ORE BANK IT SEEMS THAT THE BED MUST BE QUITE AS THICK, BUT THE RICH PART OF THE SAME BED AT THE BARTON ORE BANK IS SAID TO HAVE BEEN WHEN OPEN ABOUT FOUR FEET THICK. AT THE OTHER ORE BANKS ONLY THE LOOSE LUMPS OF THE OUTCROPS ARE TO BE SEEN, EXCEPT AN IMPERFECT EXPOSURE OF THE BED AT THE HARDBARGER ORE BANK; BUT THE LUMPS ARE NUMEROUS AND SOMETIMES VERY LARGE, EVEN SIX FEET THROUGH AT THE STALEY'S CREEK MAIN ORE BANK. THESE FEW IMPERFECT MEASUREMENTS GO TOWARDS SHOWING AN AVERAGE OF SEVEN FEET OR MORE FOR EACH BED'S THICKNESS AND THE MULTIPLIER OF THE TON NUMBERS IN THE TABLE.
SOUTHEASTERN EDGE OF THE GREAT VALLEY OF VIRGINIA.
N
EXTENT OF LAND
ACCORDING TO THE BEST INFORMATION
THOMAS TRACT
HENDERLITE
WRIGHT
CAMPBELL
REST OF THE REGION
CROCKETT TR
E. M. WILL'MS
MARCHANT
ELSEWHERE
AMOUNT OF IRON ORE
ABOVE THE LOWEST WATER LEVEL OF THE REGION AS SHOWN ON THE MAP, FOR EVERY FOOT OF AVERAGE THICKNESS OF EACH BED; ALSO LENGTH OF OUTCROPS.
DAY ORE BED | THOMAS O. B. | COLL ORE B'D | O MTN O. B. | ALL FOUR O. B.
TONS MILES | TONS MILES | TONS MILES | TONS MILES | TONS MILES
THOMAS TRACT 1,700,000 | 2,100,000 | 3,330,000 11 | 3,490,000 | 10,880,000 34
HENDERLITE " 1,180,000 3 | 1,230,000 | 480,000 1 | 440,000 | 3,330,000
WRIGHT " 800,000 | 730,000 | 290,000 | 230,000 | 2,090,000
CAMPBELL MAIN TR 4,620,000 5 | 1,710,000 3 | 1,670,000 | 1,900,000 | 9,900,000
8,360,000 | 5,780,000 | 5,970,000 | 6,080,000 | 26,190,000 37
REST OF THE REGION 2,450,000 | 2,240,000 | 2,400,000 | 3,410,000 | 10,500,000 26
10,610,000 | 8,020,000 21 | 8,370,000 | 9,480,000 | 36,690,000 63
SECTION ACROSS THE SADDLES, IN THE LINE AB.
A
B
SECTION ACROSS THE SADDLES IN THE LINE CD
C
D
SECTION ACROSS THE SADDLES, IN THE LINE EF.
E
F
MARION
STALEY'S CREEK
MARION FURNACE
BARTON'S FORGE
NICHOLS'S SCHOOL
SOUTH FORK OF HOLSTON RIVER
POND MOUNTAIN
STOREHOUSE MTN.
ROUGH MOUNTAIN
CAMPBELL
HENDERLITE
OLD MOUNTAIN ORE BANKS

ARTICLE IV.

ON THE TOPOGRAPHY AND GEOLOGY OF SANTO DOMINGO.

BY WILLIAM M. GABB.

Read before the American Philosophical Society, October 18th, 1872.

INTRODUCTION.

The present memoir is the result of a three years' reconnoisance of the greater part of the Republic of Santo Domingo, and comprises a description of the geology of about 15,000 square miles, or about half of the island, of which the sister Republic of Hayti occupies the western one-third.

The examinations and surveys were made during the years 1869, '70 and '71, by the author, aided by a corps of assistants varying in number from three to six, besides two draughtsmen, who were employed most of the time in preparing a series of maps of the topographical portion of the work. The geological work was mostly done by the author, assisted at times by two of the party.

The origin of the work is perhaps anomalous in the history of geological surveys. The Government, with an enlightened policy in advance of the majority of Spanish-American nations, felt the necessity of a careful geological examination of its territory, to ascertain the exact facts in regard to its mineral resources. At the same time, in consequence of the numberless revolutions through which the country has unhappily passed during the last three quarters of a century, it was so crippled financially, that it was clearly impossible to find the funds necessary for the expenses of such an enterprise. It is not necessary to record the details here. Suffice it to say that, finally, a contract was made with some gentlemen in New York, who pledged themselves to pay the costs of the work, receiving a grant of a portion of land belonging to the government, to reimburse themselves.

In the meantime, the writer was selected by the diplomatic agent of the Government in the United States, and on the completion of the negotiations, he began his examinations early in 1869. The manner in which he has been sustained and assisted by both the contracting parties is alike creditable to each, and leaves him nothing to complain of on either side.

The assistants were at first but three, Mr. S. Speare, Mr. William Courtis and Mr. C. Runnebaum. Mr. Speare had been previously engaged in the copper mines of the Nigua, and his acquaintance with the country and the people made him very useful, especially at the beginning. He continued with the party until the close of the work. Mr. Courtis, being soon found incompetent, was dismissed in July, 1869, and Mr. Arthur Pennell engaged in his place. Both this gentleman and Mr. Runnebaum continued to the end of their work, employed in making topographical surveys. During 1869 Mr. William Barnes and Mr. A. Bonaczy were also engaged. The latter was employed part of the time with the topographical parties, and for a year assisting in detailed geological labors. Of the former but little need be said. "*De mortuis nil nisi bonum.*" At the end of a year he was discharged and went to the United States, where he died shortly after. It was found necessary for Mr. A. Pennell to do all of his work over again. In the early part of 1870 Mr. L. Pennell joined the party as a topographical assistant, and remained in that capacity until the middle of 1871, when a better position in the United States induced him to leave. During almost the whole of the work Mr. Juan A. Read has been engaged as topographical draughtsman, and during the last half Mr.

J. de la Cruz Martinez has also been employed in the same capacity. In 1869 Mr. Charles Ohle was sent to the country by the contracting parties in New York, but independent of the survey, to examine the gold placers more in detail than was consistent with the character of our work. I have availed myself of his results in the Jaina region.

For the draughtsmen, the map, photo-lithographed from the manuscript, speaks itself. They need no higher praise from me than an exhibition of their work. To the Messrs. Pennell, Messrs. Runnebaum, Bonaczy and Speare, I owe sincere thanks for their hearty coöperation in all of my plans, and for the zealous manner in which they prosecuted their work, often at the cost of great personal inconvenience and discomfort incidental to out-of-door work in the rainy season of the Tropics. I would be remiss were I to forget to acknowledge our indebtedness to the various officers of the Government with whom we have been brought in contact. From the President, General Baez, and the Minister of the Interior, Mr. Gautier, down to the lowest official, we have experienced, almost without exception, only courtesy and kindness. Their assistance and attention have materially lightened our labors and forwarded the work. To mention a few would be invidious, and to name all of our kind friends would be almost to write a directory of the leading men of the Republic.

The topographical map is based entirely on new surveys over all of that region where our work extended. These surveys were conducted by triangulations from two carefully measured base lines, one near Bani, the other in the northern valley between Vega and Moca. All of the principal roads on the north side, all of the passes east of the Constanza route, and all of the roads on the south side, as far west as Azua, were carefully chained. The coast-line, from Monte Cristi to Azua was also re-surveyed, as far as practicable, by chaining along the beaches elsewhere by triangulation. These coast and road lines were used also as bases for triangulations; one system of work thus assisting and at the same time checking the other. We also availed ourselves of the local surveys of the British and American naval officers in Samaná and Calderas Bays, as well as of the table of astronomical positions on the coast in the United States sailing directions. Among the latter, however, there are occasional discrepancies which render them a little doubtful. It will be thus seen that every precaution in our power was exercised to make the map accurate, so far as the limited force and time at our disposal would permit. At the same time, it must be borne in mind that it is but a reconnoisance at best, and that it cannot be more than approximately accurate in the details. The whole of the Haytien part, as well as that portion west and northwest of Azua and the Constanza road south of the mountains, is copied from the map of Sir Robert Schomburgk.

That each member of the party shall receive the full share of credit or discredit to which he is entitled for the degree of accuracy of his work I insert the following list: For myself I do not claim any further credit or responsibility in the topographical work than must necessarily attach to the chief of a party, in that he must answer for the reliability of the employees under his charge. So far the responsibility is mine. Beyond that I take great pleasure in awarding to them all of the credit.

The Survey of the Province of Santo Domingo was made by Mr. A. Pennell, assisted by Mr. Runnebaum; that of Vega, by the same party, with the additional assistance of Mr. L. Pennell; that of the Province of Santiago, north of the Yaqui, by Messrs Runnebaum and L. Pennell; that of Santiago, south of the river, Samaná and all that was done in Azua, by Mr. A. Pennell; and that of Seybo, by Mr. Runnebaum. Most of the road and coast surveys were made by Mr. Runnebaum and Mr. L. Pennell.

Heretofore, the Island of Santo Domingo has been practically a perfect *terra incognita*, geologically. In 1853 Mr. T. S. Heneken published a short description of the northwestern part of the Republic, principally noteworthy on account of its inaccuracies. I have said all that is necessary on this subject in the text and have nothing to add here. The valuable papers of J. Carrick Moore, George B. Sowerby, and Dr. Duncan, in the Quarterly Journal of the Geological Society of London, made the fossils well known, but threw but little light on the geology of the country. In the early part of 1871 I published a very short resumé of my results to that date in the American Journal of Science. The short sketches accompanying the report of the United States Commissioners can hardly be said to have contributed much to our knowledge of the geology, and beyond these, nothing has been published.

PART I.

TOPOGRAPHICAL DESCRIPTION.

CHAPTER I.

TOPOGRAPHY OF THE MAIN CHAIN.

The Republic of Santo Domingo is an irregular triangle, covering about two-thirds of the island of the same name, with its apex at the eastern extremity of the island, and its base abutting against the sister Republic of Hayti, which occupies the remaining western one-third. Its greatest length, from east to west, is about 270 miles, and its base is about 150 miles north and south. Its area is estimated at a trifle over 20,000 square miles, while Hayti comprises about 10,000 square miles more, including the whole western coast region and the two long peninsulas which project towards Cuba. The boundary between the two countries is well defined, being to a great extent a chain of mountains and hills. This line was surveyed and agreed upon in the last century between the Governments of Spain and France, when the whole island occupied the position of colonies of these two Powers. Since then there has never been a formal change of the boundary, although Hayti has persistently attempted not only to occupy a little more than its share, but also to conquer the whole Spanish portion. At present the Dominican Government is in peaceful possession of all the area claimed by it, except a narrow strip bordering Hayti, which is abandoned by both Powers and occupied only by a handful of roving desperadoes, who hold themselves amenable to no government and are equally willing to rob their so-called friends, as their acknowledged foes.

The Spanish portion of the island, that of which we have to treat, is irregularly divided into two parts, by a chain of mountains known as the Cibao range; each part being again sub-divided by spurs of this chain, or by separate ranges. North of the Cibao Mountains, lies a long east and west valley called by the same name, extending from the Haytien frontier to Samana Bay, and bounded on the north by a range parallel with the first, which borders the coast from Monte Cristi to the extremity of the Samana peninsula. South of this great central back-bone, the country is a series of broad level plains and wide valleys, separated from each other by spurs running nearly parallel with, or at narrow angles from, the main Cordillera. For a better understanding of the subject, I propose to describe, somewhat in detail, the physical peculiarities of each region, before entering on a consideration of the geological structure.

The great central mountain chain, variously known as the Cordillera, the Sierra or the Cibao Mountains, extends the whole length of the island, beginning at the eastern extremity and running out to the end of the northern peninsula of Hayti, sending off spurs some of which attain to the dignity almost of independent chains. At its eastern end it is low, rarely acquiring a height of more than a thousand feet. But going westward it rises until some of its peaks are 8,000 and 9,000 feet high. Its general direction is a little north of west, although the numerous side-spurs, of variable length, serve to hide to a great extent the actual trend of the real watershed.

The highest points are not always on the main ridge; some of the side-spurs bearing peaks which rise two or three thousand feet higher than the mother chain.

The Pico del Yaqui, or "el Rucillo," as it is oftener called, from its head being almost always enveloped in silvery clouds, is the culminating point. It is almost exactly in the centre of the island, and is an immense rounded mass on the main ridge, said by Schomburgk to be 2955 metres high. I have never been able to repeat the measurement, although I once spent twenty-four hours on its flank, in the endeavor to reach the summit. On reaching the height of 5500 feet, I was stopped by thickets of fern and the absence of water; but the peak, in full view, seemed to be about four thousand feet higher. The above measurement, if not exactly correct, is at least very nearly so. From this mountain start two of the largest rivers on the island; the Yaqui of the north, on the north side, and the Yaqui of the south, sometimes called the Neyba River, on the south side. Lower Tina, southeast of el Rucillo, is said by the same authority to be still higher. This point, I have never visited, having only seen it at a distance. It is in the heart of a great mountain mass, northeast of Azua and east of the Constanza Pass, nearly inaccessible. The people of the country say that it is impossible to reach its summit, the route lying through dense forests, every step impeded by vines and bushes, and on reaching its flanks it must be necessary, as is the case in all the other high land of Santo Domingo, for the traveller to cut his way through thickets of fern, often so close that he must crawl on hands and knees through a tunnel, as it were, scratched by thorns, and blinded by the fern spores at every step. This peak is neither on the main chain, nor is it on one of the principal accessory spurs, but seems to be to a great extent isolated, the culminating point of a group of hills.

From the Pico del Yaqui, and the mountain mass of its vicinity, there are sent out several long ridges running more or less directly to the northward, embraced between the streams which form the head-waters of the Yaqui River. The first, adjoining the river on its west side, is a long, very crooked chain of hills, called "Limpia Nariz," from a thorny vine which grows abundantly on its sides. West of this is another ridge culminating in Loma Joca, between 7,000 and 8,000 feet high, after which it falls gradually into the rolling hills which border the Cibao Valley. Between these ridges are many pretty little valleys, supporting a scattered population, such as Humunucu, about 2,500 feet above the sea level, Manabao, perhaps 500 feet higher and the Cienega, almost at the foot of el Rucillo.

West of this region, the spurs which run out between the Bao and Amina Rivers are not of special importance. Their cañons are very deep, very narrow and rarely penetrated except by straggling pig hunters. An illustration exists almost on the edge of the village of San Jose de las Matas, which town, although far out of the main mountains, is on the margin of a cañon 500 or 600 feet deep. Southwest of this town, making the terminal point of a ridge, is a prominent little peak, el Rubio, between 4,000 and 5,000 feet high, a good land mark from the east, north and north-west, but entirely lost sight of when seen in connection with the great mass of Pico Gallo and its neighbors. Next west of it is one of the largest, if not the largest spur sent out by the range, on its north side. This is Pico Gallo, a ridge lying between the Magua and Cenobi, two branches of the Mao River. The main chain averages here about 7,000 feet high. From it the cross-ridges start very close together, but most of them fall rapidly, while the present one extends, with very little variation in height, for ten miles northward, bearing in that distance two higher points, the most northern and most prominent of which, el Gallo, is nearly 8,000 feet high. From this peak the ridge falls with many undulations to Punta Lanca, a point about as high as el Rubio, and fully as prominent a land-mark. In the summer of 1871, accompanied by two or three companions, I made an excursion into the mountains, penetrating to the base of the dividing ridge, and obtained not only a good cross-section of the geology, which will be described in its proper place, but also some valuable notes on the topography of this almost unknown region. The ridges are innumerable and remarkably narrow and sharp; the cañons are very deep and often flanked by precipices of naked rock. The outer hills, up to an elevation of say 4,000 feet, are clothed with a continuous pine forest, carpeted with a scanty growth of grass. Higher up, the greater moisture of the air produces a belt of trees similar to those nearer the coast, followed in its turn by a region producing nothing but fern thickets. These last extend to the summits of the highest peaks, and make it next to impossible to climb them. It is for this reason that the higher mountains of the island are so inaccessible. I have been assured by old mountaineers, born at the base of Pico Gallo, that so far as they know, nobody has ever reached its summit. There is nothing to prevent the ascent except the fern. Its slopes are gradual, and a dozen feasible routes can be selected from below by an experienced eye. Two men attempted it a few years ago, and one of them told me that, after struggling all day, chopping every step with their machetes, they were obliged to sleep on the mountain side, and returned next morning, giving up the attempt in despair.

West of the vicinity of the Pico Gallo, there are no mountains of note on the north side of the range except the little hill of Chaquet, west of Saraneta, remarkable only for being somewhat isolated, and consequently a good land-mark. Across the border in Hayti, Monte Diablo stands out, a noble peak; and south of the water-shed, Nalga de Maco, another splendid hill, towers above everything. The latter, as seen from Saraneta, seems to be a dozen miles or more south of the dividing ridge. It is a peak of perhaps 7,000 to 8,000 feet high, abrupt on its eastern side and sloping at an angle of 25° to 30° to the west. The Artibonite River rises far to the northwest of it, runs around its north, east and south sides, almost isolating it, and then runs down the valley towards Hayti. A peculiar feature of that part of the mountain range included in the water-shed of the Yaqui River and its tributaries is the extreme tortuosity of the ridges and the consequent great length of the stream, as compared with what might be anticipated from a knowledge of the width of the range. Thus the Mao River sends branches far into the southwest, heading, so to speak, all of the streams of the vicinity of Saraneta. These ridges are generally high, narrow and very crowded, their summits often being so very narrow as to well merit the idiomatic term of "cuchillo" (or knife), which is usually applied to them. It is not a rare thing to travel for hundreds of yards along a crest hardly more than three or four feet wide.

The foot-hills of this portion of the range are different from any other part of the island. They are generally high broad rolling lands, clothed with pine and grass, almost always with a red gravelly soil and cut up by very deep ravines. As a result of the loose gravelly character of the soil and the scarcity of rain it is the most barren region in the Republic. But little is cultivated on the hills beyond the food necessary for the sustenance of the scattered population; though in the little mountain valleys and in the not infrequent river bottoms good crops of tobacco are raised for sale. The people are an independent, hardy race of mountaineers, very light in color, often nearly white, showing a large admixture of Indian and but little trace, usually, of African blood. In fact many of the men would be mistaken in the United States for "half" or "quarter-breed" Indians. The men occupy themselves principally in the raising of horses, cattle, goats and pigs, the cultivation of their little garden-patches and an occasional hunting excursion into the mountains after wild cattle and pigs. The women, besides their very simple domestic duties, find abundant employment in plaiting the leaf of the "guana" palm into ceroons for tobacco, which command a ready sale in Santiago.

East of this region is the first pass that is used habitually in crossing the range. One route does exist, now never used however, from near Saraneta to the Artibonite, thence to Banica. A second, used very rarely, is along the cañon of the Bao, thence to San Juan. The present one is by way of Jarabacoa, across the head-waters of the Jimenoa River to the Valley of Constanza, thence down the Rio del Medio to the valley above Azua. The route is terribly rough, crossing high ridges and deep ravines constantly. From Santiago, the road first winds over rolling hills, skirting the Yaqui River, sometimes at the water's edge, sometimes climbing a steep ascent or plunging down a rapid slope to the village, or rather neighborhood called Tabera. Here, scattered over a few thousand acres of nearly level land, is a little world of itself, shut in by the high mountains behind and the wall of hills in front. From Tabera, the trail climbs to the top of a pine-covered ridge and winds apparently to every point of the compass until the traveller suddenly finds himself on the end of a high hill overlooking a beautiful valley several miles across, backed by an unbroken range of mountains. In this valley lies the pretty little village of Jarabacoa, the centre of a population of perhaps a thousand souls, half of whom live in the village itself. It is directly on the bank of the Yaqui River—here a brawling torrent twenty yards wide—its bed strewn with granite boulders, often tons in weight, witnesses of its prowess during the rains. The Jimenoa River which rises not more than ten miles southwest of Jarabacoa describes a course of thirty-five or forty miles long, nearly in a circle, and empties into the Yaqui but half a dozen miles from the town. A mile out of Jarabacoa, the trail crosses a stream of some size, a branch of the Jimenoa and then almost immediately commences to ascend the ridge. A climb of three miles brings the traveller to the top whence he can see on a clear day, not only the village and valley at his feet, but an interminable sea of mountains, the Cibao Valley, and beyond it, the north range, indistinct in the hazy distance. To the west, almost within reach, so close does it seem, stands the noble peak of the Rucillo, its top almost always enveloped in cloud; while to the south and east the eye becomes bewildered in trying to reduce the innumerable ridges to some kind of an intelligible system. The ridge along which the road runs is one of the most crooked I have ever had occasion to traverse, though even it hardly justifies the very poetical description of Sir Robert Schomburgk, who travelled over it about 1851.* It winds not only entirely around the head of the Jimenoa, but seems to take especial pains to double also all of its tributaries. After nearly half a day's ride, the road descends gradually to the Jimenoa, here dwindled to a rivulet hardly three yards across. The water is beautifully clear, and very cold. A plunge in a shady basin, followed by a lunch prepared us for the remainder of our ride, and, after a few moments of rest we mounted again for Constanza, which we reached just about nightfall. From the Jimenoa, the trail still follows ridges, but neither so high nor so crooked as those preceding them. Finally we descended into a flat plain or valley, densely wooded, through which we rode for a couple of miles, at last emerging into a grassy plain dotted with little tongues and islands of pine timber, and enlivened by groups of horses and cattle. The village, if it may be so called, consisting of about a dozen huts, is almost at the extremity of the plain, in the edge of the woods, and on the banks of the Limon Creek. From the remains still existing, it is evidently on the site of a former aboriginal village of no small importance. Earthworks several hundred feet in extent, similar to those found in the Mississippi Valley, are still visible, in a good state of preservation, overgrown in places by trees two feet in diameter.

Leaving Constanza, which is on the branch of the Southern Yaqui, the Limon Creek above mentioned, the trail climbs rapidly to the hill side, and follows down the valley of the Limon to that of the Rio del Medio, or middle river. At el Rancho de Limon which, as its name implies, is a single rancho or shed, it descends to the river, to follow it for a mile or two, and then climb, on the other side, the steepest trail I have ever seen on the Island. Reaching the summit again the jaded traveller winds among rolling hills, occasionally catching a glimpse of the yawning gulf he has just crossed, until again he finds himself descending to the river. Here the climb is not so steep, although bad enough, the more so since he has a thousand feet of up hill work before him, on the other side of the stream. This overcome, he begins another gradual descent, arriving at the little village of five or six houses, called las Lagunas. From Lagunas, an easy down hill ride of an hour brings him to the Rio

* *See Athenæum*, 1852, *No.* 1291, *p.* 798. "Narrow deep valleys on each side of the interlacing ridges force the traveller to continue on their summits, although he is in consequence, obliged to make long detours; and instead of advancing steadily to the south-southwest—which is his true course to Constanza—he is often obliged to follow the ridges to the north and eastward before he is able again to continue to the south-southwest. Our guide had already told us, that so eccentric are the ways of these mountains that two friends meeting in the morning, the one coming from Constanza, the other from Jarabacoa, in opposite directions, and having each parted on his several way, might at noon have another opportunity of saying 'How d'ye do?' across some chasm in consequence of the twistings and turnings which both had to take. We did not understand what he meant at the time, but it became clear to us now."

de las Cuevas, when his troubles are practically over; since he finds himself at last on the plains, an hour's ride from Tubanos and a good half day's travel from Azua. Nobody who has crossed this pass once will be apt to repeat the trip for pleasure, even with the reward in view of the picturesque beauties of the mountains south of Constanza. They are certainly grand, unsurpassed, and hardly rivalled by anything I have ever seen in the Sierra Nevada; but not grand enough to warrant a second journey.

East of the country of the Yaqui and its branch, the Jimenoa, the character of the range changes rapidly. The pine forests disappear almost at once, the hills just west of Vega and those of the upper portion of the Maimon River being the last bearing this class of vegetation. A peculiar feature is, that where pine grows at all it makes the entire forest, and when it disappears it does so suddenly and along well-defined lines.

Towards Bonao the range becomes much narrower and the spurs are lower, the valleys running up between them becoming more marked both in length and width. The road from Vega to Cotui, running east-southeast, skirts along the extreme outer margin of the hills, often making long reaches out in the plain far off from them. From Cotui to Cevico a few of the minor spurs are crossed, although the latter village is still further to the southward. From Cotui a trail runs to Bonao, thence up a valley and across the hills where the head-waters of the Maimon and the Jaina approach to within a few miles of each other. The mountain pass is a trifle, so far as height and roughness are concerned; though in all ordinary seasons it is a river of mud, worn into stepping holes by the feet of the animals that have been travelling it for centuries. The first high point reached on this route, in travelling from north to south, is a grassy hill-top called the Laguneta Savana; although *why* it should be called Laguneta, when the nearest water is hundreds of feet down in the ravine, can only be explained by the rule of contraries. The view from this point, in beauty, in variety, in all that goes to make the picturesque, is only equalled by one point, if any, and is certainly not surpassed on the Island. Its rival is the "Santo Cerro," or Holy Hill, a few miles from Vega. From the Laguneta a large part of the north side of the range can be seen—all of the Vega Real or Royal Meadow, so called by Columbus; and the horizon is bounded northward by a high range of ragged mountains. A friend once travelling as a tourist, not accustomed to "roughing it," who had reached this point, half dead from a protracted struggle through the mud of the whole mountain pass, declared to me in his first rapture that he was fully repaid for the whole journey from New York to the spot. To one who had been all day in the wet woods, almost out of reach of sunlight, wading through mud knee deep to his horse, obliged repeatedly to dismount to extricate the poor brute "mired" belly deep in sloughs, scratched by thorns, cut by the sharp-edged *Yabacoa* grass, splashed to his eyes with not over-fragrant mud, and worn out between unaccustomed fatigue and hunger, the relief of finally reaching at the same time sunlight, a resting-place, and an exceptionally beautiful view, was certainly something to remember. But to continue: from the Laguneta the road runs about three miles through the woods, usually on top of a narrow ridge, almost always very muddy. At the end of this distance is a resting-place of a third of a mile of grassy hill side called the Savana de la Puerta. Here the road again enters the woods, now almost down to the level of the plains, in the valley of a stream called the Guananitos, following this stream to the Jaina River. Along the whole distance from the Puerta to the Jaina the road is an almost uninterrupted bog, the wet mud of a river bottom on which the sun never shines; land which, if cleared and cultivated, would yield crops of such magnitude that no one having a regard for his reputation for veracity would dare describe.

East of this pass is another but little used; a mere third trail through the woods, preferable for its shortness in very dry weather, though nearly impassable in wet seasons. It has nothing to warrant especial mention except the fact that it winds through very low hills, crosses almost innumerable small ravines, and finally strikes the head-waters of one of the branches of the Ozama, reaching Yamasa, on the margin of the southern plains.

Still another, longer than the two preceding, but much better in every respect, is that by way of Cevico and San Pedro. Although twenty miles longer, and crossing rougher hills, this route is almost always selected by persons travelling in a hurry from Santo Domingo to Cibao. Almost immediately after leaving Cevico the road commences to climb the rolling grassy hills that border the range, and at the distance of an hour's ride enters the forest for the first time. It crosses first a ridge, called the Cuesta Blanca, or "White Ridge," with some mud and much rock; thence crosses a pretty level tract pleasantly varied between forest and savana, watered by three good-sized streams; thence by a gradual ascent climbs a high ridge the main divide here, known as the "Sillon de la Viuda," or "Widow's Saddle," and leaves it by an equally gradual descent, entering the plains near a now almost deserted grazing station, called San Pedro. From this pass there is no other to the eastward until we reach the vicinity of Samana Bay, when we find the road running south from Savana la Mar to Santo Domingo, a trail that enjoys the unenviable reputation of being, in many respects, the worst on the Island. The mountains in the intervening distance have no features to render them peculiar or worthy of special mention. They are low, inconspicuous, and have here dwindled to a single ridge with a few spurs, all densely wooded.

At San Lorenzo Bay, a little side branch of Samana Bay, the hills reach the water's edge, and present an entirely different appearance from any other part of the range. This is due to their being here composed of horizontal Tertiary rock, very hard and weathered into the most fantastic outlines. They are from 200 to 300 feet high and start up, often with precipitous sides, so separated from each other, and yet so similar as to present at a great distance a rude resemblance to a battlemented wall. The process of elevation is evidently going on at present, and has been doing so for a long time past, since the water-face of these rocks is invariably worn into caves of all sizes, from a mere overhanging ledge to an excavation of two or three hundred feet or more in depth. Some of these have been occupied by the Indians, as will be described further on. The eastern shore of San Lorenzo Bay is a sandy plain, continuous with a savana which borders the whole south side of the Gulf of Samana, though often interrupted by projecting hills. The only prominent hill in the vicinity is Monte Redondo, or Round Mountain, a pretty good landmark, from its being isolated and standing close to the coast, just outside the mouth of the bay. The forest land of this part of the Republic is always wet from the double circumstance of a constant and heavy rainfall, and the impossibility of the ground drying when shut off from all access of sunlight and wind. The road, travelled from time immemorial, and never mended, is in such a condition that the ordinary rule of travellers over this route is to avoid going anywhere where they can see any signs of a road. It is worst in the part called the "deshecho de los Franceses," or Frenchmen's turn-out, a region where the road is probably in places a quarter of a mile wide, the endeavor of each person being to pick a place where nobody has gone recently. It is a good horse that will carry his rider from Savana la Mar to Pulgarisi across the range in one day's journey, barely more than twenty miles. Just before reaching the bad part of the route the traveller reaches a little settlement of half a dozen houses called the Valley. Here he enters the woods, crosses the dividing ridge and flounders along as best he can, gradually descending until he reaches Savana Grande, a grassy tract of a thousand acres, a breathing spot, and a sort of half-way station where most travellers either take a meal or spend the night. After this some more bad roads and a couple of hills, the latter of which, however, the loma de los Castellanos, is dry and gravelly, bring the unfortunate victim of circumstances out on the margin of the broad prairies of the south side.

I have made but little mention of the rivers of the central chain, considering them rather to belong to the region through which they run than to that in which they take their rise.

CHAPTER II.

TOPOGRAPHY OF THE REGION NORTH OF THE MAIN CHAIN.

Owing to the almost complete geological identity of all of the region lying north of the central mountain chain, it is best to include all in a general description, although one half is valley, the other half mountain. It is true that Samaná is in a manner isolated, both topographically and geologically; but the first is hardly evident on the map, and the last difference is only a repetition of another exception in the mountains near Puerto Plata.

The great northern valley—called, as a whole, the Cibao, from the range of mountains adjoining it—is divided into two unequal portions, watered respectively by the Yaqui and the Yuna rivers and their tributaries. The former portion, from Santiago to the Monte Cristi, is usually known as the Valley of Santiago, or of the Yaqui; while the latter is always called the Vega, or the Vega Real—the Royal Meadow—a name given to it by Columbus, and one well merited by its beauty and fertility. This valley occupies a depression between the central or Cibao range on the south, and another on the north, which has no distinctive name, but which might be called, for convenience, the Monte Cristi range. Both extremities of it are low and marshy. Large salt-water marshes and lagoons occur near the mouth of the Yaqui River, and other mud flats, similar in every respect, border the mouth of the Yuna. In the latter region, the same valley or depression is prolonged still further, existing as Samaná Bay, having the same trend, and nearly the same width, as the valley of which it is the evident continuation.

The valley proper, from the mouth of one river to the mouth of the other, has an entire length of nearly one hundred and fifty miles, while its average width is about a dozen miles. In no place is it less than ten, and in perhaps none is it over fifteen miles wide. The highest point is near Santiago, from which it falls very gradually towards either end. Between the towns of la Vega and Santiago, that is to say, between the Yaqui and the northern branches of the Yuna, there is a low range of hills, which nearly divides the valley into two parts. But these hills do not reach entirely to the Monte Cristi range, a narrow interval of land intervening, so that one can travel on the plain from Santiago to Moca, and from Moca to la Vega, although the road from Vega to Santiago is rolling throughout almost the entire distance. This is of importance, since the question of railroad routes in this vicinity has been much mooted lately; and it is possible that the configuration of the land may have an important bearing in this connection.

Santo Serro, or Holy Hill, is one of the most prominent points in this spur, and is doubly interesting from its having once been the scene of a battle between Columbus and the natives, when, as tradition declares, the Virgin Mary personally descended, and, perching on an arm of a cross, turned back the arrows of the heathens against themselves. The cross has disappeared, but the hole in which it was planted still exists; and, if further proof of the miracle is required, it can be found in a painting in the chapel erected over the spot, showing the manner in which the thing was done. The hole is not likely to grow smaller, since the earth from it has miraculous healing properties, and is sought for eagerly by pilgrims, who make long journeys for the privilege of stepping into the hole, and taking therefrom a spoonful of dirt—at twenty-five cents a head. But to the less reverent or less credulous traveller, this lovely spot has a greater charm. But a couple of hundred feet above the valley, it is so far out from either range of mountains, that it commands a view of both for a hundred miles of their length, and one glance takes in the entire Vega Real, only cut off by the dim distance, towards Samaná.

East of Vega the spurs that are sent out into the valley by the southern mountains are without any remarkable peculiarities. They are low and inconspicuous in their similarity one to another. A few little valleys run up into the hills, among which may be mentioned those along the Yuna and Jima Rivers, the Maimon River, at Hatillo, or about Cotui, Cevico, and the valley of Payabo Creek. But these are all alike—a meadow of from one to a couple of hundred acres, bordered by forest, and nestling among trees. On the lower Yuna, below the mouth of the Camu, the low spurs reach almost down to the river, and many of them are similar to the peculiarly-shaped hills of San Lorenzo Bay. North of the Yuna, near the hills in the vicinity of and east of Macoris the plains are rolling and gravelly. A little further down towards the river the soil is more clayey, and in the river bottom it is a rich black loam, supporting a dense forest growth. At Almacen, where the river bluffs give an opportunity of examining it, the loam is at least ten or twelve feet thick, and the river level did not give the means of ascertaining how much deeper it reaches. West of Macoris the loam widens out at the expense of the gravel, and nearly the entire distance from Macoris to Moca is over a black mud, bad enough to travel over when dry, but almost impassable in wet weather. The same description may be applied to the roads from Macoris to la Vega, from Vega to Moca, or, in great part, that from Moca to Santiago.

The road from Vega to Santiago runs also for a couple of miles on the same black, sticky soil, then crosses some rolling, gravelly hills, then, making three passes of the Verde or Green River, it crosses some more hills. Here, the Tertiary rocks coming to the surface, the road is dry, and the soil usually shallow; but immediately afterwards, entering again the black loam region, there is a stretch called the "Laguna Prieta" or "Black Lake," a mile or two of road which, during the entire rainy season, fully merits the name.

There is a marked dissimilarity in the vegetation of the eastern and western ends of this valley, caused by the difference in the amount of moisture in the air, and the difference in the rain-fall. The trade-winds from the Atlantic draw into the gap of Samaná Bay as into a funnel, and are conducted by the mountain chains, as between two walls, directly down the valley, depositing their vapors, either as rain or dew, over the eastern end, even too abundantly at first. But in their progress they generally become drier, until just after passing Santiago there is a very appreciable diminution in the rain-fall, and a consequent change in the character of the plants. Within ten miles west of Santiago nearly all of the forest trees common in the Vega disappear; *Acacias* of two or three species take their place, disputing the ground with *Cacti*. Of the latter, one of the most conspicuous is an arborescent *Opuntia* with a peculiarly flat, narrow leaf, often carrying this tendency to compression to the extent of having its woody stem of a foot thick of a long elliptical section. The plant not rarely acquires a height of twenty feet, and occasionally one of twenty-five feet high may be seen. Besides this, a columnar *Cereus*, rivalling it in height, and very similar to one known in Lower California as "*Pitahaya dulce*," is equally abundant. Two other species of *Cereus*, three or four of *Opuntia*, one *Melocactus*, a little gregarious *Mammillaria*, and two or three climbing species of *Cereus* (?), make up the list. It is not to be understood that this change in vegetation is abrupt. A straggling little *Opuntia* or an occasional *Cereus* may be found even as far east as Santiago, and the forest of the more eastern type clings to the damp spots along the river botton almost to Guayubin; but so marked is the style of the plants away from the river, that in the foot hills north of Guayacanes I could have imagined myself on the plains of Magdalena. North of the Yaqui the road, very wide and very level, runs nearly parallel with the river, rarely touching it, usually at the distance of a mile or two, directly down the valley, through some very good land, now used for grazing solely, and apparently barren, but which, properly irrigated, could be made to yield excellent crops. It is, however, so inferior to other regions in the Republic that the population must increase many fold before such artificial aid will be resorted to here. There is another drawback which would doubtless have great influence. There are but few streams, and these are small, running out of the northern or Monte

Cristi range, and the fall of the Yaqui is comparatively trifling, so that the difficulty of obtaining a sufficient supply would be great. The nearer we approach Monte Cristi, the drier and more parched the country looks, the more abundant becomes the cactus, and the more scarce and wilted the grass. I was assured by a friend, riding along the road, that at that spot no rain had fallen for fourteen months previously.

South of the river, the same causes produce like effects, modified, however, to some extent, by the proximity of the mountains. Outside of the mountains the country consists of a broad belt of foot hills, a curious basin, bordered by an east and west range of tertiary hills, outside of which, adjoining the Yaqui, is a flat plain of variable width. From Santiago to the Amina River most of the ridges of the foot hills are rather narrow and steep; gradually become broader towards San Jose de las Matas. West of the Amina, towards Guaraguano they develop into broad rolling hills, and finally lose themselves in beautiful level savanas at Savaneta. Below the mouth of the Bao River, adjoinging the Yaqui, and for a distance of half a dozen or more miles west of Santiago, there is a reasonably level tract, with excellent soil and and admirably adapted for farming, if the crops in the little "conucos" or garden patches scattered through it are a criterion. From this same region runs a range of low hills extending westward, parallel with the river, to a point beyond Savaneta. They are cut through only where the rivers Amina, Mao, Gurabo and other southern tributaries of the Yaqui have forced for themselves passages. At the eastern end, these hills are hardly separated or distinguishable from the foot hills proper of the main range; but from the Amina to the Mao they are separated by a deep though narrow valley, and from the Mao westward the separation is rendered complete by the broad savanas of Savaneta and their eastern prolongations. On the Mao River, at Caña Fistula and Hato Viejo, the valley which separates the foot hills below Guaraguano from the Samba Hills, as this range is called, is terraced; four well-marked levels, making an aggregate of perhaps as much as 300 feet from the river to the surface of the upper terrace. The terraces seem to indicate that the Samba range once acted as a dam to the river which thus widened out into a small lake.

About Savaneta the foot hills of the main chain retreat southward, forming, as it were, a sort of bay and a broad, nearly level tract, clothed with grass and dotted with trees, makes a pleasing variation in the landscape and furnishes admirable grazing ground for numerous herds of cattle and goats. This savana country extends to the Haytien frontier with very little variation. The soil is gravelly and the atmosphere, owing to the proximity of the mountains, is more moist than further out towards the centre of the valley.

But little need be said about the Samba Hills. They are a low chain of dry gravelly and sandy hills, two to four hundred feet high, and, as above stated, occupy an isolated position in the valley. They are composed of the same Tertiary rock as that underlying the valley itself, and are entirely destitute of water except where the rivers from the main range have cut narrow channels through them. They are covered with an almost continuous tangled thicket of thorny bushes, with a plentiful sprinkling of cactus; and are so nearly destitute of grass as to be almost useless for grazing and utterly valueless for any other purpose. The narrow strip of land between the range and the river is barely, if at all better than the hills themselves. It is equally dry, equally barren and, except along the rivers, it is entirely uninhabited. Some small spots in the river bottom are cultivated, and others might be, if irrigated.

In the region just described are the two most important rivers of the Republic. The Yuna river drains all the region east of Santiago, and receives two or three large tributaries. The principal of these is the Camu, flowing past the village of La Vega, itself 70 to 80 miles long, and which drains more than half the valley and the adjoining hills. The Yuna rises further east than the Camu, and like all of the streams flowing out of these mountains, first pursues a general northerly course, afterwards bending abruptly to the eastward. This river is easily navigable at present for twenty to thirty miles from its mouth, and canoes loaded with tobacco descend every day, returning with merchandise for the store-keepers of Moca and Macoris. I have descended it from Cotui to the mouth of the Camu in a canoe, when the water was more than usually low, and Mr. A. Pennell, on a previous occasion, ascended to the same point, from the mouth. His report is that large trading canoes have no difficulty in ascending to El Platanal, just above the mouth of the Camu, although a few shallow places exist. I found that over my part of the route, no obstructions exist which cannot be overcome by the simplest of engineering contrivances. In most cases, all that will be necessary will be an ordinary wing dam to throw the water into a narrower channel or the occasional rapids. The river is usually about 100 yards wide and, at the ford at Cotui, is three feet deep in the channel, with an average of one foot on the rapids, at extreme low water, in the dry season. I have not explored it in detail above Cotui, but am familiar with much of it, and my opinion, backed by all the testimony that I have been able to collect, is, that the same appliances which will be required below Cotui, can be successfully used above, so as to give at least a hundred miles of navigable river on the Yuna and its tributary, the Maimon, certainly as far as, and perhaps some distance above, Hatillo. The advantage that must accrue to the valley by opening this river, is almost incalculable, giving, as it would, a natural outlet to its products, which in part pass through Santiago and on pack animals, forty-one miles across the mountains over a very bad road, to Puerto Plata.

The western part of the valley is not less fortunate than the eastern, in having a large river, which could also be rendered navigable to within a few miles of Santiago. It is probable that the expense of opening the Yaqui would be greater than that of the suggested operations on the Yuna. But this is rather hypothesis on my part, than based on detailed examinations. Some of the rapids I have examined seem to be much more violent and extensive than any on the Yuna, the fall over at least a part of its course is greater and difficulties exist at the mouth, which, although easily overcome, must be expensive. The river has been for ages constantly shifting its bed, for the last twenty miles of its course. At present, it runs through a series of shallow lagoons and narrow channels nearly choked up by drift wood and bushes. The present mouth is at Manzanilla Bay, while one of the old mouths is near Monte Cristi. Old beds like dry canals show where it ran at one time and another; and lately, the Government has taken steps, though perhaps on too small a scale, to divert the water into one of these dry ditches, changing the mouth to Monte Cristi. Should this be accomplished successfully, even if only a part of the river finds egress by this route, so long as enough water is diverted to float a canoe, the benefit to the people of the valley will be far beyond the amount expended. Now, the river is never used for navigation. The few canoes to be found on it are only kept for crossing from one bank to the other; not a freight boat of any description exists on the Yaqui. Mahogany "crotches" are sent on mule or donkey back, from Guayubin, on the river, to the coast at Monte Cristi.

The tributaries of the Yaqui on its north side are so few and so petty in size, as not to merit even a mention. On the south side, however, they are numerous and large. The Jimenoa, rising south of Jarabacoa, and describing three-fourths of a circle, uniting with the Yaqui north of the same town, is really the longer of the two branches into which the river divides. The other branch, bearing the title of the main stream, rises in the peak of the same name, and runs nearly north until it reaches the middle of the valley, just beyond Santiago, when it suddenly bends at a right angle to the west. Just above Santiago, it receives the Bao, or Cibao River, almost as large as itself, which rises in the main range, west of the spur on which is Loma Joca. West of the Bao, we find successively the Amina, Mao, Gurabo, Canna, Guayubin, and half a dozen other rivers and creeks of smaller size. The five named are pretty nearly of the same size, the Mao being perhaps the longest and carrying the greatest volume of water.

Geologically speaking, the valley just described, and the mountain tract to the north of it, are identical. The same rocks compose the mountain that underlie the plain, the elevating forces having acted along but a single anticlinal, and leaving the valley undisturbed, with the trifling exception of the Samba Hill. These mountains —for which, in default of a better, I have proposed the name of the Monte Cristi range—are about one hundred and fifty miles long, and vary from ten to thirty miles wide. In its lowest part, towards the extreme west, it is but a few hundred feet high, while a dozen peaks ranged along its entire extent exceed a thousand, and one, Diego Campo, near Santiago, is nearly four thousand feet high.

The range partakes, to some extent, of the same climatic influences as the valley, though to a much less degree, as might be anticipated from its lying nearer the ocean. The eastern end is not unlike its neighbor Samaná, while the part from Isabella west is dry, arid, and much like the valley to the south of it. Standing on the table-land at the mouth of the Isabella River, the site of the first settlement of Columbus on the island, the view is cheerless in the extreme. As far as the eye can reach, nothing is visible but a succession of dry yellow hills, parched and barren. No green thing is to be seen in the distance, except a rare mangrove swamp, suggestive of mud and quicksand. To heighten the effect, the spectator sees a similar growth at his feet, reeking with foul odors, and around him is nothing but thorn-bushes and cactus. It is difficult to imagine what could have induced the great discoverer to have pitched on such a spot as this, when the coast of Hayti to the west, and the entire coast of Santo Domingo, to the east of Isabella, offered so many more inducements — equally good and better harbors, more accessible and better water, rich vegetation instead of a desert, equally defensible positions, and, in a word, all the conditions for the safe establishment of a weak colony in a strange and hostile country. There are a few fragments of roughly-built stone walls still standing, barely more than a foot high; and the owner, who acted as my guide, expressed his perfect willingness to sell site, ruins, landing, cactus, mangrove swamp —all, for a hundred dollars.

The appearance presented by the range from Isabella is not belied by a closer examination. It diminishes rapidly in width and height as it approaches its western extremity. The scarcity of rain produces not only a desert vegetation, but also a scarcity of springs and running water. A few small fertile valleys exist on the north side, and near the base, on the south side, are a very few springs. But two land-marks exist in this part of the range; but these are well marked, and, being visible from the coast, are of great use to seamen. Silla de Caballo is, as its name implies, a saddle-shaped hill, and Monte Cristi is a table-mountain, isolated from the range, of which it is the terminal point. It is but eight hundred feet high, but its solitary position and its peculiar shape make it the most marked point in the whole range, not excepting Mount Isabella de Torres, back of Puerto Plata.

It is not to be inferred that the barren, desolate character just described applies to any large part of the Monte Cristi mountains. Even in the neighborhood of the Isabella River a change occurs, and back in the hill, some of the "conucos" (as the farm patches of an acre or two are called) show proofs of good soil and a sufficiency of water. The absence of cactus here, away from the coast, is a corroboration not to be disregarded; this family of plants growing habitually, only where moisture is very scarce. From Isabella there is a pass across the mountains to Guayacanes, which follows up the Isabella River to Maimon, a flourishing little settlement; thence climbs a very steep hill to the summit and descends a long cañon to the plain. Many other passes exist through these mountains, the principal of which are the Alta Mira and Palo Quemado routes, between Santiago and Puerto Plata, one from Moca to Batei, one from Macoris to the mouth of the River Jobo, and from Macoris to Matanzas. In fact, there is a pass wherever the necessity for one exists, the range being so simple in structure, that the difficulties of finding a practicable route across it, almost anywhere, are not great. The Alta Mira pass starts about nine miles west of Santiago, and after ascending the arroyo of Limon Creek for half a dozen miles to Limon, climbs the range by a very steep trail to the summit, around the west side of mount Diego Campo; thence descending a little to the little hamlet of four or five houses called Alta Mira, it clambers along a muddy ridge, crosses a stream, and winds along another ridge, more muddy than the first, winding around the western flank of Mount Isabella de Torres, and reaches the plain about three miles from Puerto Plata, by a road more muddy still than the mountain pass. It is over this road, bad as it is, that an annual hundred thousand ceroons, of a quintal each, of tobacco have to be carried, on horse, mule, donkey, and bull-back, at an annual cost of about half a million of dollars, and nobody thinks of mending the road. The Palo Quemado pass is shorter, but so much worse that it is rarely traveled. It climbs a high ridge, quite near to Santiago, then descends to the head of the Yasica River, crosses it, then crosses some low hills, emerges into a plain bordering the coast. This road could be easily improved so as to be reasonably good. Next, east of this, is a trail from Moca to Batei, twenty-seven miles east of Puerto Plata. This is the worst road, if road it may be called, over these mountains, and, in near approach to impassability, is inferior only to the Savana la Mar trail. It is useless to repeat the same story of steep hills, rocks, and mud; this route abounds in all; but a pleasant relief is experienced when the traveler, emerging from a network of bad road, wood-trails, and mahogany "drags," suddenly comes in view of a pretty little valley at his feet, on the edge of Jamo River, with a neat-looking farm-house and its group of dependent out-buildings, fields well fenced, and with luxurious crops well cultivated; the plantain patch, with its trees actually planted in straight lines; abundance of cocoa-nut and other fruit-trees, and, in short, many unwonted signs of comfort and good taste. This is the farm of an old Spaniard, Don Narcisso Roca, who has lived in the country for many years, and who rules his little domain like a prince. His boisterous, good-natured hospitality is notorious, and the pleasant recollection of it is not soon forgotten by those who have shared it. From Don Narcisso's there is one trail down the river to Puerto Plata, a good half-day's ride distant, while another crosses a long ridge, with plenty of mud, as usual, striking the Yasica River, along which it descends a mile or two to Batei. At Batei is the farm of a gentleman, an American, Mr. C. Schaffenberg, which, in the appearance of the buildings, fences, gates, fields, and, in short, everything, betokens more advanced ideas than those held, or even understood, by his neighbors. The land is excellent, and the manner in which its owner has arranged his surroundings and availed himself of the natural advantages at his disposal, is not equalled anywhere else in the Republic. An unusual feature in Santo Domingo is the existence, near the house, of a fine large spring, giving rise to a good-sized stream of clear, cold water. In this neighborhood is quite a large colony of American negroes and mulatoes. These were brought to the country from Florida by a Mr. Kinsley, during the Haytien occupation under President Boyer. Kinsley made a contract with the Government that, as they were his slaves in the United States, they were to remain apprentices for a term of years, and then reach the full-fledged dignity of freedmen and citizens. Of course the experiment failed. The to-be citizens became impatient of the delay, and became unmanagable, in a country where a white man was not as good as a negro, and consequently having no redress. Kinsley was ruined; died; his sons, also coloured, and his former slaves, now form a colony, harmonious, industrious, and flourishing, and no persons on the north coast are more respected or more highly spoken of than the "Kinsley boys."

East of Batei, the country is almost without an inhabitant. A few scattered families occupy the more eligible sites at the mouths of the rivers, or where some little stream trickles down from the hills, until we reach Matanzas, a little village which owes its existence to the fact that it is at the extremity of the pass over the mountains, between Macoris and Samaná, and that there is a little harbor here for coasters. From the mouth of the Rio Jobo there is a trail across to Macoris, which ascends the river to the summit, near which is a collection of three or four houses, called Blanco. From the top of the ridge it descends another stream, emerging on the plain two or three miles northwest of Macoris.

The route from Macoris to Matanzas has nothing remarkable about it, except the great number of times it crosses the Rio Magua, a very rocky stream.

The only two streams in these mountains worth mentioning, are the Isabella River and the Yasica. The former river, south of Puerto Plata, flows northwest, through a long valley, and empties at the site of Columbus' first colony, from which it derives its name. It is too small to be of any practical value. The Yasica takes its origin in the same vicinity, and flows northeast, receiving several large branches. It reaches the sea about thirty miles east of Puerto Plata. The lower portion of this stream is quite deep, and is much used for floating mahogany from the interior to the coast.

The north coast has a number of good harbors. Manzanilla Bay is an excellent port, but now never visited. Its proximity to the Haytian frontier renders it unsafe for residence, and there is consequently no settlement there. The mouth of the Yaqui is so nearly choked by drift and bushes, that there is no river-trade, and Monte Cristi monopolizes all the commerce of the region. Added to this, the extensive marshes in the vicinity render it extremely unhealthy. Monte Cristi is a good little harbor, well shut in, and yet easy of access both by land and sea. Vessels enter easily, and are well sheltered, while there are no streams or marshes landward to cut it off in that direction, like Manzanilla Bay. The shore is very shelving; mud flats run out a long distance, and nearly a mile in width of the shore is subject to overflow at very high tides. But a causeway and pier will remedy the defect, and the flats can be turned to good account for the manufacture of salt. Should the Yaqui River be diverted to this point, Monte Cristi cannot fail to become a place of great importance.

Following the coast eastward, the first harbor of importance is Isabella. This is an indentation in the coast, open to the north and northwest. There is an abundance of water, and vessels resort there constantly for mahogany, satin-wood, and fustic. After this follow a number of little bays, like Sufflet, Blanco, and Isleta, available for small coasters, after which we arrive at Puerto Plata, a small but well sheltered harbor, at present the principal outlet of the tobacco trade of the Cibao. It is easy of access and egress, and will always be of importance, in consequence of a a good sugar-country surrounding it, even if the produce of the interior should find another outlet, a consummation not likely to be long delayed.

East of the Puerto Plata, the harbors are small and but little used. Cabarete, the headquarters of the Kinsiey colony, is a little bay, of but little value, available for small coasters. But little need be said of Samaná. It is a peninsula, or rather island, about thirty miles long and eight or ten miles wide; separated on the south from the mainland by Samaná Bay, and on the west by the Gran Estero, or Big Creek, one of the numerous mouths of the delta of the Yuna. Topographically, Samaná is a continuation of the Monte Cristi chain—that is to say, on looking at a map, one would not hesitate to include it all under one general term; but geologically, it is independent, belonging as it does, both by the contained rocks and by the date of elevation, to the same age as the main central chain. Almost the entire surface is a mass of mountain-land, with innumerable flats, not only adjoining the coast, but nestling everywhere among the mountains.

A chain of hills runs throughout the entire length, usually nearer the south than the north coast, and sends out numerous spurs, especially on the north side. One of these, near the eastern end, forms the promontory called Cape Cabron, while the end of the chain reaches to Cape Samaná. At the point where the Cape Cabron spur starts off, there is a high, conical peak called the Sugar Loaf, visible in every direction, and a good landmark from the sea. Monte Diablo is a smaller, broader, and less conspicuous peak near the eastern coast, also useful as a landmark.

The soil in the mountains is often thin and stony, but the valleys without number are exceedingly fertile. Some of the best coffee and cocoa-land in the Republic exists on Samaná. I found in several places in the woods, perhaps forgotten by the owners, old cocoa plantations, with the trees in full bearing, despite the forest growth which had sprung up around them. The valley of the little stream called San Juan River is a type of numerous spots on the peninsula. It is a long, not very wide valley, with a rich, deep soil, and so completely shut in from all sunlight by the vigorous vegetation, that it is almost always muddy. Almost the entire course of the stream is bordered by clumps of bamboo, their graceful stalks bending over and interlacing from side to side, so that the river runs, as it were, through a living archway of foliage. Towards its mouth, the land becomes rougher, the cañon narrower, the soil rocky, and its mouth is as wild a spot as can be well imagined; a long sand-beach, ending abruptly against a high bluff of black rocks, with the broad Atlantic thundering against it with a ceaseless roar.

At the eastern end, between Puerto Frances and Rincon Bay, there is a broad tract of land, admirably adapted for cultivation of coffee or sugar-cane. There are no streams on it, however, and the occupants would be obliged to depend on wells for their supplies of water.

Rincon Bay is a good-sized harbor, well protected by Cape Cabron. It is bordered by a nearly continuous sand-beach, on which grows a forest of thousands of cocoanut-trees. The whole north coast is nearly without occupants. Port Jackson has a shed or two, and the same may be said of Limon and Rincon; a few scattered sheds, occupied by occasional pig-hunters, being the only signs of humanity. A couple of families live at the mouth of the San Juan, and the next settlement is at Puerto Frances, where there are two or three houses. Here there is a little nook, in which small vessels can find a partial shelter. Just south of it, the coast is as wild and forbidding as it can possibly be. The limestone is worn into sharp points, bluffs, coves, and islets, over which the surf beats with great violence.

In strong contrast with the wild nature of the scenery on the northern and eastern coasts is the quiet of the shore of Samaná Bay. Every little piece of beach is crowded with graceful cocoa-palms. The hills are wooded down to the water's edge, except where a rocky bluff is too steep to support trees, and then bushes and trailing vines take their place. The roar of the ocean gives place to a gentle ripple, and every new picture seems to struggle to excel its predecessor in beauty. The south coast is a succession of hilly headlands and little bays. Almost every indentation has its level tract, and even far up on the hill sides are seen the garden patches and the thatched cabins of the inhabitants. Many of them are American negroes, who emigrated to Santo Domingo a generation or more ago. Most of the original emigrants have died, or remain as very old people. Their children and grand-children remain, a separate people, who rarely intermarry with the natives; usually speak English among themselves, and retain a sort of Protestant form of worship; much more intolerant of the religion of their Roman Catholic neighbors than these same neighbors are of them. They are quiet, industrious, thrifty, and always well spoken of as good citizens; but they all look forward longingly to the time when annexation to the United States shall give them a permanent guarantee of peace. The region principally inhabited by these people is just around the port of Santa Barbara de Samaná, from la Flecha to a point half a dozen miles west of the town.

The little bay of Santa Barbara, which often assumes the name of the larger bay, is a little land-locked harbor, entirely shut in from all winds, partly by the hills with which it is surrounded, and partly by a group of small islands lying in front of it. It is hardly equalled, certainly not excelled, in security or accessibility, by any port in the West Indies. The larger bay itself is an excellent shelter, although opening, as it does, to the east; it is sometimes disturbed by winds from that quarter; but once inside of the lesser bay, or behind any one of the numerous points, a vessel is as secure as if she were docked. West of Santa Barbara, there are five of these points, forming a succession of little side harbors, some deep, some shallow, but all well protected. This part of the peninsula is pretty well populated, and the clean, well-kept houses, nestling along the shore, present a scene of quiet beauty long to be remembered.

CHAPTER III.

TOPOGRAPHY OF THE REGION SOUTH OF THE MAIN CHAIN.

There is a marked contrast between the appearance and topography of the two sides of the island. South of the central chain, there are broad prairies, immense level tracts of forest, and long, heavy mountain ranges, reaching, some almost, others completely, to the coast. The region is naturally divisible into three parts, each having its local peculiarities, and differing alike in topography, climate, and vegetation. The first of these includes all the eastern part of the Republic, as far west as the Jaina River; comprising all of the Province of Seybo, and part of Santo Domingo. The second may be said to extend from the Jaina to the vicinity of the Ocoa River, covering the remainder of the Province of Santo Domingo, and overlapping the margin of the province of Azua; while the third and last region covers the remaining portion of Azua to the Haytien frontier.

The extreme eastern end of the island, forming the peninsula of Seybo, is made up of the low, terminal portion of the mountains, and a broad plain. This plain comprises about one-half, or nearly so, of the width of the tract on its southern margin, and is in part savana, in part forest. As will be explained in detail in its proper place, the character of the vegetation is dependent on geological causes, and the presence or absence of woodland is a certain key to the character of the underlying formation. All that portion adjoining the coast, from the Jaina River eastward, around the eastern end, until the mountains reach the sea, is clothed in trees. This strip of forest is of pretty regular outline. It is from eight to twelve miles wide, and west of Santo Domingo City, and gradually grows broader, until, near Higuey, it acquires a width of fifteen to twenty miles. Immediately adjoining the coast, there is almost always found a series of terraces. These acquire in all a total height of a little over one hundred feet; although they are not always strictly recognizable as terraces, but rather as a series of slopes. Near Santo Domingo City, but three can be distinctly made out—one on the edge of the river, corresponding to the bluff wall of rocks of the sea-margin; a second is in the village of San Carlos, just outside of the walls; while a third is directly outside of the village. A mile back of Santo Domingo, the land is remarkably level, and about one hundred and fifty feet above tide water. All the wells are of this depth, while in the city, their average depth is about fifty feet. On the southeastern coast, this terrace character is well seen from the sea, one bluff rising behind the other far inland.

In the neighborhood of the Jaina River, where it emerges from the hills, the soil is a coarse gravel, often containing large boulders. Going eastward, the gravel loses it coarse character, becomes gradually sandy, and finally almost a clay. All the region east of this river, from the tree-belt to the hills, is a succession of beautiful savanas, cut up by occasional water-courses, and, in parts, plentifully sprinkled with ponds and little lakes. The savanas continue to beyond Higuey, interrupted by strips of timber along the streams, and a little clump occasionally in low places, where the drainage of the water supplies a greater amount of moisture than over the other parts of the plain.

The line of juncture of the prairie and the coast forest supplies some of the prettiest park-like views that can be imagined. In the vicinity of San Antonio de Guerra, for example, the first intimation of the proximity of the savana is the occasional appearance of a little grassy opening in the woods. These become larger, more numerous, and close together, until finally the country becomes one continuous park, carpeted with green, dotted by clumps of trees, through which the cattle roam in herds, while here and there may be seen the palm-thatched cottage of a herder, embowered in a cluster of cocoanuts. On its northern margin the boundary of the savana is exceedingly irregular. It is encroached on by numerous spurs of the mountains, and, in its turn, not only sends long tongues back into the hills, but even surmounts them in places. A very few of the hills are entirely grass-covered, while many of the outer ones are divided between grass and forest. The peculiar-looking hills near Bayaguana stand out like islands in the plain, and near Monte Plata are some smaller spurs, not quite so isolated, but equally naked. About San Pedro and Yamasa the plain forms deep bays, nearly shut in by the hills, and on its extreme western edge the Savana of Santa Rosa is a similar extension, reaching to the Jaina River.

Sierra Prieta is a prominent hill running out into the plain, the terminal point of a long ridge between the Isabella and the Ozama Rivers. It is a low, conical peak, but can be seen for a long distance, owing to its isolation. West of the Sierra Partridge, directly west of the Isabella River, is a very marked mountain range running south from the central chain, and bearing two or three peaks worthy of notice. The most northern of these is Siete Picos, or Seven Peaks, so called from the number of peaks that can be counted on its summit. Directly south of it, not more than ten miles off, is Mount Mariana Chica, a fine hill with a square top, one of the best known and most easily recognized mountains on the south side. Isabella River* rises in the ridge between these two peaks, and running around the east side of the the latter, it empties into the Ozama. Along the western base of the Mariana Chica ridge, adjoining the Jaina, is a beautiful and fertile farming country that must some day attract a thriving settlement. It is pleasantly variegated between savana and woods, borders a fine river, and in some places acquires a width of upwards of a mile. It was in this tract that there existed a town in the time of the early Spaniards, now entirely destroyed, and its name forgotten by the people of the vicinity. Not having access to any work on the history of Santo Domingo, I hardly feel warranted in being very positive, though I have an indistinct recollection of having been told that it was destroyed by an earthquake. It was called Buenaventura, and the spot is now known as Monte Pueblo. The entire tract is overgrown with large forest trees, one in particular, two feet in diameter, growing out of the corner of a wall, while others equally large have sprung up among the ruins. The walls of a few houses, probably the more important ones, still exist as lines of stones, usually rough, though in one case nicely squared. They are rarely more than a foot or two high, and in one instance indicate a building of considerable size. One house stood in what is the line of the present road, and the horse-trail actually winds among the stones that once formed its walls, and crosses its principal room, the outline of which can still be made out. Although the town was at a long distance from the river, and, in fact, far from any considerable stream of water, but a single well has been detected, and that is now dry, doubtless choked by *debris* from above. Another excavation exists, in the shape of a vault, neatly lined with brick, about eight feet square, five or six deep, and accessible by means of a well-like aperture of two feet square. This is usually said to have been the treasure-vault of a Government mint, established here to coin the gold washed in the vicinity. I have never been able to learn if this is a tradition founded on fact, or if it is simply a theory based on the presence of gold in the

* It must be borne in mind, that many local names are repeated in Santo Domingo, and care must be used not to confound them. Thus we have this river, as well as the Isabella west of Puerto Plata; we have two Yaqui Rivers, two towns called Macoris, and, stranger still, two places in the Cibao called by the old Indian name of Hu-mu-nu-cú, within thirty miles of each other in a straight line!

neighborhood, and the difficulty of explaining the existence of the cellar in any better manner. Immediately below Monte Pueblo, on the east side of the Jaina, the savanas begin, here high rounded hills, which fall gradually into the savanas of Porto Rico and Santa Rosa.

West of the river, and entirely across to the Nigua, the hills are of pretty nearly the same contour; but they are mostly wooded. This tract is well watered by a succession of pretty little creeks emptying into the Jaina, and most of them are lined with settlements, a house and its accompanying "conuco" being found at almost every turn, their presence indicated at a distance by the inevitable cluster of cocoa-palm. These hills end rather abruptly in an elevated plateau, where there is a little cluster of houses called Cobre, which owes its existence to the effort—unsuccessful, however—to establish here a mining town. The principal condition of success was unfortunately wanting. Nobody has been able to find a mine of copper, or anything else.

Similar attempts, with no better results, have also been made on the Upper Nigua River, about nine miles above San Cristobal, where a few houses were built and a trail cut. The houses have nearly fallen to pieces, but the road remains, and, poor as it is, it is a boon to the scattered mountaineers who live through these hills. The Nigua River is a small stream with a wide, gravelly channel, often dry, except in holes, for several months, and again, during the rain, a torrent that nobody dare cross. At Tablasas it forces its way through and over a bed of limestone, forming a fine group of falls and rapids. Further down the bed is usually a dry gravel beach. The beautiful spring of "La Toma," (San Tomas?) three miles above San Cristobal, from which pours a never-failing body of water, that gave me, on measurement, fifteen square feet of cross section, fully accounts for the phenomenon. This is one of the most beautiful little spots on the Island. The spring is a basin of over twenty feet across, eight or ten feet deep, as clear as crystal, and boils out from subterranean channels, some of them as large as a man's body. It is at the foot of a steep hill, the part over the pool being a precipice of white limestone, overgrown with moss, festooned with vines, and with a graceful cluster of fern springing from every crevice. On one side is a magnificent clump of bamboo overhanging the pool, while on the other, large trees shut out the sun, and almost the light of day. The water runs down a narrow valley for a few hundred yards before it enters the main channel of the Nigua River. At a couple of hundred yards below the spring was a fall of some twelve or fifteen feet, and this was taken advantage of (tradition says) by the Spaniards, to build a fine dam of mason work. The water was thus carried off by a ditch, partly to a mill, ruins of which still remain, and part was carried through a hill by a tunnel, of which some traces can still be made out. This ditch, after winding around a point of hill, crossed the gravel bed of the Nigua by means of a channel confined between two stone walls, and then skirted the left bank of the river for half a mile or more to another mill, the walls of which still remain pretty well preserved. The foregoing information is derived partly from surveys made by Mr. R. Pennell and myself, and partly from the statements of an old Haytien, M. la Plene, who assured me that when he arrived in the vicinity with Touissant l'Overture, in 1801, then a boy of fifteen, the ditch across the river was distinctly visible, almost intact. The dam is now ruined from want of care. The water has undermined it in several places; the greater part finds outlet along the old creek bed, but during the last year (1871), another channel has opened. The top of the work, seven or eight feet wide, and as solid as a single rock, forms the only stone bridge in the Republic! This place is much resorted to by pic-nic parties for the beauty of the scenery, and the unusually good bathing facilities.

Another spot in the same vicinity, although equally noted, is not so much visited, partly because of two additional miles of travel to reach it; partly because of the very rough, rocky trail. This is the group of caves, known as Pomiel, on the same ridge, but further up the river. The caves are several; two large ones connected by a few narrow passages, but each having its outlet, form the principal attraction; while the others are mere indentations in the face of a bluff. These larger caves are several hundred yards in length, excavated through the white limestone of the mountains, and consist of successions of large chambers, sometimes connected by good-sized corridors, though oftener by passages so narrow as to admit a person with difficulty. There are but few stalactites, and none of them of any beauty. One of the caves is frequented by myriads of bats, whose dung forms a coating of a foot or two deep over the floor; while the other, known as the "White Cave," is almost entirely free from these inhabitants.

From the vicinity of the caves the view out is beautiful. Half a dozen miles of the narrow valley of the Nigua River can be seen, winding among the hills, while on each side, the lower foot hills roll off like billows as far as the eye can reach, bounded by the blue haze, or by the blue ocean.

The bottom land of the Nigua is wonderfully rich, and the cane fields, small as they are at present, are an earnest of what could be, if a more energetic race were to take them in hand. At the mouth of the river, half a dozen miles below San Cristobal, are the ruins of a very large sugar estate. The walls of the house, built on a stone terrace, indicate a degree of comfort nowhere found now in the interior; and the remains of the mill show that there was a time when at least one establishment in Santo Domingo rivalled the great sugar estates of Cuba.

West of San Cristobal the long spurs of the higher mountains run down so as to cut the plains bordering the coast into a series of bays. Immediately adjoining the river, there is a range of hills reaching almost to the beach; while the most direct road westward from the town is over a high ridge. The coast here has a strong trend to the southwest, and the hills run nearly parallel with it, leaving a comparatively narrow strip of level land on the margin. Most of this land, especially near the hills is a very rich black mould, unsurpassed for the cultivation of sugar-cane. Further west, after passing the Nizao River, the soil becomes gravelly and the climate drier, and near Bani our old friends the cactus begin to re-appear, becoming more abundant the nearer we approach Azua. Many pretty spots occur along the coast, such as Savana Grande, Palenque, and Nizao, each with its little settlement, and each is the centre of a small sugar-growing region, which judged by its capabilities should at least rival the most productive regions in the West Indies. Since the abolition of slavery in Santo Domingo the country has been in an almost constant state of anarchy. The repeated revolutions, each one destroying all the improvements made during the preceding interval of peace, have completely ruined the people, depriving them of all hopes of benefit from their labor. Three-quarters of a century of such experience has almost eradicated all ideas of industry; and the poor wretches dare not begin any work on a large scale, for want of guarantee that they will be the better for their trouble. The last four years of uninterrupted peace have been an epoch almost unprecedented in duration, and the government certainly seems to be gaining strength, slowly, but surely.

With this return of peace, there is a marked change coming over the industries of the country. Clearings are being made, more and more numerous every season; fields of cane and tobacco are being planted, and the increase in the production of these two crops is already very perceptible. This change is especially marked in the region in question, and new fields are rapidly being cleared, and cane planted in almost every available spot. With continued peace, it is not rash to predict that in a few years this will be the greatest sugar district on the Island.

About Bani the country is nearly level, the soil gravelly, and the vegetation similar to that in the Santiago Valley. Near the town there is a very peculiar little hill, extending about a mile out into the plain, called Loma del Pueblo, and directly west of this, about eight miles distant, is another, longer and higher, called las Tablas. The intervening plain, as well as that part to the south is almost perfectly level, and clad in a good growth of grass among the trees. It supports large numbers of horses and cattle, and about Savana Buey are not a few sheep. The latter do not seem to be even as highly appreciated as goats. They are never sheared, and are rarely used for food. The plain runs up into the hills at Honduras, much less fertile than nearer this coast, and strewn with large pebbles and boulders, the remains of an old beach. Below Savana Buey, the plain runs down three miles to Calderas Bay, some parts of whose shore are mangrove swamps, the remainder sand. On the long sand spit which serves as break-water to shut the bay in from the ocean are one or two large salt-water lagoons, communicating with the sea at high tide, and admirably adapted to the manufacture of salt. The bay itself would be an excellent place for an excursion, with plenty of gunning and fishing. The clear sea-bottom, a floor of sand on which the star-fish and mollusk lie side by side, giving place in deeper water to the forests of coral, through which myriads of fishes, more brilliantly colored than the rainbow, loiter at their ease, or dart like flashes of red, green, or silvery light; the endless variety of life below as well as above the water would give pleasurable occupation alike to the sportsman or the naturalist, were it not for the infernal pest of sand-flies, —a very Egyptian plague, so small as to be nearly invisible, and so painful in their bite that a Jersey mosquito cannot compare with them.

Between the region just described and the main mountain range is a broad tract made up of heavy mountains, with small intervening valleys. East of the Nizao River is a high mass extending to the Jaina, in which the Nigua River heads. Again, west of the Nizao, a similar ridge runs southward from the peak of Vanilejo, and following close to the river it suddenly bends to the westward, carrying some of the largest mountains visible on the south side of the range. The principal of these are Manacla!, east of the Nizao, and west of it Barbacoa and loma de los Pinos. These latter occupy the position of what Schomburgk calls Valdesia, though on what ground I never could learn. His name is not even known in the neighborhood. Among the southern spurs of Mt. Barbacoa the Bani River takes its rise, and along the upper part of its cañon is quite a good sized little settlement, called Recol, perched on the hill sides. The principal occupations of the inhabitants are pig-hunting, and the culture of coffee, for which their steep hill sides are admirably fitted.

In the valleys of the Upper Nizao, as at Rancho Arriba and Rancho Abajo, not to mention a hundred other spots in this practically unknown region, coffee flourishes in a manner almost unknown elsewhere. Mr. Runnebaum reported to me a coffee-tree at Rancho Arriba which he declared had more than a bushel of ripe berries! The whole of this tract is a mass of sharp ridges, broad sloping hill sides, and beautiful little nooks on the sides of mountain streams; a district capable of supporting thousands of inhabitants. The only place permanently inhabited is the valley of Maniel on its western region, on the Ocoa River. The two spots, Ranchos Arriba and

Abajo, are simply a house each, used periodically by the pig-hunters. I have seen flourishing farms in Oregon infinitely worse off in location, soil and accessibility than the average of this region. In 1869, I spent a week among these mountains in company with Mr. A. Pennell and a party of natives. There was nobody sufficiently acquainted with them to serve as guide, and we were obliged to pick our way across as best we could. Between Maniel and the Nigua there is not a single inhabitant and hardly a trail. Pig-hunters' trails penetrate from one side and the other, but none cross the tract. The Valley of Maniel is a beautiful little spot of but a few thousand acres, shut in by mountains on all sides, except where the cañon of the Ocoa River gives a pretence of a level road. The road from Honduras to Maniel crosses the river only thirty-five times! Of course this means that during the rains this route is impassable, and the inhabitants of the valley must cross the mountains towards Azua, if they wish to communicate with the outside world.

West of the Ocoa River the mountains are quite heavy, and send a spur southward which reaches entirely to the beach. This spur is low and is crossed by two passes, one from Maniel, the other called the Pass of the Numero, a road running around the north side of Las Tablas hills. Still a third route skirts around the end of the range, following the coast, often on the beach. This, though longer, is often used in preference to the Numero on account of its being much smoother. The vicinity of Azua, that is to say, the tract lying east of the town, could hardly be more desolate. It is a nearly flat, perfectly dry tract, overgrown with thorny acacias and cactus, while thickets of the Maya or hedge pine-apple, render it yet more impassable and unattractive. The whole neighborhood of the town is alike barren, dry and thorny. But three or four miles to the southwest, at los Conucos, the character of the country changes suddenly and entirely. This is a level, sandy region, where from geological causes, the subsoil at a depth of but six or eight feet is permanently saturated with water. Here is the richest sugar-cane region on the Island, although it is at same time one of the most unhealthy. In ordinary years, rain is almost unknown here; but when, as occurs sometimes, it does rain, the whole region becomes little better than a swamp.

Back of Azua, that is to say, up to the hills, the same acacia and cactus thicket continues, broken only where a miserable little stream furnishing a narrow strip of moisture, produces a corresponding change in the trees. On the Agua hedeondo, or stinking water, there is a grove of Mango trees, and more remarkable still, the only date-palm I have seen on the Island. Its rough stem and almost solid ball of foliage looked like an old friend, the more welcome because I came upon it unexpectedly in the woods. Although so old as to be almost past bearing, its vigorous, healthy appearance was proof abundant that the climate is not inimical to the plant. This tree must be of very great age because, not only do its size and general appearance indicate it, but a gentleman now over fifty years old told me that he remembered it an old tree in full bearing while he was a very little boy.

Directly north of Azua there is a great mass of mountains lying east of the Constanza Pass and northwest of Maniel, entirely uninhabited and practically unknown. We have penetrated it for short distances from various directions, but in the absence of all trails or guides, and in view of the almost impassable character of the jungle with which it is clothed I have not dared to attempt to cross it. On Schomburgk's map are placed several peaks in this region to which we obtained bearings, but I have never been able to ascertain how he obtained the data for the heights attached to them. So far as I can learn, after careful inquiry, he did not ascend them or even get so near to them as we did; and I cannot believe that Loma Tina is as high as his figures make it. So far as an eye estimate will warrant me in the expression of an opinion, I do not think it so high as the peak of the Yaqui, although it is certainly a high mountain. It is a long slope ending in a point from which the opposite side descends precipitously. It is surrounded by many other points approaching it in height, say over 6,000 feet, so that it is not so prominent, nor so imposing an object as the silver-capped "Rucillo," the father of the two Yaquis.

Unfortunately, the disturbed political condition of the region towards the Haytien frontier, including all or nearly all of the country to the west and northwest of Azua, has prevented us extending our investigations in that direction. Accompanied by Mr. Pennell, I have made a single journey across the Constanza pass, emerging on the south side, almost in view of San Juan; Mr. Pennell had previously visited the same part, and afterwards made a boat-journey along the whole coast to the Haytien line at the mouth of Rio Pedernales, including a visit to Beata and Alta Vela Islands. There trips, meagre as they were, gave us all the information we possess, beyond what can be culled from common report and the maps of our predecessors. I have not hesitated to follow the map of Sir Robert Schomburgk in detail, in this region, as well as to copy the whole of Hayti from the same source, since I found that this map is excellent in its main features; very much better than could have been expected, considering the circumstances under which it was made; and have consequently availed myself of it in this, the only region where our own work did not extend.

For information in regard to the character of the San Juan Valley, I am mainly indebted to His Excellency, President Baez, who has frequently described this region to me in most enthusiastic terms. From the road between Constanza and Azua, there can be seen a broad valley extending to the northwest as far as the eye can reach, bounded by high hills on each side, and occasionally encroached on by a small spur. This valley seems to be nearly level, and its appearance at a distance certainly warrants the glowing pictures painted by all who know it. It is said to be extremely fertile. It seems that the dry character of the Azua and Monte Cristi regions does not extend to it, and the "Guinea grass" with which it is clothed perennially is said to completely hide the animals grazing among it. During the "old Spanish time," before the revolt of the colonies, this is said to have been the richest region on the Island.

Myriads of cattle roamed on the plain where now not an animal is to be seen. The Government is now gradually resuming its occupation of and jurisdiction over the valley, and even as I write, news arrives that San Juan has been made a permanent military post. The significance of this step will be apparent when we consider that the place has been abandoned since 1868, or only occupied for a day or two at a time by "raiding" parties. South of this region, separated by a range of high hills, is another valley which runs uninterrupted from Azua to Port au Prince. This is said to be narrow, and except at its western end, not so fertile as the other. In it are several lakes; two of them of considerable size, neither connected with each other nor with the sea. Still south of these lakes, is another range of hills, the Sierra Baburuco, which form a sort of wall cutting off the southern peninsula from the adjacent regions. Mr. Pennell describes this peninsula as a flat region, densely wooded and well watered. Mr. Luis Durocher, a very intelligent and well educated gentleman, and one unusually well acquainted with most matters connected with his country, informed me that this tract is sparsely inhabited by a people most probably the descendants of fugitive slaves. He describes them as apparently pure negroes, savage, nearly or quite naked, not living permanently in any one place, and speaking a language peculiar to themselves,—an almost unintelligible patois of French. It is said that the peninsula is full of mahogany, and other valuable woods, almost untouched as yet by the axe.

The south side of the Island is watered by many more rivers than the north side; but they are smaller and comparatively unimportant. They may be divided into two classes: those that take their origin in the central chain of mountains, and those that flow from the spurs and subordinate ridges. To the first class, belong the Macoris, Ozama, Jaina, Nizao, Ocoa, and Southern Yaqui, sometimes called the Neyba.

The first two of these are the only ones worthy of special note, since they are navigable for a few miles from their mouths. The others are not navigable even for canoes, and are only of interest from the amount of area that they drain. East of the Macoris are the rivers Yuma, Puiabon and Soco, small streams winding through the plain. Between the Macoris and the Ozama is the Brujueles, a mere rivulet in width, but of great length, which has no mouth, but sinks into the plain at a distance of several miles from the coast. The Ozama receives two branches, the Yabacoa from the east, and the Isabella from the west, both large streams, the latter coming out of the mountains near the head of the Jaina. The rivers of the second class, those rising at a distance from the main water-shed, are the Nigua, Bani, Via, and others of less note. Although so much of this side of the island is plain, it is all well watered; the traveller need never suffer from thirst, unless perhaps in the vicinity of Azua, where streams are scarce.

The principal harbors on the coast are the great Bay of Ocoa, well shut in from all winds except that from the south; Calderas Bay, an entirely land-locked lake, opening to the westward, and furnishing as good a harbor as could be desired, and Santo Domingo, a mere roadstead. Vessels here have to lie a quarter or even half a mile from the shore, where a good anchorage is afforded, although with but little protection from storms. Vessels drawing not more than ten feet of water can enter the river, and tie up at the city front. Besides these, there are innumerable little ports, available for coasters; the best one of which is Palenque, near the mouth of the Nizao River.

Off the coast are a few islands of but little importance and, except Alta Vela, uninhabited. Saona Island at the southeast corner is nearly crescent shaped, about fifteen miles long and two or three miles wide. It is flat, densely wooded and abounds principally in mahogany, goats, logwood, and mosquitoes. Catalina and Catalinita Islands near it, are much smaller, very similar and even less remarkable. Off the extreme south point of the southern peninsula is Beata Island, very similar to Saona, except in size and in being slightly elevated in the middle. It is about three miles wide by five long, and is covered with a thorny thicket in which the "cat's-claw" or "wait-a-bit" vine predominates, to the detriment of the clothing of the unfortunate who ventures to explore it.

Southwest of Beata is the still smaller islet of Alta Vela, a high hill of five or six hundred acres, looking at a distance like a ship under sail, whence its name. It is noted for a deposit of hard phosphate of alumina, which has attracted various persons who have mined here with indifferent success for a number of years. The island is entirely without fresh water, the supply being either brought from Beata or distilled on the spot. In its neighborhood is a group of naked rocks known as Alta Velita, having nothing about them, however, worthy of note.

PART II.

GEOLOGICAL FORMATIONS.

CHAPTER IV.

THE SIERRA GROUP.

No formation older than the secondary era, has been found on the Island; the oldest group, being the great mass of slates, conglomerates and limestones which form its core. These are uptilted and broken by numerous intrusive masses of crystalline rocks which may be, for convenience, grouped under the generic term of syenite, since they almost invariably consist of the three necessary minerals, quartz, feldspar, and hornblende.

Flanking the slates, etc., of the Sierra, there is a broad development of Tertiary marking all the northern and a part of the southern side of the Island, and this in turn is bordered by a more recent deposit of limestones and gravels which I shall call the coast formation.

The SIERRA GROUP forms all of the great mountain mass of the interior, extending the entire length of the Republic.*

It also constitutes the greater part of the Peninsula of Samana, and appears as a single little outlier, under the Tertiary, near Puerto Plata. It everywhere shows the evidence of active subterranean forces, being not only metamorphosed, with hardly a single local exception, but is everywhere much uptilted, and usually, strongly folded. Over much of its area, the metamorphic action has been so complete as to destroy the traces of stratification, or to so nearly obliterate them, that they are apt to be confounded with cross fractures. This is most markedly the case in those regions, especially in the eastern half of the Island, where the rocks take on a serpentinoid character. Near Yamasa, for instance, I amused myself on the face of a fine bluff in trying to decipher the lines, and found that I could construe them to suit any theory of direction of dip desired. The same thing occurs again at Piedra Blanca on the Maimon River in the Province of Vega.

But enough of the stratification is preserved to show conclusively that these beds

* And it seems to form at least one, if not both the long peninsulas of Hayti; at least the appearance of the mountains is such that it induced me to draw this inference when, a year or two ago, I skirted along the coast, a mile or two off shore. The contour and general character of the mountain ranges of Hayti are identical with those of the central range of Santo Domingo, — high, rough, irregular and heavily wooded.

lie in a series of east and west folds, the line of folding and upheaval corresponding very closely with the axis of the mountains. The thickness of the deposit is very difficult to determine, since no continuous section exists, where one can be certain of having all the beds, and of not being deceived by repetitions. On a very rough estimate, not based on measurements, however, but only on the broadest kind of vague generalization, in the cañons of the Ocoa and Nigua Rivers, and again on what I saw of the formation in the vicinity of the Pico del Gallo, we might set down the total thickness at anywhere between 2,000 and 4,000 feet. It must be understood that this broad margin is not the result of want of care in observation, but arises from the almost absolute impossibility of finding a reliable section. In one region a group of conglomerates occurs; in another, within forty or fifty miles these same beds are represented by limestone, without a pebble, and on the same strike within another twenty miles, neither limestone nor conglomerate is to be found; all is a semi-talcose slate too friable to yield a hand specimen, and with no distinguishable stratification. Add to this the partial obliteration of character by different degrees of metamorphism, and the sometimes total obliteration of bedding, and the reasons of my cautious statement must be sufficiently obvious.

In the interior of the mountains, especially in the western two-thirds, the disturbance has been greatest, and the reason appears, in the existence of great masses of eruptive rock which have pushed up the slates, broken them, and in some cases penetrated them by dykes to a distance of several miles from the parent mass. In some cases pieces of the wall rock are found inbedded in the syenite; and pebbles one-half syenite the other jaspery slate are not rare.

In its original state, this group of beds seems to have consisted of a series of clay shales, thinly bedded, others more heavily bedded and with layers of sandstone, conglomerate, limestone, and heavy bedded sandstones. The changes produced in these rocks by metamorphism are almost infinite. On the Ocoa River the shales are so nearly unaltered that I have repeatedly searched in this region in hopes of finding fossils. In the cañon of the river they are gray and friable, with an occasional bed of sandstone; further south they are red, and give rise to numerous salt springs; still further south they contain more numerous beds of sandstone, and are brown and more sandy in texture. These same shales are modified at Recol into a granular, greenish-black material resembling an impure serpertine,* while on the Nigua they appear as green, gray or brown jaspers with broad conchoidal fractures, gradually changing

* A similar change occurs on the north flank of Monte Diablo, California, where I have followed the same bed of rock along a series of outcrops; in one place, simp'e unaltered sandy shale, gradually modifying until it became in another a nearly pure serpertine. See *Whitney, Geol. Report Cal.*, vol i. p. 22.

again within a few miles to a more serpentinoid form, to reappear as the same jasper on the Jaina, and to again change, on the Upper Jaina and in nearly all the mountains eastward, into a whitish rock, more or less talcoid and profusely stained with iron. On the north side of the island the modifications of the shale are just as great. The sandstones also undergo an equal number of variations, appearing of all colors from black or dark gray sandrock to a white, granular quartzite. In short, nearly every color is represented; and naturally, all degrees of texture from the coarse conglomerate of San Jose de las Matas, or Maniel, to the shale above described. In one place only did I find siliceous segregations like the chalk flints, or more probably, like the corniferous limestones of the New York geologists. In the hill just west of Bani the rock is a limestone, and in it are numerous streaks, lying in the plane of stratification, of a light brownish limestone, very tough and breaking with an irregular fracture. Near the base of the series, apparently, are strata of conglomerate, made up of pebbles very similar to those of the surrounding beds. These pebbles seem to have been brought from long distances, since they are almost invariably rounded by attrition. They are largest on the Upper Ocoa, near Maniel, and on the north flat of the range near San Jose de las Matas; but at these points they are rarely more than a few inches in diameter. I have endeavored in vain to find the probable source of these pebbles. They are certainly not from the adjoining beds, although lithological researches were not wanting. They are not derived from any deposit encountered by us on the Island, since the conglomerate strata extend nearly, if not entirely, to the base of the stratified rocks. It is not probable that further examination to the westward, in the yet unknown portions adjoining Hayti, or lying within its borders, will develop their origin, since such a discovery would be foretold by increase in the size and angularity of the pebbles in that direction. They must therefore have been derived from some land then existing most probably to the north or northwest of the present island, but now submerged or destroyed. The conglomerate is variable in its character and the changes take place over comparatively limited areas. On the north side it is almost always cemented by a coarse-grained red sand, the surfaces of the contained pebbles being stained by the ferruginous nature of the matrix. This is the rule where the metamorphosis is not very perfect. In one place, west of San Jose, the whole mass is rendered nearly homogeneous in texture, the fracture crossing matrix and pebbles alike. In another, on the Mao River, the whole is changed to a dark olive green, the coloring matter having stained even the interior of the pebbles. On the Ocoa, some of the conglomerate is cemented by lime instead of sand, and in this case the pebbles are not so numerous as to be always in contact. This peculiarity gradually changes to the eastward, so that the conglomerate is represented on the Nigua by a group of beds in part pure limestone, in part an impure limestone, containing occasional pebbles. This last is the stratum from which fossils were obtained.

One bed near Maniel is made up of little grains half as big as an ordinary pea, almost uniform in size and with little or no cementing sand. On the Nigua River the limestone acquires its greatest development. Here the metamorphic action has been unusually well marked and the formation is represented mainly by limestones and jaspers. The stratification also is unusually well preserved, so that a good section is attainable. The lime-strata of the Ocoa are apparently all repeated on the Nigua, and the conglomerates are replaced by beds containing but few pebbles, the matrix being either a pure, or more usually, an earthy limestone. This latter rock, at two localities on the river, yields fossils, in a bad state of preservation for extraction, although occasionally recognizable. The shell substance is completely crystallized so that it is next to impossible to extract a thick shell in such a manner as to expose its surface. Of hundreds of attempts to obtain a specimen of a very common *Trigonia* I have only succeeded once or twice in obtaining a little piece of the surface; the fracture always taking place among the crystals of calc-spar into which the shell has been cemented. The univalve shells invariably break across and, in a word, the collector has to content himself with the few imperfect fragments found weathered out. Nowhere else have fossil mollusca been discovered in this formation in Santo Domingo, and only in one other instance have I found any other fossil in it. Three or four miles west of San Jose de las Matas I was fortunate enough to discover two fragments of the same limestone, being of a dark bluish-gray color, on the surface of which can be detected, faintly marked, the stars of a coral. Doubtless by means of polishing they can be brought out. These are of especial value, being the only traces of corals yielded to us by the formation; unless indeed a stray pebble, found on the surface of the ground near Bani, also containing corals, may belong to the same group. On the Peninsula of Samaná the limestones are highly metamorphosed, and here occurs a very curious mixture. In some cases the limestone has a few scattered scales of mica imbedded in it; in others the mica is so abundant as to form layers, while not infrequently, especially in the eastern part, mica slate, alternating with the limestone, is not an unusual feature. This is the more remarkable since it occurs nowhere else on the island, and in only one other locality is mica slate found and there in hardly noticeable quantities.

With so few data it would seem hazardous to venture a determination of the geological age of the group of rocks in question. But a careful study of the scanty material at my disposal reveals the existence of a serrated *oyster*, a *Trigonia*, a *Turritella*, shells resembling *Ancillaria*, *Natica*, *Pugnellus* (*?*) and *Mactra*, besides a *Fusoid*, one fragment that seems to belong to the group of *Pterocera*, at least it is an alate shell, bivalves that may prove to be *Cucullœa* and *Lima*, and better than all else a beautiful little *Ammonite* in perfect preservation, and a fragment that I think more careful study will decide to be a piece of a *Baculite!* From the above list it will be seen that there can no possible doubt of the Secondary age of the rocks. The *Ammonite* restricts it so far. The style of the *Ammonite* besides confines it to the two groups of Jurassic and Cretaceous, a determination corrobated by the *Trigonia*, which further belongs to a type much more common in the latter than in the former formation, resembling *T. Emoryi*, Con., *T. Evansana*, Meek, and *T. Mooraena*, Nob. (*T. crenulata* Roem., *not* Lam.) In fact I am not sure but that the second of these species is also found in New Grenada, whence it was previously described by Mr. Lea as *T. Tocaimaana*,* and that the present one may have to be included under the same name. The gasteropodous shells are of but little real assistance, although the *Ancillaria* belongs to a type as yet only known by one or two species high up in the Cretaceous; the oldest members of the family being in that horizon. The *Naticoid* of course has but little weight, while my generic determination of the (?) *Pugnellus* is not sufficiently sure to warrant me in availing myself of this really valuable aid.

The *Mactra* is not of any great stratigraphical value, and the other bivalves are of still less importance. The *Baculite*, if it should prove to be such, is a little fragment so imbedded in the matrix that it will have to be developed by grinding or polishing, since any other process would inevitably destroy it. It will be thus seen that the formation is either Cretaceous or Jurassic, and the preponderance of evidence is in favor of the Cretaceous. This receives additional weight from the results of the labors of other geologists in the Caribbean region.

Mr. Robert Etheridge examined a small lot of fossils from the coast of Venezuela for the Geological Survey Commissioner of Trinidad, with a view of throwing light on the age of a similar deposit in that island, and reported† "*Pteroceras*, *Cerithium*, *Turritella*, *Trigonia subcrenalata*,‡ *Ostrea Couloni*, *Arca*, *Cardium* and *Echinus*;" observing that "the *Trigonia* may with certainty be referred to the same species obtained at Bogota."

The Geologists, Messrs. Wall and Sawkins say of the fossiliferous limestones

* Trans. Amer. Phil. Soc., Philadelphia, 1840, p. 255, pl. 9, fig. 8.

† Report on the Geology of Trinidad, 1860, pl. 166.

‡ Most probably identical with Lea's *Tocaimaana*.

(p. 34): "Limestones are rare, do not exceed ten to twenty feet in thickness, are extremely compact, and their fossils usually partially or entirely transformed into highly crystalline spar." Had they been describing the Dominican deposits instead, they might have used the same words.

In 1860 Mr. L. Barrett, then colonial geologist of Jamaica, published a short note in the Journal of the London Geological Society,* in which he describes the Cretaceous deposits of that island and mentions the existence of *Inoceramus*, *Hippurites*, *Nerinea* and *Bulla*, but does not attempt to fix the exact age. Still later, Mr. Etheridge prepared a memoir for the geological report of Jamaica,† in which he discusses all of the information obtained to date. By a clear and exhaustive examination, he proves that the Jamaica Cretaceous is most probably on or very near the horizon of the Gray Chalk. The total number of fossils collected by the Jamaican Geologists is 13 species of Mollusca, 1 Echinoderm, 5 corals and 1 Rhizopod; but little better luck than we have had.

Dr. P. Martin Duncan has elaborately studied and described the fossil corals of the West Indies,‡ having had large collections from nearly all of the islands at his disposal. He is quoted by Mr. Etheridge as anticipating the discovery of Cretaceous rocks in Santo Domingo on account of some corals from the Miocene of the Cibao, which seemed out of place in that formation.‖

From a long familiarity with the "Nivaje shale," which is simply the middle part of our Miocene, I am incline to doubt Dr. Duncan's specific determination of the coral, rather than accept his conclusion. All of the Cretaceous debris in the Miocene of Santo Domingo—and it occurs abundantly—exists as highly metamorphosed pebbles; the metamorphic action seeming to have been completed before the deposition of the overlying fossiliferous strata. In fact Dr. Duncan himself§ is not perfectly sure of

* *Loc. cit.* Feb. 1860, p. 324.

† Appendix V. Geol. Report, p. 306 *et seq.* 1869.

‡ Quart. Jour. Geol. Soc., vol. xix. p. 406, and vol. xx. p. 20.

‖ Etheridge, *loc. cit.* p. 308, says, "Dr. Duncan has also stated his belief that "the Hippurite limestone exists in the neighboring island of Santo Domingo, basing this opinion upon the fact that corals having very decided lower cretaceous affinities were noticed in Miocene Strata" in that island. He noticed having found the European lower chalk coral *Astrocœnia decaphyllia* in the Jamaican Miocene; *Phyllocœnia sculpta*, from the Gosau and Uchaux beds, was also found in the Nivaji shale in St. Domingo, associated with four other species of Turonier affinities in the same shale."

§ P. J. G. S. vol. 19, p. 450. He says: "In the yellow shale there is a ramose coral which, provisionally is classed with *Phyllocœnia.* With one exception its structural characteristics agree with a very remarkable coral, which has been referred to many genera, having been called by Goldfuss, *Madrepora limbata*, by Brown *Oculina limbata*, by M'Coy *Gemmastræa limbata*, and by Milne-Edwards *Stylina limbata.* Our species has no columella visible, and although it is notorious that the little sharp collumellæ of *Stylinæ* constantly fall out, still I have considered it advisable to disregard this and to classify the form with *Phyllocœnia*, and to state the probability that other specimens will determine the presence or absence of a columella. Another species so closely resembles *Phyllocœnia sculpta* (Michelin, Zooph, pl. 71, fig. 1 and 3), *that it can only be considered a variety* with a tile-shaped corallum." The italics are mine.

the identification, so his prophecy has received a better fulfillment than it merited. In saying this, however, I do not wish to be understood as having the least desire to disparage the really valuable work done by that excellent student.

Before leaving this formation there is another subject that merits at least a passing notice. Almost everywhere the metamorphosed slates carry quartz veins, sometimes barren, sometimes auriferous. These veins are usually small, rarely more than a foot or two in width, although one instance occurs on the Upper Jaina River, where a width of over twenty feet is attained. In no case have I had reason to suppose these masses filled fissures, in the ordinary sense of the term. In every instance where a good outcrop occurs, so that its nature could be clearly made out, the quartz is found inter-bedded or inter-stratified with the slate, following its contortions and intimately united on the sides. In other words they are true veins of segregation. They are most numerous in the vicinity of the injected masses of crystalline rock. They occur also quite abundantly in the whitish talcose rock of the main ridge, as for instance, on the Bonao road, and again in the neighborhood of Yamasa. But one strongly marked feature has been observed to characterize all of the veins. Those nearest to the intrusive rocks are always gold-bearing; and those at a distance from them are invariably barren. This has been abundantly proven by innumerable examinations. No vein-mining for gold has ever been undertaken on the island, but I have caused numerous analyses to be made of specimens from various localities, always with the above results; and further, as a natural influence, every stream running through the metamorphic rocks in the immediate neighborhood of masses of syenite carries gold in its sands, while all of those running exclusively in the syenites, or at a great distance from them, are without the precious metal. Thus the Nigua and Jaina Rivers are barren at their heads, but immediately on entering the slates they and all of their tributaries are gold-producing. The upper waters of the Nizao, Ocoa, and their upper branches carry gold, while the Majoma, entirely in crystalline rocks, is barren. Not to multiply examples, the same may be said of all the north face of the Cibao range, west of Santiago, while east of Vega in the north, and east of the Jaina River on the south, that is, east of the eruptive rocks, no gold has ever been reported.

It is also in this formation that the little copper of the Nigua and the fine iron deposits of the Maimon occur. These will be described in detail in their proper places in connection with the description of the local geology.

CHAPTER V.

INTRUSIVE ROCKS.

The Cretaceous rocks which form the basis of the Island are elevated into a series of folds and undulations by an immense mass of granitoid rocks, which appear as a "*massive eruption*"* occupying the heart of the range and forming a belt, sometimes entire, but more usually consisting of two, three or more parallel lines. Although the Pico del Yaqui is entirely composed of this rock it is the exception rather than the rule to find it making up the higher points. It seems to have forced up the metamorphosed slates in great masses, and shows itself at their bases or along their flanks, exposed as often by denudation as by actual outflow. Its general direction is much more to the northwest, as a whole, than the axis of elevation of the chain; so that although its western half coincides with the trend of the mountains its eastern end bends far to the southward. This eastern end also covers a greater width than any other part, extending continuously or nearly so from the head of the Jaina to far down on the Nizao. In the mountains northwest of the Peak of the Yaqui the eruption has taken place along three parallel lines, throwing up the slates into the high summit-ridge to the south, and making two marked synclinal axes, on the edge of one of which is the tall Pico del Gallo. The most northern of these exposures is quite near the northern base of the range, and it is more than probable that this is due to denudation, since the slates, although uptilted at high angles, are not raised to an altitude at all comparable with those further south.

On some parts of the margin of the eruption the overlying rocks have suffered much fracturing, and the subjacent molten matter has been injected into the fissures, sometimes to a distance of several miles from the nearest surface exposure of the parent mass. This is notably the case on the Jaina and Nizao Rivers. On the former stream, at and even below the mouth of Madrigal Creek, the jaspery slates are seamed with dykes of all sizes from a mere thread up to many feet across; while the nearest exposure of the mass is near Catare, eight miles further up the river. So on the Nizao, dykes occur almost as far west as Maniel, while the western margin of the main eruption is between the Nizao River and its tributary, the Majoma, which enters it from the east.

A remarkable feature of the intrusive rocks of Santo Domingo is that, although all are of Tertiary age or at earliest, some of them may date back into the latest

* Richthofen, Natural System of Volcanic Rocks, p. 9.

epochs of the Cretaceous, while the newest are even more modern than the Miocene, they are similar in composition and in all their leading features to what have heretofore been considered peculiar to older geological periods. Richthofen* dwells at length on the idea that granites and "granitic rocks," as well as "porphyritic rocks" are almost exclusively palæozoic, quoting as a modern instance of the latter, the Liassic age of some outflows in the Sierra Nevada of California.†

The same author uses the fact of the eruption taking place during or subsequent to the Tertiary as one of the characteristics in his description of "Volcanic rocks," from which he strictly excludes all forms similar to those found in Santo Domingo. The oldest eruptions here must have taken place after the deposition of the Cretaceous; but since we are not yet able to decide the exact position in the scale for our Cretaceous strata we are equally unable to determine the earliest possible epoch at which such eruptions could have taken place. It could not have been earlier than the period of the White Chalk of Europe (Senonien); and the probabilities are in favor of their occurrence during the long Eocene period. Ample proof exists that the main range acquired its present contour and nearly its present height, that the eruptive rocks had appeared, and that the metamorphism of the Cretaceous was completed before the deposition of the Miocene began. But another point yet remains not less remarkable than the first, when examined in view of this theory. The Monte Cristi range is composed, with one or two insignificant local exceptions, of Miocene Tertiary. Its elevation could hardly have taken place before the Pliocene, and possibly was not completed until late in that era. Near the summit of the range, for a distance east and west of forty or fifty miles, dykes are not rare, and some of them are of considerable size. These dykes are composed of a rock not only having a general resemblance to that of the Cibao range, but I have collected hand specimens north of Macoris which would defy the most practiced eye to distinguish them from portions of the main central mass. Not only do they contain the same minerals, but those minerals are combined in the same manner and proportion, and the general appearance of the two are the same. Yet it must be borne in mind that the Cibao rocks cannot be later than the Eocene, while those in the Monte Cristi range cannot be older than the Pliocene. The whole Miocene period intervened between the two sets of eruptions, and still a uniformity of character was retained. Nor can the objection be raised that the resemblance is only a partial one, due to a second eruption in the Cibao range synchronous with the dykes further north. It is not impossible that such was the case, although I have never seen any reason to suppose so; but granting it, all of

* *Loc. cit.* pp. 9, 35, &c.

† *Loc. cit.* p. 41.

the eruptive rocks of the range have so strong a family likeness that the objection falls to the ground.

The resemblance that runs through all the intrusive rocks of Santo Domingo is much more marked than would be anticipated over so large an area. Little or no true granite exists, but in its place occurs syenite, varying in the size of the crystals and in the proportion of admixture, but in almost every case a compound of recognizable grains of quartz, feldspar and hornblende. Usually the material is so grouped that one ingredient preponderates but little over the other, and the mass presents the ordinary mottled-gray appearance. But occasionally one mineral increases at the expense of the others, or perhaps disappears entirely. On the Jaina there is a locality where the rock contains large crystals of hornblende, the interspaces being filled up with smaller ones of quartz and feldspar. In some of the specimens collected by me the hornblende is almost the only mineral visible. Mica rarely occurs, but in the same vicinity is another locality where a yellow rock is composed exclusively of quartz and mica, and yet another which yields a mixture of quartz and feldspar only. These, however, are very trifling local exceptions and form but a small percentage of the whole. For more detailed descriptions of the variations which these rocks undergo, I must refer the reader to the descriptions of the local geology.

Besides the granitoid rocks, there remains one other yet to be described. In the mountains north of Bani there is an outflow of porphyry, which I have never succeeded in discovering, although I have at various times encountered, perhaps in all half a dozen, pebbles and boulders in the river. The rock is a dark-brown or black paste, in which are embedded crystals of feldspar an inch across. Despite three years of constant, careful search I have never found this or any other true volcanic rock elsewhere on the Island.

An instance of the uniformity of the geological phenomena in the Antilles occurs in the fact that similar rocks ejected at about the same period are found also in Jamaica. The geological report of that island describes "metamorphosed secondary shale, sandstone and conglomerate" underlying undoubted cretaceous beds cut through by "dykes of intrusive diorite, syenite and granite."

CHAPTER VI.

MIOCENE.

All of that part of the Island which lies north of the Cibao Mountains, except a part of the peninsula of Samaná, is made up of Tertiary rocks, usually bordered by a narrow strip of more modern age. They also form one or two insignificant deposits on the south side about San Cristobal and the Nizao, and are said further to cover a part or all of the valley of the lakes running to Port-au-Prince in Hayti.* The work of the geological survey not having extended to the latter region I shall confine my observations to the others.

The district covered by this formation in the north, including its extension into Hayti, towards Cape Haytien on the west, and into Samaná and south of the bay east, is little less than 150 miles long, although, cutting off these prolongations, it forms a compact area of about 100 miles long by 30 miles wide, or say, in round numbers, about 3000 square miles. It abuts against and even overlaps the lower foot hills of the central chain, underlies the whole valley of the Yaqui and Yuna, makes up the entire northern or Monte Cristi range, and sends others along both sides of Samaná Bay. In the south it forms a little group of hills extending from near the Jaina River across the Nigua, and thins out in a few isolated patches towards the Nizao. Its total thickness in the vicinity of the Nigua River is about 400 feet, and it is made up of a succession of brown earthy and sandy beds, occasionally calcareous, superposed on a thin stratum of conglomerate. The top of the series is a rather compact calcareous deposit containing corals. The fossils, except the corals, are usually badly preserved and very meagre in species; a small oyster, two species of Pecten, and some echinoderms being the only recognizable forms. Besides these, a few internal casts of gasteropod shells have been discovered. The corals are so imbedded in their matrix that they can only be collected satisfactorily when they are weathered out, and this same process of weathering is only too apt to destroy the delicate structure of their surfaces. They are however nearly all of

* Quart. Jour. Geol. Soc. Lond. vol. IX. p. 116.

Dr. Dickson, of the U. S. Steamship Swatara, kindly presented me with two or three fossils, too imperfect for determination beyond the facts that they are new to me, and that they are evidently Tertiary. He brought them from Azua, but did not know their exact locality.

the massive forms, and are so thoroughly fossilized as to be well adapted for polishing.

But while the formation is so small in area and so unsatisfactory in general characters on the Santo Domingo side, it becomes, in the Cibao, the most interesting on the island. Cut through by all the tributaries of the Yaqui the sections are numerous and excellent for study. Its local modifications are well illustrated by sections innumerable, into and across the Monte Cristi range on one side, and into the southern hills on the other. In short, it would be difficult to find a region where the facilities furnished to the geologist are greater, or where the results could be more certainly arrived at. Add to this that a larger part of the formation is highly fossiliferous, and that the fossils, whether shells or corals, are almost always preserved entire and hard; as beautiful as the famous fossils of the Paris basin, or as the less known though equally beautiful specimens from Jackson, Mississippi.

The entire thickness of the formation in the Cibao is probably over 1500 and under 2000 feet. It is made up of coarse sandstones at the base, sometimes bearing beds of conglomerate, which are however rather local in extent. These beds are best developed between the Bao and the Yaqui, where, being uptilted, their thickness is best seen, and are about 600 feet thick. They gradually merge into gray shales, which form a transition to the heavy blue shale beds underlying the town of Santiago, and called by the English Palæontologists the Nivaje shale. The upper part of this member is always of a light yellowish brown or buff color and sometimes, especially at its upper part, contains beds of sandstone. The whole of this shale member may be safely estimated at about 800 feet of average thickness. The remainder of the formation, say 400 feet more in all, varies locally. It caps the greater part of the Monte Cristi range, and while, north of Moca it forms high bluffs of a nearly white earthy rock, in which it is doubtful whether the argillaceous or the calcareous ingredients preponderate, it forms north of Esperanza sheets of a compact limestone, which, less pure, forms the cap on the isolated table-mountain of Monte Cristi. Near Cevico it appears as an impure lime-rock containing corals and foraminifera, and similar beds occur also on Samaná and south of Savana la Mar; while the caves of San Lorenzo, in the same beds, are in a hard, coarse-grained, calcareous sandstone. Nor do the variations cease here. Near the mouths of the ancient Miocene rivers running from the then much smaller islands now constituting the Cibao Mountains, and among which the Mao was probably the largest, the gravel debris of these streams was deposited, occasionally alternating with a bed of coarse sandstone, synchronously with the formation of the coral reefs and beds of fine white mud which now glistens in the sun on the top of the Monte Cristi range. We have thus an ideal section as follows :

White calcareous marl, north of Moca ; white or light brown limestone ("Tufaceous limestone" of Heneken) ; light brown calc sandstone, San Lorenzo Bay ; gravels of Mao and Savaneta ; limestone of Samaná, San le Mar, Cevico and the north face of the Samba Hills ; oyster beds of Samba Hills, south of Guayubin.	400 FEET.
Brownish or yellowish shale of Guayubin ; conglomerate of Angostura of the Yaqui ; sandstone strata near Santiago ; dark blue shale of Santiago ; gray shale with beds of sandstone of Rio Verde and in the hills north of Moca.	800 FEET.
Coarse gray sandstone with some conglomerate ; seen best in the hills south and southeast of Santiago ; also in a few places in the north range.	600 FEET.

These three members are so intimately united that their separation is purely arbitrary. Beds of sandstone are found in the shale; and beds of shale extend far down into the lower member. Very few if any fossils have been found in the sandstone, though the gravels of Angostura yield shells abundantly, in connection with fragments of fossilized wood. The same species of fossils occur in all parts of the series, and I have collected from a bed of sandstone at the very summit of the Mao gravel a series of shells identical with those imbedded in the rocks of the "non-fossiliferous sandstone" plain* east of Guayubin, and which are found abundantly in the blue shale of the Gurabo, Amina or Verde.

* All the information previously possessed in regard to the Santo Domingo Tertiaries was derived from a Mr. T. S. Heneken, who sent to the Geological Society of London a valuable collection of fossils, which formed the basis of some excellent papers by J. Moore, Geo. B. Sowerly and Dr. Duncan. Unfortunately the notes accompanying the specimens were not so valuable as the collection, and for the reputation of their author had better have been omitted. It would be a thankless task for me to attempt to discuss in detail the paper (*Quart. Jour. Geol. Soc., vol.* 9, *p.* 115, *et seq.*), which is the most extraordinary tissue of incorrect observations and false deductions I have ever encountered. A reference to the sections accompanying this memoir will show that his "red sandstone" existed only in his imagination. It seems to have been made up of the heavy beds of Miocene sandstone south of Santiago, which however are gray, not red ; of the nearly horizonal beds of Mao gravel which cover the plains about Savaneta and perhaps also of the low-dipping strata of metamorphosed cretaceous conglomerate near San Jose de las Matas. At least I can find no better explanation after a two years' search. It is very certain that the strata forming the middle of the valley, given in his sections as "non-fossiliferous red sandstone, underlying the Tertiary," are usually high up in the series ; blue shales at Santiago, light-brown shales between Esperanza and Guayubin, and his "Tufaceous limestone" at some points south of the river !

Fossils are not regularly distributed either vertically or laterally, but seen to occur in colonies. The blue shale bluff under the city of Santiago, sixty feet high from the level of the river, does not show a single streak where they are ever abundant enough to repay the trouble of hunting, although isolated shells occur throughout. At Puñal but a few miles off near the Rio Verde shells and corals abound. The same irregularity exists throughout, and although there is but little change in the species of the mollusca in their vertical range, there is a marked difference between the eastern and western ends of the basin. Shells that are absent or scarce on the Verde are common on the Gurato and westward, and *vice versa*. The corals found in the shale are almost always of the *cup* forms, while the massive corals are almost exclusively confined to the upper beds and are particularly abundant on the north flanks of the Samba hills. In all the shale beds and to the extreme top of the series foraminifera occur, and in some places are found in great numbers. They are not very numerous in species, probably not exceeding half a dozen. The *Orbitoides* ranges throughout all the strata and is not only found wherever any other fossil occurs but is often, especially in the higher beds the only recognizable organic remains. It has more than once proven of great value to me in distinguishing these limestones from the overlying Post Pliocene calcareous beds.

With one or two small exceptions all these rocks are entirely unaltered. On the southern limit in contact, or nearly so with the underlying cretaceous in the vicinity of the Bao River and on the Yaqui, the coarse sandstones are slightly modified, though still retaining their stratification and mechanical structure unchanged. On the Yaqui at Tabera this rock is highly uptilted and slightly contorted as will be seen by reference to the description of the locality. Also in the northern range a similar slight metamorphism occurs southeast of Puerto Plata.

The geological age of the West Indian Tertiaries has been so thoroughly and ably discussed, and by such competent authorities that it might seem unnecessary for me to reopen the subject. J. C. Moore,* Geo. B. Sowerly,† Dr. P. M. Duncan,‡ R. J. L. Guppy,§ Robert Etheridge,‖ and Sir Robert Schomburgk,¶ have all contributed to the general fund of our knowledge, and have unanimously agreed in placing the

* Quart. Jour. Geol. Soc., Vol. IX., p. 129, and previously in 1850, *loc. cit.*, p. 39.

† *Loc. cit.*, p. 44, *et seq.*

‡ Quart. Jour., Vol. XIX., p. 406, and Vol. XX., p. 20.

§ *Id.*, Vol. XXII., p. 281, *et seq.*

‖ Geological Survey Report, Trinidad, App. J., p. 161, and Geological Survey Report, Jamaica, App. V., p. 311.

¶ Hist. of Barbadoes, p. 531, *et seq.* See also Nelson in the Bermudas; Trans. Geol. Soc., 2 Ser., Vol. V., part 1, p. 103; and on the Bahamas, Quart. Jour. Geol. Soc., Vol. IX., p. 200.

greater part of the fossiliferous strata, including all the Santo Domingo beds in the Miocene Tertiary.

Shortly after the appearance of the joint paper by Moore and Sowerby, Mr. Conrad published a short note,* having more particular reference to the Vicksburg deposit in Mississippi, asserting that he found an "analogy," and even adding "whether all the forms in this group in St. Domingo are *synchronous* remains to be proved, but the probability is that they are." He claimed to have identified three species as occurring in the two regions; his determinations being based on Sowerby's figures. My own camparison of specimens completely disproves even this. There is not more than the ordinary generic resemblance. But I have found a single species in common—his *Ficus Mississippiensis.* Even were there a dozen it would be poor proof of synchronism. He explained the small number of common species by the geographical dissimilarity.

But still later he repeats the assertion of the Eocene ("Oligocene") age of the Santo Domingo beds in such a categorical manner as to demand an equally pointed refutation,† the more especially since Mr. Conrad is the oldest and best informed of the authorities on the American Tertiaries.

In view of this expression of opinion being so evidently only a mere guess, I should have disregarded it and have quietly acquiesced in the opinions of my predecessors were it not for the numerical richness of the collections I have been able to make, and which have doubled the number of species known to exist in the Dominican, if not in the West Indian Tertiaries.

In 1849 Mr. Heneken sent his first installment of fossils to London consisting of "fishes' teeth, a crab, 84 species of Mollusca, an echinoderm, 18 species of coral, numerous foraminifera, dicotyledinous wood." The mollusca on being critically examined by Messrs. Moore and Sowerby, and compared with recent and fossil species, gave 13 living species, 2 doubtful, and the remainder extinct; or a percentage of 17 to 19 with a greater resemblance to the European than to the North American Miocene. The other remains also corroborated this result at the same time. "Mr. Sowerby was much struck with the resemblance of many of the shells to recent species inhabiting the seas of China, Australia and even the western coast of America." In 1853 Mr. Henecken added another collection to the first which raised the number of known species to 163 mollusca, of which 127 were gasteropods, and 36 bivalves.

* Proc. Phil. Acad. 1852, p. 198.

† See Smithsonian Check List, Eocene and Oligocene fossils of N. A. (Sm. Misc. Collection, No. 200), p. 37, where he simply says: "The Oligocene has been found in St. Domingo, &c."

This collection confirmed the results derived from the previous one, except that the percentage of living species was reduced to 8 or 9 per cent. according to Mr. Moore, who sums up the results as follows:

"1st. These beds contain Mollusca of which from 8 to 9 per cent. are now living.

"2d. The recent species are principally living in the adjoining seas.

"3d. Many bear a strong resemblance to shells now living in the Indian seas and the Pacific, and one or two appear to be identical.

"4th. None are identical with American fossil shells, except two, both of which are also recent.

"5th. The fossils which present the nearest analogies as a group are those of Malta and Bordeaux in Europe, and the Upper Eocene beds of South Carolina."

In Trinidad the collections were made incidentally and apparently with little care. On being submitted to Mr. Robert Etheridge, the able Palæontologist of the British Surveys, that gentleman found 8 species of corals, 1 echinoderm, 2 annelids, 3 cirrhipedes, 2 crustacea, 64 mollusca (38 gasteropods, 25 bivalves, and 1 polyzoon) and 3 fishes. Of these, 15 species are in common with the formation in Jamaica. It is to be regretted that Mr. Etheridge did not make out a specific as well as a generic determination, as a comparison with the Dominican series would have been instructive and interesting. He says of the "Newer Parien" which includes the above "Caroni Series;" "the fossil remains of this deposit resemble those of the Falunien or Miocene age."

In 1866 Mr. R. J. L. Guppy published a valuable paper on the Miocene fossils of Jamaica,* in which he describes 61 species, many of them previously unknown. My collections show that of the 61 species, all but 4 are also found in Santo Domingo.† Mr. Guppy acquiesces in the general results arrived at by Mr. Moore, but differs from his fourth proposition so far as to identify the *Petaloconchus*, with Lea's species, *sculpturatus*. He says "among the new facts brought to light is the very remarkable resemblance of a portion of the West Indian Miocene fauna to that of the Maltese beds." A resemblance which however had been noticed before by Moore. His most important generalization is a provisional classification of the Caribbean Tertiaries. "From my examination of the Jamaica fossils I am of opinion that with the middle

* Quart. Jour. Geol. Soc., Vol. XXII. p. 281.

† I have not yet found Cyclostoma bicarinata, Neritina Woodwardi, Venus Woodwardi, nor Cardium inconspicuum.

Tertiary beds of Santo Domingo and Cuba, those of Cumana (Venezuela), and the Caroni series in Trinidad, the Miocene of Jamaica is to be considered as representing the upper or later part of the West Indian Miocene as at present known; while the chert formation in Antigua, the Anguilla beds, and the beds exposed at San Fernando in Trinidad belong to the lower or oldest part of the Miocene." Or as tabulated by Etheridge* it stands thus:—

"Middle Tertiary Series	of	St. Domingo	Later or Upper Miocene.
" "	"	Cuba	
" "	"	Cumana	
Caroni	"	Trinidad	
Miocene	"	Jamaica	
Chert formation of Antigua			Older or Lower Miocene."
Anguilla beds			
San Fernando beds, Trinidad			

"Not," as Mr. Guppy observes, "that these divisions should be received as being absolutely equivalent to the lower and upper Miocene of Europe, but merely as marking what seems to be the relative antiquity of the Middle Tertiary or Miocenes of the Western or Caribbean area;" and "the connection between the formations found in all the localities mentioned could only be shown by a general table, including all the known species from those localities."

The next author who wrote on the subject was Dr. Duncan, in the 21st and 22d volume of the Geological Society's Journal. Beyond the mere describing of species, his results are mainly valuable in confirming the middle Tertiary age of the formation, and in corroborating the synchronism of the various deposits.

For the Geological Survey report of Jamaica (1869), Mr. Etheridge contributed an article (Appendix V.) by far the most elaborate and valuable contribution yet made, to our knowledge, of the subject in question. He availed himself fully of all the information accumulated by his predecessors, and appended a table of the distribution of all the known fossils of the Caribbean area, and their correlation with those of Europe. Exclusive of crustaceans, radiates, etc., this list contains the names of 152 species of Mollusca and exhibits their geographical range and geological position at a glance. The Santo Domingo beds have yielded us more than twice that number, and, practically, all that have been found in Jamaica, thereby establishing beyond controversy the identity of the formation in these two islands at least. The present collections have so materially changed the correlation between the fossil and living faunæ that it is necessary to do the greater part of the work over again. With the object of showing these relations in as intelligible a form as possible, I have prepared the following table.

* Jamaica Report, p. 312.

GENERA.	No. of Extinct Species.	LIVING. West Indies.	LIVING. Panama Province.	LIVING. Elsewhere.
Diacria	1			
Balantium	1			
Styliola	1			
Planorbella	1			
Atlanta	2			
Murex	4	1	1	
Trophon	1			
Muricidea	3			
Typhis	2			
Fusus	2			
Hemifusus	1			
Melongena				Everywhere 1.
Metula	1			
Metulella	2			
Turris	14	1	1	
Glyphostoma	1			
Cordiera	2			
Borsonia	1			
Mangelia	4			
Tritonium	1	2	1	
Distortio	1			
Bursa		1		
Phos	3		1	
Nassaria	1			
Ectracheliza	1			
Cyclops	2			
Cuma			1	
Harpa				1 W. C., Africa.
Oliva	4	1		1 ? Pacific.
Plochelæa	1			
Fasciolaria	2			(1 ? West Indies.
Latirus	4	1		
Turbinella	1	1		
Vasum	3			
Lagena	1			
Scapha	1			
Lyria	1			
Mitra	6			
Marginella	2	1		
Strombina	6			
Cassis	1			
Cassidaria	1			
Cypræcassis		1		
Cassidea		1		
Morum	1			
Malea			1	
Ficus		1	1?	
Natica		2		
Mammilla		1		
Amaura	1			
Scalaria	2			1 North America.
Terebra	2		1	1 " "
Obeliscus	1	1		
Ringicula				
Turbonilla	4			
Auriculina	1			
Aclis	1			
Eulima	3			
Menestho	1			
Niso	2			
Iopsis	1			
Architectonica	1			

GENERA.	No. of Extinct Species.	LIVING. West Indies.	LIVING. Panama Province.	LIVING. Elsewhere.
Torinia	1			
Conus	9	3	1	1 loc. ? 1 Miocene Europe.
Strombus		3		
Orthaulax	1			
Dolophanes	1			
Cypræa	3			1 Pacific. 1 Atlantic and Pacific.
Pustularia				1 Pacific.
Cancellaria	3	1	2	
Cerithium	17			
Cerithidea	1			
Triforis				1 U. S.
Bittium	3			
Modulus			1	
Turritella	2	1		
Vermetus		1		
Petaloconchus				1 fossil U. S.
Cæcum	2			
Onustus	1			
Phorus		1		
Crucibulum			1	
Trochita	?			
Cypta		1		
Capulus	1			
Neritina		1		
Eutropia	1			
Turbo	1			
Astralium		1		
Cyclostrema	2			
Adeorbis	1			
Umbonium	1			
Calliostoma	1			
Omphalius			1	
Margarita	1			
Lucapina				1 U. S.
Dentalium	5			
Gadus?		1		
Scurria			1	
Nacella	?			
Actæon		2		1 also fossil in England.
Actæonidea	1			
Cylichna		1		
Cylichnella		1		
Tomatina		1		
Volvula	1			
Bulla	2			
Martesia	?			
Kuphus	1			
Rocellaria		?		
Siliqua	1			
Bothrocorbula	1			
Corbula	2	2		
Neæromya	1			
Neæra		2		
Pandora	1			
Mactrella			1	
Raeta				1 U. S.
Tellina	1	1 2	=1	1 N. A. 1 S. A.
Strigilla				
Tellidora			1	

		LIVING.					LIVING.		
GENERA.	No. of Extinct Series.	West Indies.	Panama Province.	Elsewhere.	GENERA.	No. of Extinct Series.	West Indies.	Panama Province.	Elsewhere.
Donax	1				Lithophagus	1	1		
Venus				1 Pacific.	Avicula				1 Brazil.
Chione	1	2			Arca	3	2		
Callista	2				Axinæa	2	1	1	
Caryatis	2				Limopsis	1			
Cyclina	1				Nucula	2			
Cardium	3	1			Leda	1			
Chama		2			Yoldia	1			
Lucina	1	5		1 of W. I. fossil in	Pecten	6	1		1 Europe.
Loripes	1			U. S. Miocene.	Janira	1			
Mysia	2				Pleuronectes	1			
Erycina	1				Spondylus	1	1		
Gouldia		1			Plicatula		1		
Crassatella		1			Anomia		1		
Cardita	1				Ostrea	1	2		
Crenella		1							

It is but just to myself to add here that all of this memoir except the Palæontology, was written in Santo Domingo, and that this table, the last part prepared of all, has surprised me with the very unexpected results it offers. According to the rule proposed by Lyell, I should pronounce the fossils Pliocene. But the presence of several antique types among the genera disinclines me to the step. With two hundred and seventeen supposed extinct species and ninety-seven known to be living, the only change that can take place in our proportion is the transfer of some of the former to the latter category. Many of the new species are minute, and they may yet be discovered living. Should such detailed examinations of the coast of Santo Domingo ever be made as that in Cuba, of which we have the results in La Sagras' fine work, doubtless many of our small fossils would be discovered. On the other hand, students less conservative than I have endeavored to be, may find real or fancied specific differences between the fossils and the recent species with which I have associated them, thereby modifying the proportion in the opposite direction. But in either case, the change cannot be a large one. We will always have about 30 to 33 per cent. of living forms. Lyell fixes from 35 to 50 per cent. as the proportion of the Pliocene, and says of the standard Miocene:—that of the Loire and Gironde contains but 17 per cent. We are therefore at or near the top of the Miocene. I do not yet know how far a study of the fossil-radiates of the collection would influence these results, but, numerically, they are comparatively unimportant.

I have not thought it necessary to repeat the tabulation of the distribution of fossils among the various islands. Except that I would include nearly all the known species of Jamaica, as stated above, and a few of the later-described species of Trinidad, there would be nothing to add to the table of Etheridge and Guppy. The most striking feature of the above table is the large number of species it contains which have survived from the Miocene seas, only on the west coast of the Continent. Another feature which it does *not* show is that already noted by Sowerby, of the marked Oriental type of many of the extinct species. The resemblance between many of them, like *Metula cancellata*, *Onustus imperforatus*, *Lyria pulchella*, and others, to their congeners in the Eastern seas is at least very suggestive.

So much has been said about the coal of Santo Domingo that it is necessary to refer to it more explicitly than circumstances would otherwise warrant. Throughout the country, wherever the upper parts of Miocene are found, there are small beds of an exceedingly impure lignite. It occurs in the brown shales at a number of points along the Cibao Valley, at Garabitos near San Cristobal, and on the peninsula of Samana and in the Mao gravel near Savaneta. In no case do the seams exceed three or four inches, and in no case is the material more than an imperfect lignite, earthy and crumbling readily on exposure to the air. In a country like Santo Domingo, where the demand for fuel is so limited and the supply so extensive, a coal must be of extraordinarily good quality to warrant mining. In that case it might be made available for sea-going vessels or for export. It could never be much in request for home consumption, and unless sufficiently good for export it is necessarily valueless.

CHAPTER VII.

POST PLIOCENE, OR COAST FORMATION.

A large proportion of the coast is fringed by a formation much more modern than the preceding, usually as a narrow strip, though in some places extending back several leagues. West of Azua only does it run into the interior, covering in this case at least a part, possibly the whole of the San Juan Valley, and not improbably a portion of the valley of the lakes. This, which may be called the coast formation, consists of limestones, the debris of old coral reefs, shore gravels brought to the coast by rivers still existing, beds of conglomerate resulting from the solidification of the last member, and lastly, argillaceous and sandy beds having the same origin but owing their finer texture to the greater distance from their primary source.

Along the whole north coast the formation is represented exclusively by the limestone, usually horizontal, though occasionally having a very low seaward dip. This inclination is most marked east of Puerto Plata, and especially about Cabarete where reefs and shoals run out many hundreds of feet, striking parallel with the general trend of the coast and dipping at angles often not higher than 5°, and rarely as high as 10°. At the eastern end of Samaná, at Puerto Frances, there is a little horizontal patch raised but a few feet above the sea level and bearing the brunt of the Atlantic waves. It is honey-combed, caverned and worn into points and pinnacles so sharp that it is difficult to walk on the parts left bare by the waters. At one or two points on the northern coast of the same peninsula, as for instance at point Cabron, the blue Cretaceous limestone is broken down into angular fragments, such as would fall from the face of a cliff, and are recemented by a stalactitic cement of this formation usually of a pinkish color, making a pretty contrast. In the same vicinity wherever this breccia does not occur the whole rock is more or less of the same color, although on the southeast coast between Puerto Frances and Cape Balandra it forms bluffs inland of a nearly pure white rock.

Beginning at the end of the hills of the central chain where they reach the east coast, the same limestone commences again and borders the entire southeast coast of the Island to a point between the Nigua and Nizao Rivers. Here it is so nearly horizontal that no perceptible dip occurs. The whole mass seems to have been elevated bodily. No foldings or even undulations can be detected. The lithological character is also exceedingly constant. The rock is evidently the bottom of a coral sea. It contains a few corals, almost always of the massive forms, though these are not generally disseminated, but occur rather in spots on the sites perhaps of pieces of ancient reef. Occasionally in these collections a branching species may be found, but the small solitary forms are almost unknown. Again, a mass of madrepore is sometimes seen inbedded in the matrix and isolated from all companions. But the great bulk of the rock is a very soft light cream-colored chalky material, the comminuted debris of coral, &c., such as is forming at the present day among the coral reefs of the Bahamas and Bermudas.* The local name of this material in Santo Domingo is "Caliche." It has the peculiarity that it hardens on exposure to the atmosphere, though not always to the same extent. Usually in natural exposure this hardening takes place to a depth of from two to four feet, though often the crust is not more than a foot thick. The indurated portion is sufficiently solid for building purposes, although it is almost invariably penetrated in all directions by small cavities, caused partly by the decay of the enclosed fossils. In some cases this shell is so tough that the pick hardly makes an impression on it, and it is necessary to use powder in quarrying it. It makes an excellent lime and is burnt in kilns of about three hundred barrels capacity, the loose surface blocks being preferred for the purpose, the softer material not having sufficient consistency for the kiln. Almost the entire city of Santo Domingo is built of this rock, and buildings of three centuries old attest alike the durability of both the stone and the mortar.

The soft "caliche" hardens rapidly on exposure and although as soft as clay when quarried makes an excellent road material. It makes a hard, smooth road, not wearing easily into ruts, but liable to be cut by running water. Even the harder material soon grinds down under wheel and hoof to an uniform surface, whose only objection is that its nearly white color is too dazzling to be pleasant to the eye, though it is not so bad as the painfully brilliant glare of the streets of Nassau, where at mid-day "only strangers and dogs are to be seen in the street."

The origin of this rock is at least in part sufficiently obvious. The whole deposit seems to be homogeneous. No signs of stratification or differences in degrees of hardness being perceptible below the above-mentioned crust. There can be no question but what the greater part is derived from the corals and the few shells which lived, died, and decayed on the spot. Nelson after several years of investigation in the Bermudas, arrived at this result, attributing the origin of the Bermuda "chalk" entirely to this cause.†

* See Nelson, Quart. Jour. Geol. Society, Vol. IX., p. 207, 208, also Trans. Geol. Soc., Vol. 5, part 1, p. 104 & 105.

† Trans. Geol. Soc., Vol. 5, part 1, p. 114, * * *. "But from all that I have seen during different examinations of decomposing zoophytes and shells * * *, I have no more hesitation in attributing the existence of the Bermuda chalk to such a source than I have for asserting that the obvious material of the Bermuda stone is derived from the same origin; with, however, this difference that in the latter instance the fragments are the result of mechanical subdivision, while in the former the elementary particles are due to the decay by long submersion of the membranous tissue, which pervading their whole structure, releases the constituent calcareous matter dispersed through the texture, when it is ruined by decomposition."

I am not willing to go to so great a length as that author in believing that the decay of the animal tissues whether of corals or shells, is the principal means of their destruction and the consequent formation of the semi-pulverulent rock derived from them. His Bermuda "chalk" is a small local deposit compared with the greater mass of "Bermuda Stone," which from his description corresponds in character with the rock making up the Bahama group and the Dominican coast limestone. Later the same author, then Captain, now Major-General Nelson, R. E., in his memoir on the Bahamas* suggested additional sources for the material, but he does not in my opinion lay enough stress on what must have been the main cause, the triturating effects of wave-action aided doubtless, but not replaced by the various means that he suggests.

It is a misnomer to call this material "chalk." True chalk whether derived from the English cliffs or elsewhere, is microscopically considered composed of *hollow* grains. "It is made by accumulations of Rhizopod shells, and not of coral or shell sand."† The West Indian rock *is* coral and shell sand, and is composed wholly, or nearly so of amorphous *solid* grains. In external characters to the naked eye it certainly resembles some varieties of chalk. Its nearly white color, softness, absence of "grit," and its chemical constitution ally it closely to that mineral while its origin and microscopic structure separate it. In view therefore of this difference and since no name has ever been suggested to distinguish it, I suggest that of Antillite.

As intimated above the "coast limestone" (our new Antillite) was formed as a fringing reef at a considerable distance from the then coast line. This is beautifully illustrated on the south side of the island, but more particularly in the region lying north and northwest of Santo Domingo City. The mouth of the Jaina River was then at what is now the base of the higher hills at the back margin of the low-rolling savanas. This stream as well as its neighbor the Isabella now a branch of the Ozama, brought down great quantities of gravel and even large boulders, which were of course deposited immediately along the coast and formed a gravelly beach. The gravel was carried out to a distance of several miles from the mouths of the rivers and made a sea-bottom of sand with pebbles, constantly diminishing in size as the distance from their source increased. The current evidently came from the west and carried this debris eastward along the ancient coast, so that the deposit extends from each old river mouth in a marked manner in that direction. The then insignificant

* Quart. Jour. Geol. Soc., Vol. IX., pp. 208, 212. "This calcareous mud is derived not merely from the comminution and decomposition of corallines and corals, and from the exuviæ of Foraminifera, Mollusca, Echinoderms, Crustaceans, &c., but also from the fæcal *ejectamenta* of Echinoderms, Conchs and Coral-eating Fish (*Scari, &c*)."

† Dana, Manual of Geol., p. 753.

stream the Nigua produced but little effect, and judging from the absence of gravel in its vicinity must have been even more unimportant than one might have inferred. The Nizao brought down its quota which is distributed as far east as the Miocene hills of San Cristobal. But still more marked is the immense sheet of gravel, a hundred feet thick, and with boulders of half a ton furnished by the Southern Yaqui, and which covers all the plain on which Azua is built, and aided by contributions from the Ocoa which extends eastward along the coast, almost to the Nizao. East of the Isabella the hills suddenly retire to the northward and the larger rivers like the Ozama and Macoris run almost entirely in the plain, so that at that period only their upper branches existed; streams too unimportant to produce a marked effect in the formation or modification of the sea-bottom.

But to return to the Jaina as an exemplification of the whole. The gravels are spread over the low-rolling hills and the plains of the Porto Rico and Sta. Rosa savanas, every pebble telling its own story of its origin,—the beds, except in the presence of a larger proportion of sand, being a repetition of the river bars of their parent stream. But as the distance from the ancient coast increases the pebbles become scarcer and smaller and the finer portions more abundant, until in the Savana la Venta the beds are almost entirely sand and clay with a few straggling pebbles, such as might have been transported by floating roots, &c. And here a new element begins to come in. In the Venta the deposit begins to exhibit a distinct calcareous character. This increases, and within the distance of a mile or too the sand and clay strata are entirely replaced by the deeper water deposit of the coral reefs. But in going eastward it will be seen that the current carried along with it the finer particles of the river debris and spread it like a ribbon, parallel with the old coast line, receiving trifling contributions from the smaller streams until the supply became exhausted, and then the coral deposits approached the coast until they came in contact east of Higuey. It is not necessary to suppose that the limestones were deposited in very deep water, the presence of considerable quantities of fresh water from the rivers with the accompanying mud would account fully for the absence of corals near the coast. Besides the presence in two or three spots of abundance of shells of *Ostrea*, *Lucina* and of *Veneridæ*, and the additional fact that casts of *Strombus* are nowhere rare, indicate that at least a part of the rock must have been deposited in comparatively shallow water, probably as an encircling reef similar to those existing around the eastern end of the present island and elsewhere. Lyell* devotes several pages to the discussion of the theory of coral reefs and atolls, and quotes the objection of Mr. Maclaren that no reefs have ever been elevated above the surface of the sea. That gentleman

* Principles of Geology, 9th Ed., p. 793, *et seq.*

says: "Nor in the West Indies, nor in any other region yet explored, has a bed or formation of coral even five hundred feet thick been discovered so far as we know." Although the coast limestone of Santo Domingo does not reach even half the specified thickness, it is not less a refutation of the objection and a proof of Darwin's theory of barrier reefs.

The change from gravel through sand and clay beds to this chalky rock in the Jaina country is repeated in all of its details in the vicinity of Azua. The gravels of the Southern Yaqui form high hills at las Lagunas on the Constanza trail above the mouth of the Rio de las Cuevas, spread over the plain and extend eastward to the Ocoa River. But as soon as a sufficient distance from the old shore was attained, to allow the current to carry off the mud and fresh water to the eastward, the barrier reef rose to the surface, and its remains exist as a horizontal structure of white earthy limestone, almost entirely non-fossiliferous, and hardening, on exposure to the air, to a rock which breaks with a conchoidal fracture. In this condition it forms the great southern peninsula and the little neighboring Island of Beata.

The little Peninsula of Samaná is a complete epitome of the geology of the whole island. Except the syenitic intrusions it exhibits every phenomenon discovered and every formation that exists on the main land.

The same change from gravel to limestone described above occurs on the southern coast from the vicinity of Santa Barbara to the eastward. About the port of Santa Barbara, and especially for a mile or two west the coast hill and the little islands adjoining, are made up of horizontal beds of a coarse gravel with pebbles and even boulders of the metamorphic rocks of the interior. In fact these beds are a perfect index to the geology of the Peninsula. The gravel deposit extends but a mile or two east and west, and penetrates inland to a very inconsiderable distance. But, as has been before stated at Puerto Frances, we again find the coast limestone.

The coast formation, although it covers such a wide area equal to if not greater than the underlying Miocene, is nowhere very thick. From the fact that it is everywhere horizontal, it is somewhat difficult to arrive at an accurate estimate of its thickness. Nowhere along the coast is its base visible, and a vertical measurement inland must necessarily be unfair since it must be made on the thinning out shore-margins of the deposit. Even where it is most elevated above the sea-level a fair measurement cannot be obtained for this reason. At Santo Domingo City the bluff is about 40 feet high, and the wells in the city average 50 feet deep. They consequently reach the level of the sea but do not reach the base of the formation. Further back where the surface rises in a series of terraces, the wells still reach the same level before yielding water, but in no case is the underlying rock reached. My well two miles northwest of the city, has a depth of 158 feet, and one on the farm of President Baez, distant perhaps a fourth of a mile is a dozen feet deeper, a difference due to undulations in the surface of the ground. Near the mouth of the Rio de las Cuevas northwest of Azua, where the gravel is seen lying on the upturned edges of the Cretaceous shales, clean sections of about one hundred feet can be seen; and in Samana the gravel hills are all of two hundred feet high. It may therefore be safely assumed that an average thickness for the whole deposit is not far from two hundred feet, and in the limestone it may be even greater.

The peculiarity exhibited by all of the wells in the coast limestone that at whatever elevation begun or wherever placed with reference to the coast, their bottoms must always reach approximately the same level before reaching water, recalls forcibly a similar circumstance noted by Nelson in the Bermudas and Bahamas in the same formation.* That author explains that in those islands the calcareous rock is permeated by sea water, and that the surface waters float above the dense salt water, which is distinctly affected by the tides. In Santo Domingo although the wells all reach tide level, it does not appear that the sea water penetrates to any distance inland, and although the wells nearest the coast are usually more or less brackish, it seems that the sea acts only as a dam preventing the complete drainage which takes place at higher levels. It is at least certain that the tides do not affect the wells here, and even that at the house of General Cazneau, within a hundred yards of the sea, shows no signs of their influence.

Almost wherever it occurs the coast limestone is covered by a peculiar red soil, neither very deep nor remarkably fertile though aided by the moisture of the trade winds and the constant warmth of the tropics, it supports a dense forest vegetation. This is without doubt derived from the underlying rocks and is clearly the result of their decomposition. No further proof of this proposition is required than the fact that at least in the Provinces of Santo Domingo and Seybo, that is to say, on the whole south coast east of the Nizao River, the red soil and the limestone are exactly coextensive. I dwell on this fact because Nelson notices the existence of a "red earth" in the Bermudas, as making the ordinary soil of the islands,† and again in his account of the Bahamas not only refers to it, but advances the theory that it originates as a sort of guano.‡ I infer from the remark quoted in the subjoined note

* Trans. Geol. Soc., Vol. 5, p. 120, and Quar. Jour. Geol. Soc., Vol. IX., p. 205.

† *Loc cit.*, p. 105 and Bahama Memoir, p. 208.

‡ In speaking of a "red earth" from a cave in the Bahamas, on microscopic examination it "appeared as a mass of insect remains, the *rejectamenta* of bats living in these caverns. Specimens of the earth from another part of the same cave, however, were so much altered in character that they resembled the Bermuda "red earth," and afforded a complete clue to the characters of this substance."

that the author considers all of the red soil of the Bermudas, the "five strata of Ireland" island in the Bahamas, equally with this cave-soil, to be a guano deposit. If these "earths" are similar to the red earth of the Dominican coast limestones his theory is certainly false.

In Trinidad the "Newer Parian" rocks, the "Nariva Series," probably the equivalent more or less of the formation under consideration, are said to be "composed of stiff ferruginous clays with occasional limestones, constituting an undulating, almost even surface, and affording soils of a more or less red color."* In Jamaica the "white limestone" yields a soil identical with the Dominican, and the description given by the colonial geologist would apply equally well to this island,† except that the "honey-combed" character is not so marked here as the description would seem to imply in Jamaica. In Santo Domingo there are large tracts where not a single stone is visible through the soil, and again there are regions where the soil only fills a few crevices among the projecting points and ridges of the underlying limestone.

The underlying rock and consequent soil produce a marked effect on the vegetation.‡ This is further modified by the access or deficiency of moisture in the air, so as to produce a difference between the rainy and the nearly rainless ends of the Island. But where the amount of moisture is the same on the plains of Seybo, for instance, the limestone of the coast carries dense forests of tall trees with tangled undergrowths of bushes and vines, while the sands and gravels nearer the hills are clothed only with grass.

There can be but little doubt as to the geological age of the coast formation. It lies unconformably on the Miocene and consequently must be either Pliocene or later. Its fossils are in a miserable state of preservation, but a single locality yielding mollusca in a recognizable state. In some localities internal casts are not rare, but while a few can be detected like the *Lucinas* by their well known form, or like the giant *Strombus* by their size, the majority are entirely unrecognizable. Their only value is to prove that many species existed, all identifiable traces of which are now lost.

* Trinidad Report, p. 74.

† Jamaica Report, p. 22. "The white limestone formation seems to originate two descriptions of alluvia—one white, resembling a chalky marl; the other red, free from carbonate of lime, the color being due to oxide of iron combined with the argillaceous residue of the pre-existing limestone. This formation seems particularly susceptible of disintegration and removal, which is due to the solvent action of the rain-water under the high temperature of this climate, and being probably also charged with free carbonic acid. The surface of the rock is thus worn into holes which become larger with each successive shower, resulting in the well-known 'honey-combed' appearance which renders the rock so difficult to traverse." "The red variety of soil is so distinctive as to have originated the appellation for the surface in several localities, as the 'Red Hills' in St. Andrew's, &c."

‡ See a note by myself, Amer. Jour. of Science, 1871, p. 127.

Between the Nigua and Nizao where the Azua gravel shades into the calcareous beds, there is a small deposit of a recent Oyster, and near Macoris at the mouth of the river of the same name, Mr. Bonaczy collected a series of thirty-three species of mollusca, besides corals and echinoderms. A list of these fossils is appended.

I use Lyell's names for the divisions of the Tertiary as has been already very aptly said by Mr. Guppy, not as implying that the various formations are exactly synchronous with the Miocene, Pliocene, or Post Pliocene of Europe, or even of the United States, but that they bear a relation among themselves similar to that borne by those divisions in Europe and North America, and that they approximate more or less nearly to those divisions in point of time.

The coast formation of Santo Domingo is extensively represented in most if not all of the other West Indian Islands. In Jamaica as the "white limestone" it "covers more than three-fourths of the island, and may be computed at 2,000 feet in thickness."*

It was at first considered by Mr. Sawkins as Miocene, but in the section at the end of the book it is put down as Post Pliocene.† It makes all of the Bahamas as well as the Bermudas. It exists in Trinidad as the "upper part of the Newer Parian series," covering (if we include under this title only the "Moruga series") about a fourth of the island. But the colonial geologists do not seem to be very certain whether "the different series of the Newer Parian," "were deposited each during a special epoch" or whether two or more members were not being "deposited in distinct localities at the same period."‡ In the latter case a much larger area is occupied by the formation. Schomburgk devotes a dozen pages to a description of this formation in Barbadoes,§ whence from amidst some remarkable theories, we can gather that about six-sevenths of the area of that island is covered by it. We have no geological accounts of the other islands except Antigua, and my own experience is not very extensive. I have seen no recent formation on St. Thomas, although I only know the immediate vicinity of the port. It is probable that the rock "containing *Nerineas*, &c." (Cretaceous?) at or near the east end is the most modern deposit. Doubtless between St. Thomas and Trinidad there is much coral rock, the more especially since we know the great part that the late Tertiaries play in the latter island and in Barbadoes. Dr. Nugent‖ published an account of Antigua which is quoted by Dr. Duncan.¶ From the description given of the "marl" and from Dr. Duncan's tables of the fossils of the different beds,** it seems probable that this marl belongs to the

* Jamaica Report, p. 307.
† *Loc cit.*, pp. 23 and 341.
‡ Trinidad Report, p. 59.
§ Hist. of Barbadoes, p. 534, *et seq.*
‖ Trans. Geol. Soc. Lond., 1st Ser., Vol. 5, p. 459.
¶ Quart. Jour. Geol. Soc., Vol. XIX., p. 408, *et seq.*
** *Loc cit.*, pp. 410 and 411.

group in question. A strong argument against this opinion is that, although but one of the included corals is common to this and the underlying chert beds, "in Antigua there is not one West Indian recent species."* Dr. Duncan considers the entire fossiliferous deposit of Antigua, Miocene.† By a series of careful cross-questioning of non-scientific persons who are familiar with Porto Rico, and from some few observations which I have been enabled to make, I have reason to believe that a large part of that island is Post Pliocene, and I have observed extensive bluffs on the east end of the Island of Cuba, especially on the south coast identical in appearance with the bluffs about Santo Domingo City. A large part of the Peninsula of Florida is known to be of very recent origin, and the meagre accounts we possess of Yucatan with its level plains of limestone rock seem to point to a similarity with parts of Jamaica and Santo Domingo.

Parts of the south coast of Santo Domingo east of the Jaina, and more especially the extreme southeast corner, exhibit proofs of irregularity in the process of upheaval in a series of well-marked terraces. At Santo Domingo City the terraces acquire a total height of about one hundred and fifty feet, one traversing the suburbs in the village of San Carlos, the other lying just back of the town. Looking eastward from the city one terrace can be distinctly seen running along the coast. This extends uninterruptedly to the Quiabon River, beyond which are three terraces, one behind the other on the broad little peninsula which runs down towards Saona Island. A similar terracing of the surface is noted by Schomburgk in Barbados,‡ which doubtless took place at the same time; and the geologists of Trinidad§ note comparatively recent raised beaches and other proofs that the elevating action is still going on. A geologist cannot sail among the little islands of the Bahaman group, without being forcibly struck by the idea that these islets are the remains of much larger bodies of land, which once probably covered a large part of the "banks," and that they have been separated and wasted away by the lateral encroachments of the waves. There is no evident reason for the theory that has been advanced, that they are the remaining hill-tops of a sinking land. Their horizontal stratification, their flat surfaces, their precipitous coast bluffs and the extreme shallowness of the water between many of them all point to a broad, gentle upheaval and wave-action as the principal agencies which have been at work among them.

* Quart. Jour. Geol. Soc., *loc cit.*, p. 454.

† Same paragraph.

‡ Hist. of Barbadoes, p. 554, *et seq.*

§ Report, p. 66.

PART III.

LOCAL GEOLOGY.

CHAPTER VIII.

GEOLOGY OF THE CENTRAL MOUNTAIN CHAIN.

It is hardly necessary to say anything more about the physical features of the great central chain. A reference to the first chapter, aided by the map, will give the reader all the details necessary to a clear understanding of the following description of its geology. Covering a length of at least 200 miles, with an average width of not less than 30 miles, its area may be roughly estimated at a little over 6,000 square miles, or practically a third of the Republic. Including the spurs running down towards the coast near Bani, the actual area is really greater than the above estimate, which is near enough, however, for all practical purposes.

The chain is composed of a central core of eruptive rocks, which have upheaved and contorted the sedimentary strata overlying and flanking it. This core does not extend the entire length of the chain, but begins near the middle as a great, irregularly-shaped mass lying obliquely across the axis of the range. Its eastern end is abruptly cut off in the region of the Jaina River, but to the west it stretches out in a series of parallel ribbons at least to, and perhaps beyond, the borders of the Republic. Overlying this rock, pushed up, folded and broken by it, is the great series of slates, conglomerates and limestones belonging to the Cretaceous formation. These cover the greater part of the area, not only of the mountain mass, but of the Island, and are the oldest formation yet discovered within its limits.

The foldings of the Cretaceous beds and the lines of exposure of the eruptive rocks correspond almost exactly with the trend of the chain. This is not exactly the same throughout, although the amount of variation from a straight line is very little, and the average direction is about N. 70° W. It is worthy of remark that the eastern half of the range, or that part east of the intrusive rocks, is nearly due east and west, while the remaining portion turns up quite abruptly to the northwest from Mount Vanilejo. This eastern half is much less disturbed; the foldings are not so complicated nor numerous, the absolute elevation is much less, and the upheaving force was evidently expended, in great part, towards the centre of the Island; the portions towards Seybo and Samana Bay being lifted hardly a fourth as high as those at the head of the Yaqui River and its upper branches.

Both this chain and the smaller one of Samana furnish us with excellent keys to the dates of their upheaval; Samana being simply a repetition on a small scale, as has already been said, of the larger Island. Santo Domingo probably first made its appearance above the water either during the era of the white chalk of Europe, the green sand beds of New Jersey, or in the Eocene period. It then consisted of this central chain, probably extending out to the whole length of the present northern peninsula of Hayti, accompanied by a group of smaller islands forming the southern Haytien peninsula and possibly some of the other high lands of that region. To the northeast lay Samana, a long low rocky islet, but slightly elevated above the sea, and to the south of it, a little archipelago, which now constitutes the hills of Seybo. During the Miocene period these islands were fringed with coral reefs, the fragmentary remains of which still exist as patches of limestone, lying now as horizontally as when they were deposited on the upturned edges of the Cretaceous slates. The elevating force had not ceased to act, and at the end of the Miocene, after having been probably succeeded by a period of subsidence during that era, it was resumed and has lifted the latter formation horizontally 200 feet in the middle of the Santiago Valley, about 300 to 400 in the hills south of Samana Bay, and still higher in the foot hills of the range at Cevico and west of the Upper Yaqui. In the latter case the sandstone beds of the Miocene are highly uptilted. But these upheaving forces, while they acted so gently on this occasion at Samana, in the main range and in the adjoining Valley of Santiago, were much more violent a little further north, and pushed up the formation along a line an hundred miles long, in some cases to a height of 3000 feet or more, making the Monte Cristi chain where, until the end of the Miocene, had been a level sea-bottom covered with white calcareous mud.

The Pico del Yaqui, more commonly called El Rucillo by the people living near its base, is at the same time one of the highest, if not the highest point on the Island, one of the most central and an excellent starting point for our detailed description of geological features of the range. As stated in a previous chapter, its height is perhaps a little over 9000 feet. It is a sharp ridge, very narrow, but about a mile long, a broad rounded curve, with a little sharp peak at its eastern end, lower than the top of the curve. From the eastern end a long ridge runs to the eastward continuing the water-shed and separating the waters which run north from those which empty into the Neybo River. From the same point a long spur runs out to the north, on both sides of which rise streams which unite to form the longest branch of the Yaqui

River. These streams, mountain torrents, roll and tumble over boulders, some of immense size and continue their course receiving numerous tributaries until, half a dozen miles below Jarabacoa, after receiving the Jimenoa, the Yaqui seems fully as large as it is at Santiago. The trip from the valley to the mountain is one well worth taking, giving one a new set of experiences, hardly to be obtained in any other part of the Island so easily, if at all. I started in June, 1870, accompanied by several persons, and eventually added guides and porters until we numbered, myself and eight others—servants and employees. We started from the house of Col. Jose Antonio Placencio, at Tabera on the Yaqui, a pretty spot, shut in among the hills, at the foot of a high ridge; almost at the southern border of the Miocene rocks. The road commences to ascend the ridge within a few hundred yards of the house and almost immediately entered into a region of metamorphosed Cretaceous slate standing almost vertically. A climb of a mile, varied with an occasional descent, took us to the summit of the ridge, along which we rode, through an almost unbroken forest of large trees, past a settlement consisting of two or three houses in an opening, called Aguacate, thence we descended to a pretty little mountain valley in a bend of the Yaqui, called Humunucu, where a half dozen families live comfortably raising a few pigs and cows and cultivating a little tobacco. Up to this point the slates had continued, sometimes magnesian, a little micaceous, but more usually jaspery; but they now gave place to syenite, and in the crossing of a rivulet in the valley, I detected the first crystallic rock, very much decomposed by exposure, but unmistakeable. As is everywhere else the case, the slates, near the crystalline rocks were rich in quartz veins, and Placencio informed me that women collect a little gold occasionally in the streams. From Humunucu, we climbed another high ridge called the Loma de los Caracoles, or Snail Hill, and descended a very steep trail again to the cañon of the river. On the south face of the hill, I found outside of the trail a mineral of rare occurrence in Santo Domingo—a little concretionary mass, the size of a double fist, of iron pyrites, bright and crystalline on fresh fracture, but so oxydized on the surface as to have lost all structure and to appear a mere lump of iron rust. From Humunucu, the entire region is a mass of syenite, all stratified rocks being left behind. On reaching the cañon we found a little flat of less than a hundred acres through which the river runs, here a brawling stream, a dozen yards wide, tearing its way over and among gray boulders or spreading out in sandy pools, but always in a hurry, always running with a rapid current.

This little valley retains the Indian name of Mana-bao* and is inhabited by two

*These two syllables are frequently repeated in Santo Domingo, and as well as I can recall, always in connection with streams—thus, Mana-guallata and Mana-Matuey, near Santo Domingo, and Bao or Ci-bao, the river from which the valley and range seem to have taken their name.

or three families, the last settlement back in the mountains. These people, like most of the others of this region, raise a little tobacco, which they press into cylinders three or four feet long and a little over an inch thick, rolled in a palm leaf and known as "Andullo." It is made by winding the tobacco, after being enveloped in a palm leaf, with a cord, which is taken off every day or two and wound tighter, until eventually the mass becomes as solid as the pressed tobacco of the American manufacturers. These andullos are sold at an average price of a dollar a-piece and two or three cargoes of forty andullos make a good crop, and supply the family with the greater part if not all the money with which to buy clothing, and such other outside necessaries as can only be obtained with cash. In addition to their tobacco, they sometimes manage to eke out a little by the sale of the dried meat of the wild pigs and beef cattle which roam everywhere in the less frequented mountain forests. At Manabao there are two small sulphur springs, the water running out of a little rock bluff, in the flat close to the river. It is not strongly tinged with sulphureted hydrogen and is slightly tepid, hardly blood-warm. Coming out of the syenite, and being the only warm or sulphur springs in the country, it is doubtless due to some purely local cause, probably the decomposition of a deposit of pyrites, similar to the piece found on the opposite hill. Obtaining guides and additional servants, making eight in all, and leaving our horses, we left Manabao on foot, and after following the river-bottom for half a mile, through a piece of nearly flat lánd, covered with large trees and with but little undergrowth, we climbed over a spur of hill covered with a mixed growth of palm and pine and carpeted with long grass, and pine leaves, among which grew many bushes and plants new to us, never to be seen out in the lower lands; and most unexpected of all, an abundance of an old friend from home, blackberry bushes, with a few ripe berries. The plant is so little known, growing as it does only in the high mountains, that the people did not know that the fruit was eatable, and were not sufficiently reassured by my actions to join me in my unexpected feast. On descending from this hill, we entered a much larger valley than the preceding, the greater part occupied by a marsh, covered with grass, but so soft that a man can hardly cross it.

A large band of cattle was browsing in the valley, but when they saw our party, tossing their heads and switching their tails as only wild cattle can, they started off bellowing with alarm and plunged across the marsh, belly deep in mud and water. We camped aside of the river, a short distance below the "Cienega," as the marsh is called; and hanging our hammocks between the trees we managed, by dint of several "smudge" fires to get the better of the musquitoes and sleep comfortably. Next morning we resumed our march, following up the river as far as the width of the cañon would permit, climbing over boulders and fallen pine trees, until we were forced to take the hill-side. By this time we were so high as to be on the margin of the pine woods, but well into an undergrowth of tall fern. This plant is so tangled that the trail must be cut, every foot of the way with "machetes." Sometimes the whole party would climb over the top of it, bearing it down by main force; oftener we had to crawl under it, through tunnels cut by the big "machetes" or wood-knives of the servants, and whenever we could we gladly availed ourselves of the fallen trunk of a dead tree, crawling along it like a troop of monkeys, hands and feet alike doing duty. The march was doubly toilsome because we all carried loads. Myself with a bag and hammer, and worse than all a mountain barometer, that had to be guarded against blows, and all of the others loaded down with hammocks, blankets, provisions, etc., we learned, if never before, why the Romans called baggage "*impedimenta.*" On leaving the river we left all running water behind and when our canteens were exhausted, were fortunate in finding on top of the ridge, in every sheltered place, a little clump of trees. On most of them were numerous orchids, and in the caps, formed by their leaves, which envelope like those of a pine apple, we found a small quantity, from a half ounce to an ounce, of dirty water. But old travellers are not fastidious and we escaped serious thirst. Late in the afternoon it became evident that we would not reach the summit that day, though the clouds that enveloped us would not permit us to see how far we were from our destination. It was decided however to stop where a clump of small pine trees offered the means of making a partial shelter from threatened rain. Our shed was hardly completed and covered with water-proof clothes and overcoat before a heavy shower came up. A palm leaf that had served as wrapper for our cassara bread, was hastily made into a receptable for water, and by industriously collecting from all the drips with coffee-pot and tin-cups, we accumulated more water than we needed for night and next morning. Just before night the clouds broke and there stood the grand old peak of the "Rucilio"—the silvery headed—directly in front of us, but at least four thousand feet higher. It was all of a hard day's climb off yet, judging from our experience; my men, discouraged by the hard labor and dreading thirst from the certain absence of water higher up, were grumbling, ready to mutiny, and I was forced to admit that if I went, it would probably have to be alone. I was therefore obliged reluctantly to announce that next day we would turn back. At 6 P. M. the barometer read 24.542, with the attached thermometer at 60.5 and the detached 61, and before morning we had the unwonted temperature of 47° on the night of June 1st. The night before, at the Cienega, the barometer had recorded 26.758, with both thermometers at 71, showing that we had, in a whole day, climbed only a trifle over 2,000 feet, besides crawling a couple of miles along the top of a ridge, a distance that should have been made in three hours easily in reasonably open ground.

Throughout the entire distance from Humunucu, the rock is a gray syenite, so uniform in character and appearance that one hard specimen would almost seem as a sample of the whole. It is usually of a light color, moderately coarse grain and with the hornblende in small crystals. No mica was noticed anywhere. I have been thus detailed in the "personal narrative" of this particular journey for the purpose of conveying a clearer idea of the character of the higher interior mountains of the Island, and to show that mountaineering in Santo Domingo, though not dangerous, is quite as difficult as climbing over snow fields.

From Humunucu, a trail crosses a comparatively low ridge, also in the same syenite throughout, and strikes the Yaqui again, just opposite Jarabacoa.

Returning again to Tabera, whence we started, we find the highly uptilted sierra slates are overlaid by dark gray sandstones, with occasional pebble beds belonging to the extreme base of the Miocene. This Miocene, though much disturbed, is decidedly unconformable with the underlying Cretaceous. They are slightly metamorphosed so far as to show signs of alteration, but not sufficiently to lose their sandy structure. The most marked effect of the metamorphic action is visible in their stratification. The river bluffs are here very high and abrupt, and one section, about half a mile from the house of Col. Placencio, shows an amount of contortion nowhere else observed in the Dominican Tertiary. The alteration of the sand and pebble-beds is visible along the same line of strike for a distance of three or four miles to the westward, and the strata, which usually dip at high angles to the north, vary in their strike all of the way from N. 80° W. to N. 20° W., the former being about the normal direction. These are the "secondary rocks (perhaps of the Carboniferous system), which consist of dark sandstone flags, alternating with black bituminous shales in narrow seams, dip N.N.E. < 33°."* The rock is usually a dark gray sandstone, and where the southern road from Santiago to San Jose de las Matas crosses the Bao River, it is a conglomerate of the same color, with a calcareous cement, and dips as high as 50°. From the top of the hill west of the Bao, the succession of strata can be seen almost uninterruptedly to the steep bluffs on the Yaqui at Angostura. The dip gradually becomes lower, until at the latter place it is nearly horizontal, varying from 5° to 10° from north to south along the extent of the exposure, and at Santiago, still farther north, is reversed, dipping at a low angle to the south.

* Heneken, *Quart. Journ. Geo. Soc.*, vol. x., p. 12?.

From the west end of the ridge of the Rucillo, there starts out a spur as heavy as the parent mountain. At a distance of about ten miles from the main chain it culminates in a noble peak, Loma Joca, called on Schomburgk's map "The Peak." This mountain sends out a radiating series of ridges which extend far out towards the valley, and give rise to most of the branches of the Bao River, the principal of which are the Guanajuma,* the Baguati, or Boguaci, and the Jagua. Like the main ridge, all of the region of Loma Joca is syenitic, the rock extending on the Baguati to within a dozen miles of its confluence with the Jagua. At this point on the former stream Mr. Speare collected a peculiar coarse-grained dark-colored syenite, with small scales of a shining mineral which seems to be mica. Almost immediately north of this spot, the Cretaceous beds appear as dark-colored heavy-bedded clay shales. On the same line of strike on the Jagua, about ten miles from its mouth, the rock is somewhat calcareous, and varies in color from gray to greenish, while nearly in the same line, perhaps a little further north on the Bao, the shale is black and earthy, alternating with beds of lighter color, and although not specially calcareous, containing streams of calc-spar. The amount of disturbance to which the rocks of this vicinity have been subjected is so great, that while a general tendency to a nearly east and west strike can be made out, the dip is practically vertical. Occasionally a lower incline may be observed, but it is extremely local, and it is as often in one direction as another.

Approaching San Jose de las Matas, the rock changes its character to a gravelly sandstone, often full of pebbles, and occasionally giving way to distinct beds of conglomerate. Here almost all the beds are more or less red, stained by oxide of iron; the soil is a loose red gravel, unusually barren, and the surface is clothed with grass and occasionally a patch of pine forest, interspersed with the "guano" palm, a slender little fan-palm, growing twenty feet high. The barren soil, with its consequent pine and palm-growth, seems to follow closely the metamorphic slates, from San Jose to the west. Its barrenness is due in part to the scarcity of rain. In the western part of the valley showers are rare, and when they do fall are less violent than in its eastern end. South of San Jose the country, as far as we penetrated, was made up of slates—red, brown, black—vertical or dipping slightly to either side of the perpendicular. In the side of the hill below San Jose, there is a cliff of dark reddish-brown sandy shale standing almost vertically, and with broad surfaces cleared clean in the line of stratification. The town itself is very peculiarly and beautifully situated. It occupies a little basin, nearly level, surrounded by rolling

* This must not be confounded with the Guanajuma which rises in the Pico Rubio and empties into the Amina. Much confusion arises from the constant repetition of local names.

hills, but perched on the summit of a ridge which, like all the others in the vicinity, is usually very narrow. The traveller, approaching it from either side, rides along miles of mountain crests, generally surrounded by forest, but with little occasional glimpses of deep cañons on either side; the black sierra to the south, a labyrinth of peaks piled one above the other, and on the north the broad expanse of the Yaqui Valley, not even shut off by the Samba Hills, which, too low to impede the view, lie stretched along in the middle-ground of the picture. If approaching from the east, the scene gradually changes to open grassy hills, with one ridge beyond another, over which the red line of the road can be seen winding like a ribbon over the green surface. Suddenly he finds himself in full view of the village, hardly a quarter of a mile distant—a city set upon a hill, and yet completely hidden. Almost adjoining the town is a branch of the Amina River, its cañon three or four hundred feet deep, and so narrow that a man can be heard distinctly calling across from hill to hill. A trail winds down the hill-side, disclosing at the bottom a pretty little stream of twenty feet across, of clear, cold mountain water. The pebbles in its bed show only slates; but in the main Amina, pebbles and boulders of syenite predominate. At Los Corales, southwest of San Jose, there is much slate, here altered to a coarse, semi-jaspery structure. From San Jose a but little-used trail crosses the mountains by a pass at the head of the Bao River. No member of the survey has been across this route, although I once attempted it. From the stories of copper mines near the summit of the mountains, it is probable that a tongue of the sedimentary rock extends eastward that far, or possibly the southern border of the eruptive mass may here bend to the north. The former is the more probable hypothesis. The tradition exists that nearly half a century ago, when the country was subject to Haytien rule, a party of Haytiens spent a number of months at the head of the river working a copper-mine. A fatal epidemic breaking out among them they abandoned the spot for a time, and before they were able to resume operations political changes, or some other insuperable obstacle, interposed and prevented them. A few old men still remain who, as boys, accompanied the party, and from one of these I obtained the story.

From San Jose north, the trail crosses the Amina, and then winds along the summit and side of a long ridge west of the river to its end, descending at Bohio Viego to the Guanajuma, where it strikes the Camino Real or main road. Along this route, the gravelly beds of San Jose very soon give place to shale of a more or less magnesian or talcose character. The soil is usually red, and the surface is covered with heavy pine timber, with no undergrowth except grass. In one place the shale is white, though usually it is stained by oxide of iron. A little gray sandstone was found interstratified with the talcose slate, and occasional quartz veins are to be seen; but nowhere does this quartz carry gold. A little north of San Jose, a perceptible northern dip occurs, after which the rocks again become vertical; but at Bohio Viego, where I had a good opportunity for measurement, I found a due E. and W. strike, with a dip to the S. of from 65° to 70°. At this point the margin of the Miocene covers up the older formation, and it does not reappear.

At the crossing of the Amina and again on the hill side, two miles west of San Jose, there is an exposure of a dark bluish-gray limestone, so little altered that on the hill I found a very faint trace of a coral on a weathered surface. This is the only case where fossils of any kind have been found in the formation on the north side of the island. The beds are not very thick, and dip into the hill in such a manner that the angle could not be determined with any degree of accuracy, but so far as I could determine, they have a strong northern dip. These limestones are intimately associated with and overlie the conglomerate beds found east of San Jose, and which are again repeated on the next ridge west, there dipping at comparatively low angles northwards.

The road from San Jose to Magua runs west until it crosses the Guanajuma, after which it mounts a ridge, and follows its summit southwest to the arroyo Magua. Here for the first time it enters the eruptive rocks. One dyke, or perhaps it should rather be called a streak in the mass, which extends from this point west to beyond the Jicome Creek, being encountered at several points along the line, is characterized by rather large crystals of feldspar, having a peculiar greenish tinge, and by the presence of small quantities of mica. At the crossing of the Magua, there were also found other syenites differing from this, the most marked being a white variety, with slender crystals of hornblende sometimes two inches long. This intrusive mass, which may be called the first or outer belt, is not wide on the Magua, but widens out and extends as an irregular strip to beyond Savaneta, disappearing under the Tertiary gravels.

Southwest of the little settlement at the crossing of the Magua, there is a road across the hills to Dajao, following which we find ourselves very soon on sedimentary rocks again. Here, at the "Loma de los Minas," is a well-marked synclinal axis. The above-mentioned dyke has formed an anticlinal, and another belt, No. 2, crossing south of Dajao, forming another, the country between the two is bent into a basin. The dip on this hill is at high angles to the south, and the most common rock is the same limestone as that just described as being found on and west of the Amina. It is all more or less gray; some is identical with that from the Amina, some is earthy, with white streaks of calc spar. Under the limestone is a peculiar-looking brown rock, apparently a conglomerate, but so far altered that the pebbles have lost their individuality, and seem to be fused into the mass. Further to the south is a belt of earthy, semi-talcose slates, rarely silicious, and lithologically identical with those found at Guaraguano, in both cases overlying the limestones. In these slates, as at that locality, quartz veins are abundant, and occasional copper stains are apt to mislead the ignorant into the fallacious belief that the metal may be found. It was probably this that caused the execution of some old mining work on this hill, the history of which is now forgotten in the vicinity; or the mine might have been worked for gold-quartz. The excavation is eighty feet long and about thirty feet deep; the width is from three to five feet, and a number of small pillars left standing have served to keep the walls perfectly apart. No definite vein structure could be detected either in the "country rock" or even in the pillars. We descended to the bottom of the work by means of the long cable-like roots of the Higuey trees growing on the rocks, but failed to discover any trace of metal.

The Magua drains the whole east side of the ridge of the Pico del Gallo, receiving the waters of the arroyo del Gallo, the stream which runs down from the peak itself. At the point where this creek empties into the Magua we find the dividing-line between the southern edge of the second belt, to be described further on, and the sedimentary rocks which form the whole mass of the peak. In reality, the mountain owes its prominence to the fact of its being the entire thickness of the Cretaceous system, pushed up bodily by the syenitic rocks which reach the surface in broad belts both north and south of it. Just at the mouth of the creek we found a light-colored syenite, with small slender crystals of hornblende and large white crystals of feldspar, and almost in direct contact, south of this, we encountered the Cretaceous beds changed to a soft brown mica slate, and a little further on, where the action had not been so marked, they were a greenish slate, which, according to my notes, was "seemingly micaceous."

Still further south, along the Magua, on the third and last belt encountered, and which crosses the spur of Pico Gallo between the peak and the main ridge, there is a great variety of rocks all occurring in the same mass, often having a considerable longitudinal extension; that is to say, in an east and west direction, but very limited in a direction across that of the dyke. A marked illustration of this occurs in the rock with greenish feldspar at the crossing of the Magua. Although the whole syenitic mass of this belt appears to have originated in one intrusion this particular strip can be traced from an unknown distance east of the river to beyond the Jicome. So, in the present case, a specimen of a white laminated, gneissoid rock, containing a little black mica arranged in layers, brought me by Mr. Speare from southeast of

Pico Gallo, is in every respect undistinguishable from one collected by myself in the cañon of the Cenobi southwest of the peak. Besides this, we found a bluish-gray granitoid rock, very fine grained, without mica; and another, of coarser grain, with comparatively large crystals of white feldspar. Quartz veins are not confined to the metamorphic rocks. In this region, as on the Nizao, there are segregations of that mineral forming well-marked seams, often of considerable extent. On the Magua it is usually white and milky, though in one case it was found of a greenish white.

Dajao is a little settlement on the end of a long spur from the Pico Gallo—a dozen houses, scattered in little dells or flats on the hill sides, from the banks of the Mao River to the top of the ridge. The little community is made up of people, almost all ramifications of one family, who show, perhaps as markedly as any, the strong Indian type which still lingers in the fastnesses of the hills. An innocent, peaceful tribe they are, intelligent far beyond the average of their countrymen of the same social level, and, strange to say (in the woods of this country), almost all have some sort of a rudimentary education transmitted from one to another, for schools do not exist; and a better field for the true missionary, the schoolmaster, could probably hardly be found. He would be welcomed with open arms, and bright-eyed youngsters enough could be found to keep a pretty active man busy. It must not be understood that this applies solely to Dajao. Twenty other communities of these mountaineers—equally intelligent, equally desirous to be taught, and equally needy—are scattered through the hills. More real good could be accomplished by sending to each a schoolmaster, than by sending fifty missionaries to the South Seas or to the Indians of the Plains.

But this is not geology. Half way between this place and the crossing of the Magua is the Jicome Creek which descends from the direction of the peak and runs about half of its course in the slates, the upper half in the second belt of the Syenites. Near the mouth are various beds, some of earthy brown slate, others of greenish talcose material, both abounding in specks and microscopic crystals of pyrites. These shade into each other, while again the latter become more magnesian, greenish in color and loses the pyrites. Again, this last assumes the more usual type of a white rock, evidently talcoid, though but slightly so, and profusely mottled with great stains of oxide of iron so as sometimes to become entirely red. In these shales the seams of quartz are not rare, and vary from white, either translucent or opaque and very compact, to spongy masses stained by iron as if originally filled with pyrites which had decomposed. These latter are invariably auriferous and may one day pay a profitable return to the miner. Further up the stream, as before mentioned, its course runs through the eruptive rocks. In one place, a fine-grained dark gray syenite, with no trace of mica, makes up the mass, while in another we found a coarse-grained rock with large crystals of feldspar, and in place of hornblende a greenish mineral, possibly chlorite. The mouth of the Jicome is in the outer or first belt of Syenite; and here is repeated the material already mentioned at the crossing of the Magua and elsewhere, a rock so peculiar as to be immediately recognized, although here it has undergone a slight modification, in that the feldspar is white and some parts of the mass are finer grained than usual.

Abundant proof exists of the origin of the quartz veins here. They never show well-defined walls, and whenever mica is found in the country rock it is almost always entangled in the quartz also.

In the Cretaceous belt between the Jicome and Dajao the slate is all more or less serpentinoid and of various shades of green and gray. In some cases it is nearly a pure chlorite; and by following the same line of strike to Dajao it can be seen to change gradually to a claystone varying in color through all the shades of black, gray, green, brown and rusty. Some beds are almost identical with the rock from the Bao and the Jagua, but everywhere it bears an abundance of quartz veins, not infrequently stained with carbonates of copper. Although the Mao River, which here takes a turn to the eastward, runs during that part of its course along the centre of a synclinal axis ; the fact could only be ascertained by a detailed examination of a much larger region than the immediate area in question. As has been demonstrated above, the limestones of this part of the country overlie the conglomerates and are in turn overlaid by the shale; the whole having been pushed up by the syenites which have found egress to the surface in nearly parallel east and west lines. The stratification has been so nearly obliterated that only here and there, as in case of the more compact limestones, can any dips be demonstrated. Both south and north of Dajao there are intrusive belts. The southern appears within a couple of miles of the settlement and extends more than half way to Pico Gallo. The northern makes its appearance as a comparatively narrow strip on the ridge towards Guaraguano, just after reaching the summit from the river. On the southern flank of this latter the limestone abounds without recognizable dip, and small outcrops of limestone also occur a mile south of Dajao. Between the two limestone exposures the country is a mass of clay and talcose-slates, whose principal characteristic is that they all seem to be "on end," no exposure showing a dip that can be depended on for measurement; though the quartz veins and all other collateral signs that occur seem to indicate a vertical position, or are approximately so. A full half of the width of this synclinal axis is occupied by the Mao cañon, and there being no exposures on the grassy slopes of the hills, nor in the "bottom," the position of the rocks over this space is of course uncertain.

The belt of intrusive rocks (No. 1) between Dajao and Guaraguano has little to call our attention except some small patches where the syenite is of an unusually fine texture. The quartz and feldspar in these specimens are unusually brilliant in lustre, both being remarkably glassy, but the texture is so fine as to resemble in the mass a fine black sandstone. North of this, almost without the intervention of sandstone or conglomerate, we have the same limestone repeated; here the strike being continuous and easily traceable to that near Las Matas. The dip also in this case is easily distinguished as a low one northward. Over the calcareous beds the shales dipping at 30° north extend northward and full of narrow seams of white quartz until they are overlapped by the horizontal strata of a coarse sandstone, the latest known member of the Tertiary of the valley, and which will be more fully described in connection with the Mao gravels, of which it forms a part.

The Mao River furnishes one of the best opportunities for a geological section of any line running southward into the mountains in this vicinity. At Latoma, opposite Dajao, on the west side of the river, the greenish talcose slates and claystones are remarkably full of quartz veins, and some stains of copper occur. A few years ago, a Mr. Heneken (the same who published the remarkable description of the geology of the Cibao), spent some time and considerable sums of money in searching for copper here, with the success that is clearly predicted by the surface indications. It is said also that he attempted to work some of the quartz veins for gold; but while I encountered some of the "copper mines" I could find no traces of his gold mines.

Quite close to the quartz-bearing shales, south of Latoma and almost opposite Dajao, the syenite reappears, and resembles that north of Dajao in some respects. The quartz and feldspar are both unusually glassy, and in this case the hornblende is disproportionately abundant, reminding one somewhat of the rock on the Jaina. Some of the rock, on the other hand, is nearly pure quartz, and veins of quartz are also abundant here, as everywhere else. Other of it is dark gray, moderately coarse-grained with the quartz, feldspar and hornblende in nearly equal proportions, and in still other places, especially on the Cenoba River, it is gray with little or no hornblende, with peculiar small white grains of feldspar, somewhat laminated, and contains a little pyrites.

From Dajao there is a trail, much used by the hunters of wild pigs and cattle, which runs nearly south, following the summit of the ridges on the end which the Dajao settlement is perched. About a mile back in the woods, and perhaps two from the river, in a little basin on the hill top, there is a single house, beyond which there is not another inhabitant nearer than the banditti on the Haytien frontier. Very soon after leaving the house the trail enters the region of gray syenite, usually fine-grained and showing much hornblende. This continues for a couple of miles to the crossing of the arroyo Cenoba, where the northern margin of another synclinal of quartz-bearing slate makes its appearance. The change in the underlying rocks is almost always obvious on the surface by a change in the soil. The slates are usually covered with a red open soil, retaining but little moisture and bearing a growth of large pines with a carpeting of grass, and sometimes an undergrowth of fern. The syenite, by its decomposition, produces on the other hand, a coarse sand, or perhaps more properly speaking, a fine gravel in which the pebbles are the less easily-decomposed ingredients of the parent rock, such as grains of quartz and occasionally crystals of feldspar, though the latter mineral generally disintegrates rapidly. This soil also bears pine, but the little ravines on the hill sides and the low places where a little richer soil is accumulated by the rain washings are characterized by thickets of various dicotyledonous trees, mixed with the Canna and guano palms, two species belonging to the "fan palm" group, and even the manacle, one of the "cabbage palms."

After crossing the Cenoba, the route winds along a high narrow ridge, the tall pines forming a constant shade, so thick do they grow, while the wind playing through their branches, reminds one of the distant roar of the ocean. Every few moments the traveller catches sight of the deep cañon of the Cenobi on one side and the Cenoba on the other, hundreds of feet deep, so far off that the river looks like a silver wire, and tall trees are dwindled to little bushes. The slopes are often precipitous, and generally at such high angles that it is difficult, or nearly impossible, to climb them. But wild as are these solitudes, the part that most surprises a foreigner is the absence of wild animals. These black ravines look as though they ought to be the favorite haunts of the grizzly bear and panther, and one who has been in their homes can hardly divest himself of the undefined expectation of meeting one or the other. Not even a deer is seen, timidly dashing through the trees, and the noblest game is the long-legged, long-nosed, slab-sided porker, who, with ears and bristles erect, and the last kink taken from his corkscrew tail, makes his way with a rush and a grunt through the bushes; or perchance a bull, not less timid, dashes bellowing across a grass-grown flat, with a speed that has to be seen to be believed. The agouti, a little animal the size of a hare, but allied to the guinea-pig, is the noblest wild quadruped on the island, and it is so rare that in three years I have met but a single one.

Nearly opposite the mouth of the Arroyo Canna the road crosses the Cenobi and mounts another ridge, in every respect a repetition of the first, except that much of this part of the route is over the synclinal axis lying between the second and third intrusions. The rocks are as varied as might be anticipated from the previous descriptions—dark-gray calcareous claystone, black serpentine, green talcose slate with quartz veins, often full of pyrites, greenish-gray clay shale, and brownish magnesian slate succeed each other between the southern edge of the syenite and the cañon of the Cenobi, while beyond nearly the same features are repeated, until the northern edge of the third belt is reached. A peculiar change was here noticed in the vegetation. As the route penetrates further into the heart of the mountains, while the pines still continue to make up, with patches of palm, the greater part of the forest, many other trees, natives of the valley, reappear, and here the wild *Fuchsia* and the blackberry grow side by side in the thickets, while the brilliant flowers of a dozen unknown species mingle with the most familiar forms of the moist lands of the valley. The great variety of the orchids is apt to strike the observer, but unfortunately most of the Dominican members of this family are more gaudy than pretty. The most remarkable one has a great bunch of dark purplish-red leaves, like a maguey, stuck on the side of a pine-tree or lodged in the crotch of a limb, its awkward spike of dull reddish flowers on a long stem the reverse of pretty. Others are more graceful, but none show the brilliant-colored and variously-formed flowers so characteristic of the family in other places. The absence of water is also noticeable in these hills. Streams are abundant and their volume is always great, but there are almost no springs in the low places among the hills, and wherever one does occur it is so rare a thing that a little shed is built near it for the accommodation of benighted hunters. One such spot occurs in a place so out of the way on this ridge that it can only be detected by the unwonted sign of a side trail starting off from the main route. There is nothing peculiar about it. It is simply a little pool from which issues a trickling stream; and yet perhaps the great majority of travellers turn out to it. The trail past it is more worn than the direct one. From this spring the ridge ascends somewhat, winding past the peak of the Gallo until, when nearly southwest of the mountain, it widens out into a little grassy prairie—a perfect park, studded here and there with noble pines, and walled in by high mountains on all sides. The name of the spot is Savana de las Lagunas. I was for a long time at a loss to ascertain why "of the lagoons," until I discovered near it, in a depression, two or three dried up mud-holes, hardly fifty feet long, into which a little surface-water drains in times of heavy rains.

The spot is a favorite camping-place for the hunters, who can easily bring pack animals this far, but are prevented by want of trail from penetrating more than a mile or two further. The abundance of grass, belly-high to a horse, also attracts wild cattle, and the hunter is occasionally rewarded with an unexpected supply of wild beef. Their custom is to bring into the mountains a supply of salt, and then stay, killing wild pork and beef and drying the meat so long as the salt lasts, or until they reach the full carrying capacity of their animals. The water is, as usual, scarce, but a supply exists, and of pretty good quality, in the rocky basins in the bottom of a little ravine on one side of the savana. The rock exposure here was the more welcome because rare. The red soil indicated slate, but here the slate itself appeared, laid bare by the currents of the rainy season, souvenirs of which are preserved along the channel during even the driest years. It must be borne in mind that this is at least a couple of hundred feet above the little cañon that drains these hills, and tumbles down a steep bed into the main river. I spent a couple of days in this lovely spot exploring the neighborhood. Mr. Speare, to whom the gold pan was intrusted, as usual, "prospected the gulches," and found almost everywhere a "color," and sometimes discovered a dozen "colors" to the pan. And here I may as well repeat what has already been said in more general terms at the end of the chapter on this geological formation: wherever the slates occur in the neighborhood of the eruptive rocks, there gold occurs in most, if not all, of the included quartz veins, and the streams are always more or less auriferous. I do not wish to be understood as stating that there is sufficient inducement to bring foreigners here with the exclusive object of mining gold. Usually the gravels are not rich enough intrinsically, or where they are, the quantity in any one spot is so limited that mining on any large scale is not likely to be profitable. Nor, again, do I wish to discourage the detailed examination of the quartz veins. They are numerous; and some of the pieces I caused to be examined that did not show free gold, and that were collected by myself as fair specimens, gave returns that would be considered very encouraging in California. Occasionally a vein can be found that, on account of its thickness, extent, general appearance, and the results of assays of its quartz, would certainly be opened in California. I know of no reason why it should not be in Santo Domingo.

The trail from the Laguna Savana winds around the head of a little cañon and climbs a long ridge covered with a great variety of trees, of which pine is one of the least common, until, reaching a greater height, the pines return, but now very slender and stunted, reminding one forcibly of the pine woods on the summit of the Cascade Mountains of Oregon, on the ridge of Mount McLaughlin. A fire that had recently passed through the woods had rendered good service in burning out the dead branches and rubbish, disclosing to the view a grand solitude. Not a level tract of an acre's extent was visible in the entire radius of from ten to twenty miles. To the northeast the noble cone of the Gallo stood out pre-eminent—a mountain whose summit, albeit at the top of a reasonably gentle slope, has not been stood upon by man during the memory of the "oldest inhabitant." Two of the most famous mountaineers of the region, named Durand, father and son, pig-hunters, who spend nearly all their lives on these mountain sides, and to whom climbing is no hardship, essayed the ascent from motives of curiosity some four or five years ago. They say they chopped their way through fern thickets nearly all day, and near nightfall one ascended a tree to ascertain their whereabouts. They were not a third of the way up. They slept at the root of that tree, and next day went back. They declare that to reach the apex pioneers would have to chop for a week to open a trail, and this where the nearest water is at the base of the mountain. South of the Gallo, and but very little lower, a rounded knob on the middle of the ridge is called the Corral de Mateo. Between these two the Senador cañon runs southwest to join the Cenobi, while other branches of the same stream drain a breadth of a dozen miles of the north face of the main range. The Canna drains the southwest face of the ridge on which we stood, a narrow cañon crowded in between the Cenobi and the Cidra. This river takes its rise in a peak hardly less marked than the Gallo. It is on the main ridge, and perhaps ten miles southwest of that mountain. After diligent inquiry I could find no name for it among the people, so I have ventured to propose for it the name of an honored friend, and a gentleman who has worked hard and successfully for his country's good. It is designated on the map as Pico Baez, and is the only mountain in the country to which we have attempted to give a name. The Cidra runs nearly parallel with the central ridge, receiving many little tributaries from the south, though but few from the northern side. In its course it passes also Loma Jalapa, and shortly after bends north, receiving numerous branches from the west, and empties into the Mao. On the Cidra, fifteen miles from its mouth, we found the third or most southern intrusive belt; and here we met another instance of the repetition of a lithological character as a streak in a "massive eruption." The white gneissoid rock found by Mr. Speare on the Magua, and rediscovered by myself on the upper Cenobi, is again seen on the Cidra. Its mechanical peculiarities are perfectly reproduced. Its laminated structure, found nowhere else on the Island, is marked enough to catch the eye at first sight; but in this last case there is a change in its ingredients. I could detect no mica; and hornblende arranged along the lines of lamination is so abundant as sometimes to make up a half of the bulk. I shall not attempt to theorize as to the cause of this stratification, so to speak, in what are indisputably eruptive rocks. I content myself with calling attention to it.

It will be noticed that I have, in the foregoing description of the region of the upper Mao, repeatedly mentioned the magnificent pine forests that clothe these interior mountains. With an energetic and industrious population, every stream in these mountains would float down "saw-logs," and rafts of pine boards floating down the Yaqui, destined for export, would be one of the commonest sights on the river. As it is, I have repeatedly paid one dollar apiece for ordinary—nay, worse than ordinary—boards, hand-sawed, in one of the largest towns in the valley, and in full sight of where the tree grew. In Santo Domingo City I have paid (the regular price) $50 per M. for very inferior white pine boards, rough, full of knots, and half of them split or otherwise faulty; and as a special favor I got second-class yellow pine tongued and grooved flooring for $60 per M., the ordinary price; that first asked of me being $75. Here is a chance for American enterprise.

West of the Mao River the mountains lose their importance very rapidly. The main ridge continues as high and as prominent as ever, but the spurs dwindle both in height and length. The streams that run from them are, with one or two exceptions, quite insignificant, the Guayubin being the only one of any note, although the Gurabo and several others exist in the region. The outer belt of eruptive rocks continues its course until it is covered up and disappears under the gravels near Savaneta; but the other belts continue towards and into Hayti. Since it is not my purpose to describe Savaneta in this connection, there remains but little more to note. There is a trail crossing the Mao from Dajao, running past Gurabo and thence down into the plain of Savaneta. Another runs likewise from Guaraguano and joins with the first in the little collection of houses known as Gurabo; but except the trail in from Savaneta to Almacigo, no routes penetrates the mountains. The broad flat of which Latoma forms a part, and which is really a broad-topped ridge bounded by deep cañons, is called Meseta, or the Little Table-land, and is made up of slates, &c., the synclinal of Dajao. Its open park-like groves of pine, with their thickets of two or three species of fan-palm, and their green and brown carpets of grass and pine leaves studded with flowers, form pictures incongruous in their mixture of tropical and northern types. In some parts of this region the palms are so abundant as to form the most marked feature, but usually they are in the minority. The ridge from Guaraguano has but little to distinguish it from the Meseta. Both on this part of the route and on that west of Gurabo pines and palms make up the greater part of the vegetation, and the red gravelly soil indicates that below there is either a magnesian or a clay shale. This proves to be the case; and examinations of the scanty outcrops show that, except where the "second belt" crosses the ridge, the rock is almost always a chloritic or talcose shale. In one place it is nearly white, almost a steatite; in another its color is barely different, but it is more argillaceous and has a sort of oblique cleavage in addition to the lamination of the strata; again, it is light-gray, very talcose, and contains little nodular grains of quartz, is dark-gray and without the quartz, or the common red-and-white siliceo-magnesian shale that makes up so much of the eastern end of the chain. All of this is full of quartz veins, frequently not more than an inch thick, and generally milky white. These veins are probably barren of gold, at least so the appearance of the quartz would seem to indicate.

A dozen miles further west is another little collection of houses, Almacigo, a village often without inhabitants in consequence of the never-ceasing predatory incursions from the Haytian frontier. At the time of my visit to Savaneta the Commandante urged and finally almost prevented us by force from visiting the then about to be deserted hamlet. He gave as a reason that the region was full of outlaws, and that I would be taking an unnecessary risk of my life. I can only, therefore, avail myself of the scanty information derived from one of my assistants who had previously been there and brought me specimens of the rocks. Almacigo is on a river of the same name, and about a dozen miles back in the hills from Savaneta. It is but a short distance east of the long ridge that runs north from the main range to the peak of Chaquet. It is clearly in a slate-belt, although a part of the route was described to me as being over "granite." The specimens of rock brought, and said to be a fair specimen of the region, are a white, highly metamorphosed shale, breaking into rhomboids not unlike calc-spar in shape, though more oblique and of course more irregular. Old gold washings are said to exist in these hills, and my informant, whose experience was unhappily much greater than his reliability, professed to have found the old ditches and other signs of placer-mining. It is to be hoped that the time is not distant when somebody more fortunate than I have been will be enabled to investigate this matter in the manner it deserves.

But little can be seen of the structure of the mountains from Savaneta. From conversation with the most expert mountaineers and others that I could find, I learned that, as it appeared from the town, the high peak of Nalga de Maco which towers above everything, sticking heavenward its peculiar-looking summit (not inaptly called by the whimsical name of "Toad's Rump") perhaps seven or eight thousand feet high, is not on the central ridge, but is on a side spur to the southward, similar to those which run northward to Chaquet, Gallo, Rubio, and Joca. It is said that the Artibonite River rises far to the northwest of this peak, runs southeast around its base, and then, as is well known, strikes westward, running out through Hayti.

The same causes that prevented us from obtaining more details in regard to the little corner lying between Savaneta and the frontier also debarred us from visiting the south side of the range about and to the west of San Juan. Repeated efforts were made to cross the range south from Savaneta or from San Jose de las Matas by way of the head of the Bao River, but our friends the military chiefs in the Cibao, not less than the civil authorities, combined to prevent what they considered so hazardous an undertaking. Commandantes, Governor, and Vice-President united in such a thorough course of "masterly inactivity" that all our efforts to procure guides and escort were unavailing, and we were reluctantly obliged to abandon the project and content ourselves with a section no farther west than the Constanza Pass. This is the more to be regretted because, while there are three broad strips of intrusive rocks further west which unite in the great mass around the Pico del Yaqui, and another intrusion scarcely less great east of the route, there is so little encountered on the pass that it leads us to believe that equally unexpected changes might take place to the south of where our more western explorations extended.

Although Jarabacoa is underlaid by slates, the margin of the syenites of Humunucu is just back of the town in the bottom of the pretty little valley in which the town is built. The slates are highly uptilted, dipping northward at high angles, and often standing vertically. They are nearly in every case more or less talcose, though beds of sandstone occur occasionally. The Jimenoa River empties into the Yaqui half a dozen miles below the town, the two streams coming together in such a manner that it seems as if the former were the main river and the upper part of the latter the tributary. The stream, after the confluence of the two, continues in the direction that the Jimenoa was flowing, while the Yaqui enters at an angle of perhaps 60°. On the bluff facing the entrance of the latter there is a fine exposure of highly metamorphic slates containing some pyrites. The decomposition of the mineral produces the efflorescence of large quantities of a greenish and yellowish alum, which is periodically collected by the people of the vicinity and sold to the apothecaries of Santiago and Puerto Plata. This natural laboratory is the only one of the kind I have seen in the country. The little basin of Jarabacoa is in some parts flat, though in greater part made up of low rolling ground. Directly behind rises the steep face of the hills, and the dark round knob of the Mogote frowns down directly over the village. A mile out of the town the trail crosses the River Baguati, and immediately begins to ascend the hill. The climb is a very steep one and about three miles long in all, zig-zaging up the face of a hill, the path sometimes cut into steps by the feet of the animals. From the top of this spur it winds, with very little change of level, back of the Loma

Barrero, thence back of the Mogote, and doubles on itself, bending to almost all points of the compass until, descending a comparatively short distance, it enters a muddy little river-bottom, the cañon of the Jimenoa, south or southwest of Jarabacoa. Almost as soon as the traveller leaves the town he finds himself passing over a hard coarse-grained syenite, not unlike "Quincy granite" in its general appearance. It is a part of the same eruption as the peak of the Yaqui, and forms also the Mogote Mountain and a few of the ridges, but has dwindled here to a comparatively small streak. South of it the slates reappear, but along the trail on the summit of the ridge there are exceeding few exposures, and the slates being soft there are but few pieces in the soil. It seems to be mostly of a semi-talcose character and usually of a reddish color, though occasionally the familiar greenish-gray was observed. The Jimenoa at the crossing had abundance of syenite pebbles and comparatively few of the slate, the latter being much softer. After crossing the river the trail follows the bottom a short distance and then climbs another ridge, but not so steep or crooked as the previous one. Following this summit, the whole being in pine forest except in the depressions where other trees make their appearance, the trail crosses the Tireo, the longest branch of the Yuna, here a little rivulet, and then crossing another low "divide," descends into a long flat valley clothed with grass. Just before reaching the valley, there is a good exposure on the hill side of a dark red conglomerate, the color of an over-burnt brick. This is the more striking since it is the only bed containing pebbles along the whole route, the slates everywhere else being of very fine grain. The valley of Constanza must be two or three miles long and is as flat as a billiard table. It is without doubt the bed of a now dried-up mountain lake, that emptied itself through the cañon of the Limon River. The greater portion of the drainage entered it at the southern part, while the upper end was rather "back water." As a consequence, the soil of the lower part is more gravelly, while that of the northern end is a finer sand and clay. The upper end is entirely grass-grown except on the margin; but towards the middle it is covered with scattered clumps and tongues of pine timber, which clothe the entire southern portion. Near the southern edge the Limon River flows across the valley, cutting its way between bluffs of coarse gravel twenty feet high, made up of pebbles of syenite and sandstone; some of the boulders are more than two feet across. The Cienega, near the head of the Yaqui, was another such lake at a comparatively recent period, and even yet it has not drained itself completely. If the Yaqui River, which there runs to one side of instead of through the marsh, were to lower its bed a foot or two—if it were to be deflected so as to run through it, or if a comparatively small channel should be opened from the marsh to the river—in a little while it would empty itself of its surplus of water, and would become, on a smaller scale, a repetition of the Constanza Valley. The resemblance would be perfect, even to the matter of a deep channel for the stream through coarse gravel beds on one side, with a finer soil on the other side of the basin; and on the gravel there is a growth of forest trees, while the present marsh would, judging from analogy in the other cases, doubtless continue a grassy tract.

There is not a spot in Santo Domingo less tropical in appearance than the Valley of Constanza. The settlement of a dozen houses is in the midst of the woods. There is not a palm, plantain, or other tropical-looking plant in sight. The frowning black mountains, shutting in the valley on all sides; the tall columns of the pine trees, with the prostrate trunks and yet solid stumps of their fallen brethren; the little houses, encircled with split rail-fences and bar-gates; the browsing cattle, horses, and sheep, and above all the crisp morning air, so cold as to condense one's breath into visible vapor, all point rather to the heart of the Sierra Nevada than to the interior of an island under the Cancer.

Directly in the Valley of Constanza, crossing its lower part, is a very narrow dyke of a cross-grained syenite, strongly mottled white and black by the large crystals of which it is composed. Owing to the depth of the gravel deposit, I could not ascertain its width. It crops out on the hill side at one edge of the valley, and extends under the soil. At most it seems hardly possible that it is over a few hundred yards, and I may have largely over-rated it. It is the more worthy of notice since it is the only eruptive rock encountered in crossing the mountain on this route, after leaving the narrow strip near Jarabacoa.

From the houses the pass continues to the southwest, leaving the valley within a mile of the settlement, and, climbing over a little low divide, it crosses a branch of the Limon, and then winds for several miles along hill sides by a trail cut into the slope. Although over very rough ground, the trail is good; and although no repairs have been attempted for years, it shows that it was made with considerable labor and at no little expense. It is said to have been cut for military purposes by the Haytians, who seem to have considered Constanza a point of strategic value, despite its difficulty of access. After winding along for several miles, almost always on the steep hill side, it descends the point of a spur several hundred feet to the back of the river, where a little flat furnishes the necessary space for a herder's shanty and cattle-pen. The half-acre enclosure was full of grass and supplied abundance of fodder for our animals. The descent of the hill was rendered the more difficult from the fact that it was not only so steep as to necessitate a zig-zag trail, but the rocks were laid bare by the washing away of the surface, and the foothold of the horses was extremely insecure; at the same time this denudation furnished a splended section of a couple of hundred feet at least of a dark brownish, nearly black argillaceous slate, dipping south about 35°. From the "Rancho de Limon," as this place is called, the route follows the left bank of the river two or three miles to Hondo Valle, where, on the nearly flat points of two or three hills, level enough to perch a house or two, there are three houses, occupied by as many families. What possible reason there is for people to live in such a place as this does not appear to the passing traveller. The country is not so over-populated that they should be driven here for want of room elsewhere. They can cultivate little or nothing, and it would seem that cattle or pigs would run wild if turned loose in these hills. Still there must be some inducement, for the settlement is an old one, and the people inhabit it constantly. The river cañon is so narrow that there is hardly room for a trail, and the old one was destroyed by encroachments of the river but a short time before our visit. Another, however, high up on the hill side, formerly used only in times of freshets, is now used constantly, and although much rougher and in most cases more dangerous, is by far the more picturesque. At every turn one can look down into the foaming river, rushing past precipices or between narrows of nearly black slate; and in one place, where there is a little grassy flat, the river has washed away the softer slates, and left reefs of sandstone strata hundreds of feet long projecting through the grass and running east and west, dipping south as high as 60° to 80°. Again the road descends one steep hill to cross the river and ascend one still steeper, where one has to be guilty of the meanness of helping himself to climb by holding on to his poor horse's tail; and arrived at the top, the least enthusiastic will be forced to stop to admire the grand scene behind him. Perhaps nowhere on the island is there a finer mountain prospect than from this spot. The heart of the island looms up in full view; peaks eight and nine thousand feet high shut in the picture. The Rucillo on one side and Loma Tina on the other rival each other in height, while a dozen others, hardly their inferiors, stud the interval. The mountain slopes are so steep that it would seem that nothing but a goat could traverse them. The river is a mere thread of white foam, so distant that its roar is no longer audible, and the houses of Hondo Valle, dwindled to the size of pebbles, would not be distinguishable but from a little cloud of smoke ascending from the flat. To heighten the effect and add interest to the view we saw two or three vagrant rain-storms travelling about among the hills, and one coming towards us caused an abundance of anxious speculation as to whether we would be able to avoid it or not. Of course our luck took us directly into it, and we had the fun of descending a thousand feet of steep hill side, where we were forced to dismount, and in the face of a pelting shower. But before this we rode two or three miles over ridges, coming in one place to a little marshy spot called Cañitas, in a depression where broken-down pasture-fences and a couple of dilapidated shanties told of former occupation. This seems to have been a military post, now abandoned as unnecessary. From this, one trail runs southwest to San Juan, while the other, our route, goes south to the Rio de los Cuevas, and thence *via* Tubanos to Azua. Very soon after leaving this spot, unusual from its having a spring from which runs a permanent stream of water, the route following the ridge descends the spur to the Rio del Medio, which it crosses through and over boulders of hard sandstone, derived from beds interstratified with the shale. Here palms again begin to make a marked feature in the vegetation, and in fact on the hill side are the most abundant trees. A climb of a mile and a half, with an ascent of perhaps more than a thousand feet, took us to the summit over the edges of slate dipping south almost vertically. Crossing the top of the ridge, we descended through woods whose conifers had nearly disappeared, and from which they soon became entirely absent, and in which the familiar cabbage or " royal " palm soon became common. This encouraging sign was soon followed by the appearance of three or four houses—the hamlet of Lagunas, so named from a pond or two, probably the rain-water drainage of the surrounding hills. From Lagunas a gentle though long slope runs down to the broad gravelly bed of the Rio de los Cuevas. While slates of all the forms described in the preceding pages make up all of the region just described, they are so up-tilted that no order of sequence could be made out among them; and although a southern dip predominates, it is not possible that all of this distance is made up of a succession of regularly superimposed beds up-tilted. There has been much folding, and since all of the dips are high, it is not impossible that there may have been some inversion, some folds tilted backwards. Unfortunately the entire absence of beds of limestone in this section deprives us of the most valuable key we have found for unravelling the problems of stratification elsewhere. We only know that the same high dips continue out under the plain, and even beyond Tubanos the shale is vertical. Below Lagunas, on the southern face of the hill, the upturned edges of the slate are overlaid by horizontal beds of a coarse shingle deposit of Post Pliocene age, the margin of the coast formation. This will be referred to again in the description of the geology of the south side of the Island.

Returning to Jarabacoa, the only road leading out from the valley, except that to Humunucu, is the camino real to Vega over a ridge. It crosses a mile or two of valley over the Jimenoa and the Yami. The former has a broad sandy bottom, interspersed with many large boulders of the syenites of the belt just south of the town and through which it flows a little further to the southeast. Its banks show jaspery and clay slates cropping out in the bluffs. A couple of miles northeast of Jarabacoa a gray claystone crops out, though the greater part of the rock is talcoid. In the vicinity of the Yami River there are numerous quartz veins, and the river itself yields a little gold, this being the only locality in the neighborhood where the metal has been found. After crossing the Yami the trail climbs to the top of a high ridge and follows along its summit through a beautiful open growth of pine timber, and over a bright red soil, almost all of the way in view of the Valley of Vega. The rocks are nearly everywhere a light-colored greenish-gray talcose slate, often with the soapy feel of steatite. In a few spots I found beds of sandstone interstratified with the slates. These beds, nearly vertical, have a dip towards the valley near the south end of the ridge. At the other extremity no dip could be made out with certainty, although in more than one case I thought I could detect a lamination, that seemed to point to a rather low dip southward. At the northern end of the ridge, just as the road commences its descent towards the Camu River, there is a little seam of an asbestus-like mineral, which has not yet been submitted to the examination of a competent mineralogist. Although the vein is hardly an inch thick, the fibres, running longitudinally or a little obliquely, are some of them three inches long. This is almost the only case where a mineral specimen of scientific interest has been discovered during the progress of our work, unless the little alum efflorescence at the mouth of the Jimenoa can be included in the list. At the foot of this same ridge the rock changes into a brownish-black serpentine, with oblique curved cross-fractures showing sufaces like "slicken-sides." This makes a part of the bed of the river and changes into a little different color in the bank on the opposite side. Here the cleavage surfaces are smeared, as it were, with a lighter color, while fractures show the interior to be nearly black. A couple of miles of nearly level ground in the valley, and two more crossings of the river, with occasional outcrops of light gray talcose slate, takes us to the village of Vega, spread out on a beautiful plain on the verge of the Camu River.

The *debris* of the Camu is instructive as illustrating the geology of the nearly inaccessible and entirely unfrequented hills through which it flows. I found a black-and-white coarse-grained syenite coming from the belt near Jarabacoa, very similar to some from the Jaina. Other pebbles of finer grain are not rare, and among the usual varieties of metamorphic slates and sandstones, including those just mentioned above, I found pieces of a dark-green metamorphic conglomerate, with small pebbles, almost identical with a bed in the Ocoa just south of Maniel.

Vega is the radiating point of all the usually-travelled routes across the sierra. The Jarabacoa and Constanza Pass is continued by a "camino real" to this town, while all other outlets to Jarabacoa are simply mountain trails. From here the Boneo road sends one pass across by Mount Vanilejo and another down the Jaina, while the Cotui road also sends off two branches, one to Yamoso, the other across the Sillon de la Viuda. The route past Vanilejo to Maniel was explored by Mr. A. Pennell, whose notes furnish me with all the information I possess as to that part of it lying between Aguacate on the north side and Rancho Arriba on the south. The others I have crossed repeatedly, having been over the last twenty-six times, and over the Jaina ten or eleven. Although the San Pedro route (as that by the Sillon is called) is twenty miles longer, it is so much better in the absence of mud that, except in the driest weather, most travellers prefer it to the Jaina Pass. This should not be; the latter is far the best in the matter of grade, and at a trifling expense could be made a very fair wagon-road, while the heavy hills of the Sillon and Cuesta Blanca can only be crossed comfortably by horse-trails. The road from Vega runs at the margin of the hills for seven miles before it branches, when one part starts nearly south to Bonao, and the other branch runs east-southeast to Cotui. The latter road skirts along the extreme outer margins of all of the hills, and is almost without exception level, while the former though by no means mountainous crosses occasional spurs. Four miles southeast of Vega on this road, before reaching the fork, there is in the middle of the road a little outcrop of a rock found nowhere else on the north side of the Island, although it has been observed in several places on the plains of the southern slope. It is an impure earthy peroxide of iron, and seems to be a replacement, a pseudo-morphism, so to speak, of the slates. It is by no means extensive, and is too impure to be of any economic value. The neighboring rock is not peculiar in any respect. It is slate of various kinds, usually more argillaceous than magnesian, and with occasional beds of fine-grained sandstone.

Beyond the fork, the road to Bonao runs through a series of savanas and over low rolling spurs, climbs over the red talcose slate hills of Mas-si-puede ("More if you can") and then crosses the Yuna River, with its pebbly bed full of slate and sandstone boulders from the metamorphic rocks of the immediate neighborhood, and of hard syenite from further back in the mountains. Still further south, crossing more savanas, beyond Bonao, it ascends other hills clad with pine and covered with the usual red soil. The rock is a serpentinoid shale, not unlike that described in the Jarabacoa road, and contains numerous streaks of quartz; but so far as I have been able to ascertain, both by "prospecting" the stream—that is, washing the sand in a gold-pan—and by careful inquiry, I have never been able to learn of the existence of gold in the region. After crossing the hill, which is not very long, the trail crosses a little cañon principally remarkable for the great size of the rounded sandstone boulders in its bed. Some of these, of tons weight, are as rounded as if they had been rolled for many miles, though their source is in the hill sides that flank the ravine. The sandstone is a light gray, and the size of the boulders indicates a heavy bedding, only equalled in the formation by the thick strata of the Tablas Hills west of Bani. After crossing the cañon and climbing over rough rocks to the summit, the traveller finds himself on a narrow ridge of slates, bounded by deep cañons and often with no forest growth—rolling savanas, or, as they would be called in the United States, "prairie hills," alternating with open pieces of pine woods. In the bottoms other trees take the places of the pine, and in the low-lying savanas the "ohancha" (*hojo ancha*, or broad leaf) predominates—a tree remarkable for its rounded leaf, often more than a foot in diameter, and for its straight trunk of hard wood, much used in building or wherever posts have to be planted in moist ground. The soil is of a bright red throughout these hills, and in some places furnishes an excellent clay, used, however, only for making the coarse pottery or the red earthen pipe-heads used universally by the people of the country. The underlying shales are nearly always talcose. At Piedra Blanca there is a fissile gray slate that has a decidedly semi-crystalline look, but it is limited in extent. The same slates and same red soils continue, with a rare bed of sandstone, across the Aguacate Creek to the hill of Laguneta. In the last-mentioned stream is found the usual mixture of a few slates and many sandstone pebbles that would be very apt to deceive a careless observer. The softer material is so promptly triturated to sand or mud that it does not make a due proportion of the pebbles, while the little quartz—certainly not half nor quarter of a percentage of the rock in place—in some parts makes the greater bulk of the stones in the streams.

The trail across by way of the Maimon River, Mount Vanilejo and the Upper Nizao to Maniel, breaks off at Piedra Blanca, and follows up the bottom of the Maimon, constantly crossing the stream until it reaches the foot of the mountain. Mr. Pennell describes it as being a rough mountain trail, difficult at all times, but probably almost impassible during the rainy season. He says that the syenite belt, with which he is familiar, near Jarabacoa, comes down the Maimon, almost to the fork of the road. I have observed the debris in the Maimon to be composed almost wholly of this rock, but never saw the line of division. He further describes it as extending from there past the head of the river and across the mountain, making up the whole of Vanilejo peak, disappearing under the slates on its southern slope, near the base.

From there, the heavy bedded sandstones of Nizao Arriba, and the jaspery slates extend to near Maniel. A specimen of the rock brought on from the north face of Mount Vanilejo is a black granitoid material, containing much black hornblende, very little feldspar, some quartz, and some light reddish-brown mica. From the south side I received a very fine-grained gray syenite, and from the neighborhood of Rancho Arriba, high up on the Nizao River, Mr. Pennell brought reddish brown, fine-grained sandstone with lime seams; bluish-grey jaspery slate like that of the Nigua, and a white quartz sandstone, full of small crystals of pyrites. The last rock is entirely unlike any other encountered by us, but Mr. Pennell reports that the grains of pyrites are by no means a rare feature in the beds of this vicinity.

The Bonao pass, as it is always called, continues south from Piedra Blanca, across low rolling ground to Aguacate, crosses the creek of the same name, and a short piece of rather level ground and then ascends the hill of the Laguneta. At Aguacate, is a little settlement which extends, straggling along both sides of the road, to the Maimon River. The inhabitants cultivate a little corn and tobacco, and raise a few pigs which run wild in the surrounding forest. The place owes its only importance, perhaps its existence, to the fact that it is the last spot with inhabitants; really the last spot comfortably habitable before crossing the mountains. The hills of Laguneta are too steep and the cañons too narrow to give a good site for occupation, and, although the savanas on the summit of the Laguneta ridge are broad enough for a good-sized village, the nearest water is hundreds of feet down in the bottoms. This ridge is made up of a gray to greenish semi-talcose slate, and is full of quartz veins, some of them four and five feet thick. The quartz is so abundant here as to make a very large part, possibly as much as a third of the mass. I have already alluded to the fine views obtained from this point. Half a mile of these grassy hills take us to the edge of the woods of the main ridge, and here the scattered pine trees give way along a sharp line of demarkation to a forest in every respect tropical. The underlying rock is a white shale, very soft, easily decomposing on exposure, stained everywhere with peroxide of iron, and making a clay soil of a brick red color that is almost impervious to water. It is covered with a dense growth of an infinitude of species of large trees, tangled and tied together by long vines, some of them with trunks as thick as the trees that support them, climbing to the tops of the tallest trees and hanging in festoons or loops across every open space. Nor is the undergrowth less dense. The young trees, with their entanglement of smaller vines, the bushes and shrubs are all overgrown with the terrible yabacoa grass, a climbing plant, jointed and leaved like a grass, every leaf with a notched edge that cuts like a knife. The traveller who sees a branch of it hanging from some projecting limb, puts up his hand to defend his face and finds it, not scratched, but cut so as to draw blood; the wound being the more painful because made by a rough instead of a sharp edge. The forest continues along and over the summit of the mountain which is nowhere very high, though rising in higher peaks on both sides of the pass. Within a mile after passing the highest point the forest ends as abruptly as it began, and the savana de la Puerta, into which the road opens, is a grassy hill side, bounded on all sides with trees, a beautiful rolling slope of prairie of two or three hundred acres. Near the upper end there are many outcrops of quartz, and pieces of milky white quartz are not rare in the red soil. The Guananitos Creek, which rises in the main ridge and flows along the eastern and southern margins of this savana, contains a little gold, though probably not enough to warrant any attempts at mining; although its body of water would be amply sufficient for such a purpose. Immediately on leaving the Puerta, the road becomes a mud-hole; it runs for some distance through clay that is hardly ever dry, and is usually knee deep to horses; it crosses several small streams, in the beds of which angular quartz pebbles make the greater part of the bottom, and runs down the valley of the Guananitos, a rich river bottom, where the soil is of unknown depth—a black muck, always wet, and through which the poor horses have to flounder often belly deep in mud. But this region belongs more properly to the southern district, and will be described in that chapter.

After leaving the fork, the Cotui road passes one or two points of hills made up of clay slates and the white and red talcose slate which often look like a thoroughly decomposed granite. But few other rock exposures occur until near the crossing of the Yuna, when a range of low hills is encountered, made up of hard clay slate. These show no outcrops, except little ones in the road where travel has worn away the thin soil. The spurs to the west of the road, bordering the savanas, are almost all low, long points, wooded to their bases, and with long tongues of grassy land running up between them. Some few are isolated and very steep and of fantastic forms. Before reaching the Yuna, a little grey limestone crops out as flat exposures in the valley, and one other such crosses the road about six miles from Cotui. After crossing the river, there is a long hill a mile wide bordering its southern shore, made up of gray talcose and magnesian slate, but with no ascertainable dip. From the limestone outcrops, a strike can be deciphered running, as usual, nearly east and west. A little cross trail through the woods, follows up the valley of the Yuna to the Maimon, up its valley to the Hatillo de Maimon, and thence across the hills to Piedra Blanca. This gives an excellent opportunity of ascertaining the geology of the space between the two roads, not only along the trail itself, but of all the region around the Hatillo. The section along the River is not very perfect, showing only here and there a slate outcrop, covered with a thick soil of the usual red clay, a condition of affairs that is repeated on the grassy and pine covered hills, and across the "Ohancha" (or *Hoja Ancha*) savana between Hatillo and Piedra Blanca. But, while there is no limestone seen on the Bonao road, large hills of it occur on both sides of the Maimon at Hatillo. Possibly this absence may be accounted for by its passing under one of the numerous savanas on the road, but this explanation will hardly hold good if applied to the road between Cotui and Yamasa, or still further east on the San Pedro road via Cevico.

The Hatillo is destined to become prominent in the future, should the country ever arrive at such a stage of development as to improve its water-ways, and give cheap transportation to the coast for its natural products. "Slack-water" navigation can be practiced successfully on the Yuna and Maimon to, or beyond this point, with less difficulty and expense than on the Schuylkill River in Pennsylvania. True, there are no great coal fields to be opened, but the iron deposits of the Maimon, if not so valuable as the Schuylkill coal basin, are yet important enough to pay for improving the natural outlet that exists for them to the Bay of Samaná. The agricultural interests of the Veja Valley would fully warrant all the expense of opening the Yuna to beyond Cotui, and the iron mines of the Maimon would readily repay the additional outlay required on the remaining fifteen or eighteen miles on that river to the Hatillo. And I would not dare to say that they might not warrant the entire expense, were there no collateral advantage to be derived from the undertaking. The Maimon is deep enough to float a flat-boat everywhere except on its rapids, even in the driest seasons, and the rapids are simply gravel banks, that could be rendered deep enough by confining the stream in a narrower channel, possibly aided by occasional dredging. There is not a single rocky reef along the whole stream, and no descent so difficult to overcome as the rapids of the Ohio. None that could not be ascended by an ordinary steamboat, towing its barges, as is practiced on the streams of the Mississippi Valley, or on the Feather River of California.

The Iron Mountain of Hatillo is on the south bank of the Maimon. It is a rounded hill over a hundred feet high, several hundred feet long and, in all, about three or four hundred feet across, from the savana on one side to the base on the other, almost touching the river bank. The side nearest the river is a solid mass of semi-crystalline limestone, more nearly resembling marble than any other rock on the island; while the southern half is an equally solid mass of very compact magnetic iron-stone, composed of between 67 and 68 per cent. of metallic iron, according to the analysis of Professor Chandler, of the Columbia College School of Mines, of New York. Thousands of tons lie scattered over the surface or embedded in the soil, only requiring to be picked up. There is no section exposed whereby its character can be ascertained, and without excavation it would be hazardous to venture an opinion as to whether it is a vein or simply a lenticular mass. The latter seems the more probable hypothesis, since the outcrop is so limited longitudinally, and judging from analogy with similar masses in the United States. Beyond the hill, all signs of metal disappear on the surface, except such stray blocks as can with a greater show of probability be attributed to the hill itself. But for all practical purposes, the Iron Mountain is an inexhaustible mine. Its advantages are enhanced by its proximity to a navigable stream, the nearness of limestone and by its being in the heart of a great forest where unlimited supplies of hard wood can be made to yield all the fuel required for furnaces. Nor is this hill the only deposit of the mineral in the vicinity. I visited one other about three miles distant, where the quantity of iron was still greater but, though equally well situated with reference to flux and fuel, its facilities for extraction are not so good. It is on the opposite (north) side of the Maimon Valley, in the hills, and where a railroad could be made without difficulty to the river; but the three miles, more or less of land carriage, though trifling, is a comparative disadvantage. It is a curious sight to see, as in that case, a mountain stream, tumbling and splashing down a steep ravine, under, around and over great boulders, many of them several feet in diameter, and all of them solid, black ironstone of the finest quality. Although I was told that other equally valuable "iron mines," to the number of three or four, were known in the vicinity, I could obtain no guides to them or reliable information concerning them. I spent a couple of days in fruitless search, accompanied by persons who professed to know them, and finally abandoned the hunt, with the impression that they did not exist. It is not impossible however that I was purposely misled by my guides, good hearted but ignorant people who, not understanding the object of my visit, may have become suspicious.

In the same vicinity are some "copper mines" which have been known for generations. They are two or three miles to the southeast of the Hatillo, on top of a bare, grass-covered hill from which an excellent view of the north flank of the range can be obtained. The rock is a talcose slate of a light yellowish brown color and is stained everywhere with copper. Little grains and sometimes even good sized lumps of green and blue carbonates of copper fill cavities, but not the most remote approach to vein structure exists. Here have been the most extensive mining operations in the Republic, except those in the copper mine of Monte Mateo, on the Nigua. Many surface-pits have been dug, numerous cross-cut ditches excavated evidently in search of an outcrop, and one shaft is said to have been sunk. But the caving in of the shaft, accompanied by a fatal accident, the death of the father of my guide, many years ago, led to the abandonment of all further prosecution of the enterprise; but none too soon for the pockets of the miners. There is no possible chance for the discovery of a vein on the spot. In many of its features it is most curiously like the hundreds of copper mines of the California coast range, and like them, the little "copper stain" has sufficed to delude one party after another. I see no reason to disbelieve the stories told me, of nests of copper ore being found and smelted, and of ingots of the metal having been obtained. This frequently occurs under similar circumstances elsewhere. At the "Osos" mine near San Luis Obispo, California, the superintendent informed me that the mine had yielded up to the time of my visit about $5,000 worth of copper, and at a cost, as I learned on a little cross-questioning, of about $5,000 worth of gold. But neither of us could then see any very encouraging prospect of more copper; though he apparently thought that so much copper gives a pretty good earnest of more gold from the pockets of the stockholders.

A mile or two from the "copper mine" there is a high grassy hill made up in great part of a coarse-grained brown sandstone, with an unusually low northern dip. It is less altered than is usually the case in this vicinity, and is a point of considerable interest in the neighborhood, on account of an efflorescence on the face of a sandstone bluff, near its summit, of a whitish alkaline substance. The "alkali" occurs as a powder, too fine and too small in quantity to be collected successfully; but on applying it to the tongue, I could detect no recognizable difference between it, and the snowy abomination of the Nevada deserts.

The pass across the mountains from Cotui to Yamasa runs through low hills almost all of the way in full view of this point. It winds southwestward, branching off from the Cevico road within a mile of Cotui, and winds its way across rolling savanas, crossing innumerable little streams and without crossing any hill of note strikes the upper waters of the Ozama. Although the easiest pass in very dry weather, it is bad when rains have swollen the streams or softened the soil. But it is capable of being very much improved; and except for its greater length, it is not impossible that this might not only be made much better than is possible with the Bonao route, but might become the best pass across the mountains. The low rounded hills and long stretches of valley which characterize the route, give it an advantage which is now counterbalanced by the great number of streams to be crossed and by the sticky mud that hardly ever dries, shaded as it is by the dense forest. Rock exposures along the road are very few and unsatisfactory, but, wherever found, they show invariably a shale, magnesian or argillaceous and without determinable dip. None of the limestone of Hatillo was seen.

Very different from this pass is the road that passes through Cevico and crosses the Sillon de la Viuda. After crossing some small savanas and rolling hills to the arroyo Chaquey, with the usual red soil on all the hills, and occasional outcrops of white and red talcose slates and some sandstones it crosses a bold hill, the Loma de los Palos. It has been observed that Mahogany is found only on calcareous soils, and, although no limestone has ever been encountered on this road, there is quite an extensive "mahogany cut" on the west side of this hill. I have never been able to decide whether this is indicative of a little outcrop of Sierra limestone, or is, as is more probably the case, due to the presence of an outline of Miocene sandstone, such as is found a few miles further east. The latter theory is the most plausible. The hill itself is quite stony, though few outcrops occur except at its eastern base where coarse sandstone blocks are quite numerous, although most of the little rock visible, in place, is the soft shale so characteristic of this region, and that differs but little from the superposed clay in consistency. After passing a little beyond the base of this hill, in the bed of the first stream, there is a good exposure of the highest member of the Dominican Miocene, a light-colored limestone, lying horizontally on the shales, amorphous, almost crystalline in appearance, though not in reality, and containing a few, but unmistakable, foraminifera—principally the little nummulite-like fossil so useful everywhere else in identifying the formation, and which is found throughout the formation from the blue shale to the top of the series. This commences about three miles west of Cevico and continues uninterruptedly to a mile south. At Cevico I detected in addition, corals and a few mollusca. After passing beyond the region of Tertiary, which extends back between the hills of the range like a bay, the road rises gradually over a succession of low-rolling savanas to a point five miles from the town where it enters the forest, and almost immediately begins to climb the high spur of the Cuesta Blanca, or white ridge; the horse-trail winding between and over blocks of coarse sandstone, some of them two and three feet across. Just beyond the summit on the southern slope, where the ridge is but a few feet wide, the trail is pinched so narrow that a horse can hardly squeeze through between the angular masses of a couple of beds or dykes of a whitish rock, which gives its name to the hill. I admit my inability to decide the character of this rock. Even under the glass, I could not determine, after many examinations, whether its whitish, granular appearance is due to the crystals of a fine-grained granitoid, or to the grains of a metamorphosed sandstone. The masses, whether beds or dykes, are so nearly vertical that I could make out no inclination to either side in the small outcrop exposed. As I have stated elsewhere, twenty-six times have I crossed this trail, and as I write, I am no nearer a satisfactory solution of the problemn than the first time I saw the rock and knocked off a couple of specimens.

Between the Cuesta Blanca and the main ridge, there is a broad valley watered by the three branches of the Arroyo Payabo, and dotted by little hills, mere undulations of the surface. The region is a pleasantly varied country of little park-like savanas, separated by stretches of forest, through which roam wild cattle and pigs, and although on the principal thoroughfare of the Republic, without a human inhabitant for twenty miles from Cevico to the one house at San Pedro on the southern savana. Nothing so strongly impresses one with the sparseness of the population as to see a tract like this, capable of furnishing comfortable and healthy towns to thousands entirely unoccupied. It sounds like "vain repetition" to say that here again, the white shale, usually stained red with iron and easily decomposed, showing no large outcrops and no determinable dip, makes all this valley and all of the mountain of the Sillon de la Viuda. This applies, almost without modification to the remainder of the range eastward, with the little exceptions which will be noted. Almost all of the streams wash out a few pebbles of sandstone and occasionally, as in the Arroyo Vermejo, south of the range, near San Pedro, the shale is a little harder than usual. There is no change in the character of the hills about Monte Plata and Boya except a diminished height. But on the northern edge of the range, the Miocene limestone of Cevico gains importance eastward; and sometimes as beds of limestone with a sufficiency though nowhere an abundance of characteristic fossils; sometimes as a sandstone, it borders the range or caps the summits, always however horizontal.

The best exposure of these sandstones is in the peculiar little hills of the west side of San Lorenzo Bay. The same hills border all of the south side of Samana Bay west of this point and form a very marked range inland. I can only describe its outline as one of which all of the highest points are on a level, and which is made up of a series of *lumps* of pretty nearly uniform size. Closer inspection shows, that these lumps are exceedingly steep hills, evidently formed by denudation, but so close to each other that no level land exists between them. Where they reach the shore of the bay, they usually terminate in precipitous walls, undermined by the "wash" of the tide to a horizontal distance of three or four feet. This same excavating force has also quarried out innumerable caverns of no mean size. I spent a week investigating this region and visited many of the caves, but found them so numerous that the task became at last somewhat monotonous. A few of the caverns are now far out of reach of the water, and in one of them I made my headquarters. The entire length of this cave is about 200 feet. It is by no means the largest; one in an adjoining hill being at least twice the size. This cave occupies almost the entire interior of one of the hills, the entrance being on one side, while at the extreme back end a window-like opening in the roof overlooks the water on the other side. Below the mouth is a broad piece of smooth sand beach covered with mangroves and cocoanut trees, from which a gentle slope of a dozen feet or more leads up the entrance. Inside, the floor is level throughout, while the roof is worn into a series of broad arches. Very few stalactites, and none of any beauty, occur in this or any of the other caves; an occasional opaque white fringe along a creek, or a massive shapeless column being about the only productions of this class. In no case did I find the slightest trace of stalagmitic floor. These caves give us one of the strongest proofs that exist of the recent and yet continuing uplifting of the land. Some of them are twenty feet above tide-water, while the arched-roofs of others are more than twice that height. Others are at lower levels, while still others are in process of formation or only just begun. The excavating action seems to take place only about the surface level of the sea. In all cases the bluffs are undermined a few feet, while occasionally the cavity extends a much greater distance, but so low as not to permit the entrance of a boat—an incipient cavern. Where the ordinary undermining only is taking place the excavation does not occur higher than the splash of high tide; a fact well proven by live mangrove oysters growing in great clusters under the shelves. The largest cave is in part open yet to the sea, which washes through a dozen doors or under low arches. The floor of the lower chambers is a beach of calcareous sandstone pebbles strewn with drift-wood and covered at high tides by the sea. At one end of this hall, so to speak, a little opening hardly large enough to crawl through, gives access to another series of large chambers at a higher level. The walls are all creamy-white, except where defaced by the smoke of the few candles and torches that seem to have entered here. These dark recesses do not seem to be favorite places of resort.

Careful search was made in all the caves where any depth of deposit existed over the rock-bottom, in hopes of finding some remains of cave animals, such as those described from Anguilla, but none seem to exist. In the cave where I slept there is an extensive and interesting kitchen-midden divisible into two eras; the older marked only by shells and a few turtle and fish bones, resting on the rocky floor, and through which I excavated to a depth of nine feet. Over this is a thinner layer of ashes with bones of birds, agouti, fish and turtles, and an abundance of pottery evidently of the immediately pre-Columbian era. Over this, liberally intermixed with bat guano, is a modern deposit of broken earthen and iron kettles and beef and pig bones, indicative of a higher, or at least, more modern civilization, though justice requires us to admit that the pottery is inferior in workmanship, in elaborateness and in beauty of design to the preceding era. It is a remarkable circumstance, that although the Indians of the pottery period manufactured polished stone hatchets and other implements equal in degree of finish to the finest ever discovered, and they are not rare, not a stone instrument was discovered in the cave, unless we except some rough rounded pebbles found among the shells, and which seem to have been used as hammers for extracting the mollusca. I may also mention, although irrelevant, that no arrow or lance heads have ever, so far as I can learn, been found in the country, notwithstanding that the jaspers of the Nigua, of which the hatchets were made, are admirably adapted for this purpose. The absence of any mammal larger than the timid little agouti, and of any birds fit for food, except the pigeons, equally difficult of approach, probably rendered the use of arrows for the chase nearly unnecessary; while not improbably fragments of shells, or the innumerable varieties of hard woods, much easier to prepare than stone-tips, may have answered the required purpose in warfare. This explanation is of course purely hypothetical.

The Bay of San Lorenzo is bounded on the west by these hills and the little outlying islands, while its eastern side is a flat sandy plain, with little patches of wood and broad savanas. Savana-la-Mar, a few miles further east, is at the base of the first piece of elevated land on this plain, a little low hill of Cretaceous shale, whose outcrops in the bluff are barely large enough to enable one to identify the formation. There is no pass across the mountains further east than this, and this road is so muddy at best of times that it has the reputation of being the worst on the Island. It is so bad that experts prefer to travel it when it is wettest, because the mud, always soft, is then less sticky, and although the horses sink perhaps a trifle deeper, they have less difficulty in pulling their feet *out* of the mud. The constant rains maintain a vegetation so dense that the sun never penetrates to the ground, little evaporation takes place and the wet soil completes the circle by stimulating to greater rankness the already too dense forest. Open places, like Savana Grande for instance, are not unpleasantly wet and prove that, the woods cleared away, the whole range could be rendered habitable; while the rains due to the trade-winds would diminish but little in quantity and would maintain a degree of fertility difficult to surpass.

On the level lands north of the hills there is but little mud, except in a few places where the road runs through strips of woods, but south of a little settlement called el Valle, the road enters the forest. At first the rolling ground underlaid by alternating strata of shales and thin-bedded sandstones, is not remarkably wet, but as soon as the hills proper are entered the quantity of mud must be seen to be believed. The summit of Loma de los Muertos, half a dozen miles in a direct line south of Savana-la-Mar, is capped with a not very thick horizontal deposit of the Miocene limestone similar to that near Cevico, in which I found corals identical with those from the Samba hills, and fragments of the tubes of an undescribed *Kuphus* which abounds in the yellow shales between Esperanza and Guayubin. These fossils, though not abundant, amply suffice to fix the age of the formation. The belt, which is a mere cap, is very narrow, and although it apparently unites, across the trackless hills with the same rock at San Lorenzo and on the margin of the Yuma Valley, I was able only to draw my deductions by their appearance at a distance. It evidently does not extend very far to the eastward. Its southern margin is soon reached and the clay slates and thin bedded sandstones reappear wherever the unsatisfactory little outcrops show themselves. The two or three miles between the base of this hill and the Savana Grande, are through a swamp of black mud where every traveller avoids, so far as he can, the tracks of his predecessors, and where, by the configuration of the surface, he is forced into the "road" his poor horses flounder belly-deep in mud. Savana Grande is a rolling prairie covered with abundance of grass and inhabited by half a dozen families who live by "taking in" travellers. But where everybody carries his own bed and board, hotel-keeping is not a "paying" business. Horse-feed is their principal source of revenue; for even the most careless are hardly content to let their horses forage without an extra feed with such a journey before or behind them. Beyond this place a succession of little savanas in the woods, with the regular accompaniment of dry and muddy places, over Cretaceous rocks, takes the traveller a couple of miles, after which he crosses another strip of Miocene similar to the first, except that it here fills the basin instead of capping a hill. It is also very narrow and but a few feet in thickness, as if it were the thinning-out edge of the deposit. After this, the ground becomes more rolling and drier, and the red and white shales, so often described, appear, bringing with them a different looking country. These continue to a high ridge, the Loma de los Castellanos, where the shales are much harder, some of them almost jaspery. Although the exposures are large and the shales project in many places, especially on the south face of the hill, I have endeavored in vain to decide on a certain measurement of the bedding. Except the vague statement that the strike, as usual, seems to be nearly east and west, I could obtain no apparent dip that was not immediately contradicted by another as well marked in another direction. The metamorphic action has almost completely destroyed the stratification of the rocks.

My personal explorations did not continue beyond this point eastward, but Mr. Runnebaum, who explored the outside of the range, both on the coast and inland (there are no roads across it except a few pig-hunter's trails), reported that no changes occur. The same slates, with ill-defined bedding, occasional pieces of sandstone in the creeks and a little barren quartz, make this region a mere repetition of that already described; while the absolute absence of inhabitants and means of communication render the obtaining of any information extremely difficult.

CHAPTER IX.

GEOLOGY OF THE NORTHERN VALLEYS AND FOOT-HILLS OF THE MAIN CHAIN.

The preceding chapter has been devoted, with one or two trifling exceptions, to a description at the same time of the central Sierra, and to the rocks which from being almost exclusively confined to it, I called provisionally the "Sierra Group." Except part of the Peninsula of Samaná, and a little outline near Puerto Plata, all of that portion of the Island lying north of these mountains is made up of the two members of the Tertiary described in preceding chapters. The long depression of the Cibao, including the valleys of the Yaqui on the west and the Yuma on the east, is underlaid by the older or Miocene group, which also constitutes the Monte Cristi range, while the more modern coast formation simply borders the sea as its name implies.

The base of the Miocene at Tabera has been already described, consisting of heavy beds of a coarse gray sandstone, highly uptilted and lying on the flanks of the Cretaceous slates at Tabera, on the Yaqui south of Santiago. From there an excellent natural section extends to the Angostura (or narrows) of the Yaqui near Santiago, the dip becoming gradually lower until at that place it falls as low as 5° to the north. The dark sandstones dip under, and the beds at Angostura are higher in the series; being made up of dark-colored shales, with seams of a dark-bluish conglomerate full of fossils from which I extracted with great difficulty some few species, all identical with those from the blue shale. This conglomerate is a very shallow water or perhaps beach deposit, being made up of rounded pebbles, broken shells and containing much fossilized wood, sometimes showing tubes of teredos. Over the dark shale there is a bed of the yellow shale similar to that near Guayubin, and at the top of the section a little white limestone, similar to that which caps so much of the Monte Cristi range, and the equivalent of that of Cevico and elsewhere. A broad depression in the strata, almost too shallow to be dignified by the name of a synclinal axis, causes the older beds to nearly disappear; but in the bluff at Santiago, cut through by the Yaqui on one side and by the little gully called the Nivaje which empties into it, a good section is obtained again, here entirely in the blue shale. The term "Nivaje shale" is ill chosen, the little stream after which it is named being a mere gutter, while Santiago, immediately adjoining the stream, is a place of importance and much more worthy of applying its name, should a distinctive title be considered necessary; or a dozen localities could have been selected whose names would have been equally distinctive and much more suitable.

At the mouth of the Bao (or Cibao) the dark shales are seen in contact with the underlying coarse sandstones just mentioned.

At Santiago, a vertical section of sixty feet through the blue shale shows its bedding perfectly. It is rarely horizontal in the valley, but the dips are invariably so low that they are hardly worth noting. Here it is a few degrees to the south.

In the valley of the Yaqui, after leaving the immediate vicinity of the town where the low hills run down to the river bank, there are very few exposures. At some distance from the river occasional outcrops can be seen, some in the beds of streams, others peeping through the soil; but in the foot-hills of the mountains and through the Samba range we have excellent opportunities of studying the formation. A rare circumstance in this country occurs in the existence of a few terraces south of the Yaqui. Those on the Mao will be noticed hereafter, and bordering the river on the "outer" Savaneta road, within a few miles of Santiago, the terraces are extremely well marked with bluff faces of river *debris*, which I estimated at eighty feet in height. The banks of the river are made up of pebbles and gravel derived from the rocks of the sierra and from the sandstone strata of the Miocene; but no exposures occur of beds in situ.

South of this, far back in the hills at the crossing of the Bao, the conglomerate beds of Angostura reappear, here of a dark red color and with the pebbles usually very small, cemented by a calcareous matrix. While these conglomerate beds and the adjoining sandstone strata have a high northeast dip, the overlying beds further north repeat the condition of affairs along the Yaqui, and fall gradually to nearly a horizontal.

The Samba hills, ending eastwardly in the loma Caracoles and loma Seboruco, are a low range, in part isolated from the main chain, and lie midway between its foot-hills and the river. They are made up entirely of Tertiary rocks, and afford some excellent sections for study. The last-named are low and are separated from the foot-hills only by narrow cañons. The road runs along the north base of the latter, and shows it capped with white limestone and calcareous limestone, dipping north at low angles, and abounding in corals of the massive forms. Very few mollusca were discovered in this vicinity. The soil between the hills and the river is a black mud, similar to that found opposite, at Ponton, and resembling that of the vicinity of Moca. Along the entire northern face of these hills, east of the Mao River, corals, more especially of the more solid kinds, are strewn over the surface or project from the decomposing rocks. Usually they are so weathered as to show no distinctive characters; but occasionally, especially where the matrix has been moderately soft, they are as well preserved and the surfaces as sharp as recent specimens. A great mass of *Meandrina* before me, picked up by myself, weathered out thus on the top of the ground, is as perfect as pieces I have fished up on the coast. The Amina River cuts through the range between these two hills, and exposes a bluff of blue shale, rich in fossils, dipping, as is always the case in these hills, at a low angle north. The strike, if such can be said to exist, with a dip never exceeding 10°, is strictly coincident everywhere with the direction of the hills, while the dip is equally constant towards the valley. At this point the Tertiary is seriously encroached on by the Cretaceous rocks which extend northward, their upturned edges being but thinly covered by the later formation. On the Guanajuma the two formations are in contact, but a few hundred yards south of the road that crosses at Bohie Viejo. The slates of the Sierra strike due east and west and dip south from 65° to 70°, while the nearly horizontal Miocene, here represented by the gravel beds of the Mao, overlie them at various levels. I found some little patches of this gravel a quarter of a mile south of the boundary, filling depressions but a few rods across.

Although the limestones continue for a little further west on the outer face of the range, they thin out gradually, and south of the Samba Hills they are represented by beds of gravel which bear the same relation to them that the Azua gravels bear to the coast limestone. In the hills covered with grass and guano-palm, over which the road runs between Bohio Viejo and the settlements on the Mao, these gravels first come in as an important matter of the formation; and here they consist of beds of coarse gravel, alternating with strata of coarse and fine sandstone, and a peculiar, very soft, earthy shale. This latter rock is especially well developed towards the

Mao, in the upper part of the hill above Naranjo and Caña Fistula, but elsewhere the sandstone is abundant. I had an excellent opportunity of examining the deposit in a section cut by a little stream running north, between the Guanajuna and the Mao. On the road, beds of gray sandstone alternate with the above claystone, both, but especially the latter, abounding in little Pectens. North of the road, following the spur, the sandstone forms a cap to the entire hill, but has been denuded away to different levels, presenting sometimes an appearance of a series of two or three steps, one above the other. Below this the gravel is exposed to the nearly vertical walls of the ravine, cut through to a depth of about fifty feet. I found an appearance of unconformability here that I have never been able to detect elsewhere. A little exposure of bluish shale in the bottom in one place seemed to dip slightly while the gravel was horizontal. The outcrop of shale, however, was too small to be depended on, and the apparent dip eastward is so unusual as to throw a grave suspicion on its reliability. The gravel shows, by its included pebbles, whence it came. All of the rocks of the Sierra—syenites, slate, jasper, quartz—are represented, and as might be anticipated a little gold is also found. No fossils occur in it, but the sandstone with which it is capped contains numerous specimens of some of the most characteristic species. On the hill I found *Conus*, *Pleurotoma*, *Pecten*, *Oliva*, and other genera identical with species from the blue shale.

On reaching the Mao River a series of four terraces is seen. These are best noted from the top of the ridge above Naranjo; those on the west side, above Hato Viejo, being better preserved and more marked than those on the east side. Their aggregate height is between two hundred and three hundred feet, and they are composed entirely of this gravel, which rests northward on the shale in the Samba Hills and south at the Angostura or narrows of the Mao, it meets directly upon the upturned edges of the highly metamorphosed green jaspery slates and conglomerate of the Cretaceous.

The gravel here acquires a development seen nowhere else, its total thickness being probably not less than three hundred feet, while at Cercado, a few miles further down the river, it dwindles to less than twenty feet. The little creek called the arroyo Guaraguano, emptying into the Mao from the southwest at Hato Viejo, has cut a section in these beds more marked than that on the Mao. The beds are there shown to be perfectly horizontal, and are made up from top to bottom of river *debris*, brought down by the Mao from the interior hills. South of this the gravels cap the ridge which runs west of and parallel with the Mao, gradually thinning out, but continuing horizontal, the lower beds disappearing first, abutting against the rising surface of the underlying rock. They continue thus almost to Guaraguano, and the top layers are always the same coarse sandstones, from which I have collected eight species of mollusca, all of which are common in the blue shale.

Down the Mao below Hato Viejo, where the river cuts through the Samba range, we have a section which is practically a repetition of that on the Amina, except that here the gravels overlie the shale. The section is an instructive one, as illustrating the relation between the gravel and the other members of the formation. The dark shale with its characteristic fossils forms the base, becoming lighter in color towards the top. Over it is the gravel, in this case unmistakably conformable, and above this the beds of claystone, described as capping the hills east of Naranjo, but here more calcareous, form the summit. These last beds, which in some places are interstratified with the upper part of the gravel, become more calcareous northward, and are really the equivalent of the limestones of the Monte Cristi range and Cevico.

Beyond the hills of the Mao this gravel widens out westward and covers nearly all of the little interior valley behind the Samba Hills. It covers the rolling plain to the Gurabo, and is there again seen on the margin of the hills overlapping the Cretaceous exactly as at the Angostura of the Mao. Where the Gurabo passes the Samba Hills the same section is repeated, with the trifling local variation that the dip is about 15° to the north. I here collected some species of fossils not found further east, and Mr. Bonaczy obtained for me a fine series, including many of the large *Cassis*, which is quite rare elsewhere. One may here tire himself picking up cones of a dozen species which weather out from the bluff by hundreds, and *Pleurotoma*, *Fusus*, *Turbinella* are almost as well represented, while the other shells, though not so numerous, are still so abundant that literally a good collection may be made here in a few minutes for the mere trouble of picking it up.

The lower part of the Rio Canna, the next stream west, yields fossils; but the exposure, while showing no new facts, is much less important than the preceding. Its course before reaching the hills is across the low rolling plains of the Mao gravel, which is here horizontal, and is underlaid by the brownish sandy shales so often referred to occurring near Guayubin and elsewhere. In some places these underlying shales are exposed in the bed of the stream. The back or southern boundary of the gravels is reached approximately where the stream issues from the foot-hills of the main range, the road crossing it in the slates.

From the crossing of the Canna to Savaneta there is a flat plain of beautiful prairie, with little rolling hills, the whole interspersed with groves or open growth of trees and a little cactus. It is underlaid by horizontal beds of the same gravel, in the upper part of which are occasional strata of a calcareo-argillaceous shale, abounding in fossils, among which the commonest are *Arca grandis* and *Pleurotoma virgo.* The formation is well exposed in numerous sections cut by streams, and in some of them beds of lignite occur similar to the Samaná coal. Near Savaneta, at the point where the road crosses the Yaguajal, the following section was obtained, mainly interesting as illustrative of the relation that the gravels bear to the underlying shale beds:

GRAVEL. (Surface denuded.)	20 feet.
YELLOW SANDY CLAY SHALES.	12 feet.
LIGNITE.	$2\frac{1}{2}$ inches.
YELLOW SANDY CLAY SHALES.	7 feet.
LIGNITE.	$3\frac{1}{2}$ inches.
BLUE SHALES.	Depth unknown.

There is little doubt but the yellow beds which are interposed between the gravels and the "Nivaje," or blue shale, are the equivalent of the yellow shales of Guayubin and Samaná, and which in those cases also carry equally insignificant seams of lignite, which there, like here, is impure, earthy, semi-laminated, and shrinks, cracks, and disintegrates on exposure to the air. It is not necessary to add that it has no possible economic value, despite all that has been said about "Samaná coal."

Although I carried my own examinations no further west than Savaneta, some of my assistants have been beyond there, and Mr. Arthur Pennell conducted a detailed survey of Dajabon, on the boundary of Hayti. He reports the same gravel to extend all of the way, and describes the little hill of la Gorra as being a trifling gravel elevation, capped by horizontal sandstone similar to the ridges between Guaraguano and Hato Viejo. He says this also applies to Loma Jacoba.

South of Savaneta, almost adjoining the town, the outer or "first" eruptive belt is observed covered by the southern margin of the gravels. Going north across the plain to Guayubin, by way of the little hamlet of Martin Garcia, nearly parallel with the Guayubin River, no large outcrops occur, but there are several little exposures in the woods and in one savana just south of the above-named village. The route lies over the beds of the above section, but on top of the gravel there are some small deposits equivalent to those in a similar position on the hill east of the Mao River, and closely resembling them lithologically. In the savana the horse-trail is worn sometimes a foot deep into the ash-gray calcareous claystone, here occasionally seamed with white streaks of earthy lime. Little bluffs of two or three feet high, of the same beds, are also exposed along the margins of dry water-courses, and everywhere fossils are so abundant and so beautifully preserved that it is impossible to resist the temptation to dismount every few minutes to pick up some little gem of a shell too perfect to be left behind, until overflowing pockets warn one to desist. The trifling thickness of the upper part of the formation in this region is worthy of note. The gravel-beds are hardly a tenth part as thick as on the Mao, and the underlying yellow shales have suffered a similar if not so great a loss. A corresponding difference also exists in the height of the Samba Hills, whether caused by a deficiency of material or by a diminution of the elevating force. They are barely fifty feet high immediately adjoining the Guayubin River, though twice that a mile or two east, and they almost entirely disappear very soon after crossing the river. The horizontal beds continue to their southern base undisturbed, and where the road first reaches rising ground, it climbs a few feet up the face of a sort of bluff, the exposed edges of a nearly horizontal sandstone, full of *Oysters* and *Spondylus*. Crossing the hills it is seen that this rock, which doubtless originally extended further south over the plain, and which is the equivalent of the sandstones overlying the gravels elsewhere, is bent into a broad curve, and its northern margin is thinned out and denuded away. I know of no case where it occurs except in the hills directly back of the town of Monte Cristi. Here a coarse sandstone forms a little tract of rolling ground overlooking the town; and although I could not connect it along any section with other outcrops, I consider it from its position to be high up in the series and most probably the equivalent of these oyster-beds, which it resembles closely in color and lithological character.

Before proceeding to a description of the north side of the valley, it is probably advisable to investigate the relation of the gravel beds and their accompanying sandstone and clay strata to the limestones and white marls which cap the Monte Cristi range, and which form the southern border of the formation near Samaná Bay. As has been demonstrated, 1st, wherever the gravels occur they invariably constitute the top of the series; 2d, when in contact with older members of the same formation they always overlie brownish or yellowish shales which generally carry beds of lignite, and in turn rest upon darker-colored (usually blue or bluish) shales; 3d, they are never found in the same area with the limestones; and finally, they are a shore deposit, the origin of which can still be distinctly recognized in the Mao and lesser neighboring mines, and in the contained pebbles and even gold, which alike point to the present central Cordillera, then simply a smaller island, as their source. The whole area covered by the deposit is a long narrow triangle, its base opening like a fan to the westward and its apex between the Mao and the Amina Rivers, perhaps not more than fifty miles long and averaging ten miles wide, unless we include the sandstone about Monte Cristi, which widens it at that point to nearer twenty. About the Mao the pebbles are often angular and boulders of great size are very common; but as the distance from this point increases, the large boulders become more rare, and there is a marked diminution in the average size of the pebbles, facts which clearly point to the Mao as the great source of supply, and to a current from east to west as the means of distribution. Its southern edge is everywhere in contact with and overlies horizontally the upturned edges of the Sierra slates, while its northern margin either thins out, as near Cercado on the lower Mao, or changes to a finer sand without pebbles, as on the Guayubin River.

On the other hand, the limestones (in which term I desire to include the true limestone-like parts of the north face of the Samba Hills, the rocks on the summit of the Monte Cristi range on the Alta Mira and Isabella Passes, those of Samaná and south of Savana-la-Mar, the calcareous sandstones of San Lorenzo, and the white calcareous marls north of Moca) will be found to be equally amenable to the above laws, first and second; by changing the titles of the rocks the third rule applies, of course; and although about Samaná Bay they are really shore deposits, these deposits were made in clear water, where no river brought down sediment or diluted the saltness of the sea. It is a fact not less curious than interesting, that in the same area there should be two formations whose whole history should be so perfectly preserved and of which one should be so perfectly a repetition of the other, as is the case between the gravel and the lime-beds of the Dominican Miocene and Post Pliocene.

There is but little to describe in the sixty miles of valley between Monte Cristi and Santiago. The sandstone strata—light gray, semi-calcareous, and containing oysters and a few corals—in the hills back of Monte Cristi have been already mentioned. After crossing the trifling elevation caused by these beds, the road runs along a clay flat in the river bottom, occasionally passing the point of a low hill made up of the sandy beds in the yellow shale. About two miles west of Guayubin, little exposures in the road show the yellowish shale, with a few yellow sandy clay beds, nearly horizontal and with an abundance of fossils. I collected several species of *Pleurotoma*, *Fusus*, *Natica*, *Conus*, *Cassis*, *Oliva*, *Septaria*, *Arca*, *Nucula* and corals identical with species from the blue shale of the Samba Hills; and three miles east of the town, where a little road-cutting of a couple of feet deep showed an exposure, I found all of the same species in abundance. The great *Arca patricia* was especially abundant; and this fossil, with the oyster and spondylus, with their thick nearly indestructible shells, resists the disintegration which destroys the smaller species, and lie scattered over the surface or mixed with the soil at a hundred points along the valley. But here it was found in place and in good condition, associated with little flakes and scales of imperfectly crystallized selenite. The selenite is doubtless derived from the decomposition of shells, and where it occurs I have usually noticed that fossils disappear entirely. Here they abound, though some are coated with glistening crystals of the mineral, showing the change actually taking place. East of this point very few fossils were found; but this is easily accounted for by the fact that the *debris* from the mountains covers the valley on its northern margin, while the river deposit hides nearly everything near its shores.

About Hatillo de la Palma the bottom is so low that at times the river overflows its banks. The soil is consequently marshy but exceedingly rich, and the forest-growth is like an island in the midst of the barren-looking acacia and cactus plains. But this does not continue very far, and soon the traveller emerges in the open sandy ground again. On approaching Guayacanes, the cactus becomes more numerous and the acacia-trees more dense until when the little village is reached. But a single house of its dozen or twenty is visible from the road. The remainder are scattered over a space of a mile, and usually one or two hundred yards from the road. The resemblance of this region to the arid plains of Lower California is very striking. The same dry soil covered with a scanty carpet of grass, the same low, straggling-limbed, open-foliaged acacia-trees: the same tall columnar cactus, with its undergrowth of *opuntias;* even the same cloudless sky, make the likeness complete. Near the cemetery, about three miles east of Guayacanes, a little dry water-course shows that the yellow shale continues, and at Esperanza the weathered-out shells of *Arca*, *Oyster*, *Venus*, *Cassis* and *Spondylus*, although mixed with surface pebbles, show that their source cannot be far distant; and Mr. Bonaczy reported to me the blue shale at Ynamagado, south of the river and but a couple of miles distant, dipping north at a very low angle.

From the little hill, hardly more than a *roll* in the plain, near Esperanza, and just off the road, one of the finest views in the valley can be obtained. The valley is so level that the hill commands a prospect over everything both east and west, while there is probably hardly a better spot in the whole region from which to see the high central mountains. It is directly in front of the Rucillo, and the whole range can be taken in at one view.

From Esperanza to Santiago but one or two trifling little exposures occur, and there, while showing a little more sandstone in the shale and a little more undulation in the beds than further west, give us no additional facts. The whole valley, from Santiago to Monte Cristi, and from side to side, is made up *entirely and only of Miocene* strata, and usually the more modern parts only of these beds can be seen in the valley, except where the rivers have cut through the Samba Hills. I make this categorical statement as a summary, because it has been asserted to be otherwise.*

Santiago lies at about the highest point of the valley, at a height carefully ascertained by barometer of 570 feet above the sea. It lies between the Yaqui and the base of a range of low hills which project from the south and nearly divide the valley into two parts. The water-shed between the streams emptying into the Yaqui and the Yuna is formed in part by these hills and in part by the nearly level parts of the valley north of them. Two roads run out from Santiago eastward, connecting it with Moca. The most northern running in the valley is entirely on level ground, hardly an outcrop being visible over its entire length. South of it a more direct route cuts across the hills, separating from the Vega road a mile southeast of the town. Along the former route, wherever rocks were observed they always proved to be a rather loose-grained, soft, shaly sandstone, the equivalent of the Guayubin shale, but more sandy, and not unlike some beds observed on the Canna River. Fossils were not detected, but its stratagraphical position above the blue shale is indisputable. In some places near the northern hills an argillaceous limestone appears. The dip is indifferently both north and south and constantly varies, but never rises higher than 8° or 10°.

La Vega lies close to the foot-hills of the Sierra in a beautiful flat plain on the

* Heneken. Quart. Journ. Geolog. Soc., London, 1853, p. 115, *et seq.*

south bank of the Camu River, and is connected with Santiago by a road running partly in the valley, partly over the hills back of the latter town. This road furnishes some opportunities of examining the upper part of the formation, here a little peculiar in that it contains an unusual amount of sandstone.

As has already been described, the bluffs under Santiago are composed entirely of the blue shale, a cross-section of which is exhibited by the cutting of the Yaqui and a lesser one by the arroyo of Nivaje. The suburb of Nivaje on the south side of that creek extends along the road towards la Vega, gradually rising on the flank of the hill. In the village, but more especially just beyond it, beds of sandstone crop out in the bed of the road and in the banks on each side, their dip being conformable with the subjacent shale. In many places they show fine examples of ripple marks, and in one instance I observed the peculiar surface called by D. D. Owen "mud furrows," similar to the figures in the Report of Geological Survey of Iowa, Wisconsin, and Minnesota, Table 1 D., fig. 1, though hardly so sharply defined. Some beds of the usual yellow claystones occur, interstratified with the harder rock, and some of the sandstone contains large pebbles. From this fact, as well as that the conglomerate beds of Angostura lie above dark shale and below limestone, it follows as an almost inevitable inference that those conglomerates are the equivalent of the yellow shale of Guayubin.

Very soon the sandstones become horizontal and even dip in the opposite direction, and about two or three miles from Santiago they show only a surface in the road-bed of a pebble-bearing calcareous sand seamed with soft streaks of lime. Beyond this they disappear under a soil of black loam, so soft when wet as to well merit the name of the "Laguna Prieta," or black lake, given to a couple of miles of road north of Puñal Creek. Where the road crosses the bed of the creek the bluffs show small outcrops of the brown shale so like the surface earth as to be hardly distinguishable. In fact it is not improbable that the latter owes its origin in great part to the disintegration of the former. Its dip seems to be to the northeast, though nearly horizontal south of the Puñal. The low hills of Caimitos, which unite Santo Cerro with the higher hills on the Verde, are made up in great part of a still higher set of beds, here a yellowish-white calcareous claystone or marl, with a marked northern dip; and on the Rio Verde itself, although the brown shales occur in the low bluffs where the road crosses it, the gravel in its bed contains corals like those from the north face of the Samba Hills, and which have evidently been washed out of limestone beds to the west.

Up the Verde from this point the section is not unlike a part of that up the Yaqui, except that the heavy dark sandstones of Tabera are not reached. They dip under the sources of the river. The brown shales and sandstones form most of the hills from the Verde northward, with doubtless a little limestone on top from which the corals were derived, although I never found it in place. Below this are gray and blue shales, and at their base some sandy beds, all more or less abounding in fossils. The bluff below the house of the Alcalde on the upper Verde is the counterpart of those in the Samba Hills on the lower Gurabo, Mao, or Amina; and a similar but smaller bluff on the upper part of the Puñal shows an equally good exposure of the blue shale with many sandy beds evidently well down in the series, where the numerous and perfect fossils richly reward the collector.

From the Rio Verde to the Camu the road is in part over a few low rolling hills of gravel, which cover the line of junction between the Tertiary and the metamorphic slates. This gravel is extremely local. Its origin is evidently in the hills directly west, but its age is not so clearly established. One little circumstance may throw some light on it. The Verde River is the only stream in this vicinity in which gold is found, and the Verde could not, with the present configuration of the surface, throw its *debris* over this area; but during the era of the Mao gravels that would have been possible, since the mouth of that stream was not far from the then shore-edge of the deposit, which is also very slightly auriferous. I am therefore inclined to suspect a synchronism between the two gravel basins, which, however, I am not inclined to sustain as a positive determination. Were the gravel not gold-bearing, or were there gold any nearer than the head of the Verde, I should not have even proposed the hypothesis.

The road across the hill from Santiago so Moca differs but little from the first part of the Vega road. Very soon after they separate, the Moca road leaves the hills and thence runs the remainder of the distance over flat plains of black muddy loam. In the dry season this bakes and cracks in the sun, and is as difficult for horses to travel over as a rough rocky surface. The same may be said of the route from Vega to Moca. Except that for a very short distance it runs over the margin of the base of Santo Cerro, it is entirely in the loamy valley. Santo Cerro is, as it were, surrounded by the two roads running out of Vega and a third which unites the two on its northern flank. It is a low hill running nearly north and south, the last spur of the range jutting out into the valley. It has already been referred to in the topographical description of the region, and nothing more need be said here of its position or the beautiful prospect it commands. It is made up of the brown shales and the sandstones of the vicinity, here dipping a little higher than usual to the northeast. On the summit I found, in a bed somewhat more calcareous than the others, *Septaria* and corals very similar in their mode of occurrence to that of the same species near Guayubin.

North of Moca no other rock exposures occur. The valley is flat to the base of the hills, and the black soil makes this vicinity one of the most productive agricultural districts on the Island. The region east of Moca and Vega is equally uninteresting to the geologist. A broad plain runs east between the two ranges of hills; the river bottom is a sheet of black alluvial soil of almost incredible fertility, while near the hills the gravel and sand washed down from their sides makes a porous soil which only supports grass and which is thus admirably fitted for cattle-raising. The sluggish Yuna winds its way through the middle of the valley, its banks, mud bluffs, supporting an almost unbroken forest, while its more lively tributaries, the Camu and the Jima, as well as the upper part of its own course, hurry between the banks of shingle brought down from the mountains of the far interior. But a single exception to this monotony exists. Near the mouth of the Camu, on the south side of the Yuna above Platanales, I found a single outcrop of white limestone in the side of the river bed. It is partly under the water, partly in the bluffs, and is very similar lithologically to some of the Miocene limestone of Samaná. It is Miocene, and is the most northern point at which the Cevico belt crops out. Doubtless the same rock would be found to underlie a great part of the valley if excavations were made.

The eastern end of the valley for a dozen miles from the mouth of the river is a tract of marsh. Part of it is almost constantly overflowed, while the more western portion is grass-covered and dry, except in cases of extraordinary freshets or remarkably high tides, when it is temporarily covered with water. It is intersected by innumerable creeks which divide with the principal mouth the task of discharging the waters of the river into Samaná Bay. The bay is simply the prolongation of the valley, and the marsh is now in process of being elevated into permanent dry land. The Gran Estero which separates Samaná from the main-land was a century ago a navigable channel, but is now entirely closed. It is said to have been closed by drift and mud from the Yuna. May not this elevation, which we have every reason to believe is yet going on, have something to do with the obstruction?

CHAPTER X.

GEOLOGY OF THE MONTE CRISTI RANGE.

The Monte Cristi range occupies about half the area covered by the Miocene rocks, and although it shows these strata bent and cut through in innumerable places by deep cañons, it gives us no new facts relative to them. Deposited further off shore, although probably not in much deeper water, its rocks are nearly devoid of fossils, and except in the highest bed where a few foraminifera serve to identify them, they might be searched from one end of the range to the other without yielding positive evidence of their geological age. This is partly due also to the fact that the blue shale from which the greater part of the fossils is obtained changes its lithological character somewhat, and does not seem to have been at the time of its deposition so favorable to the existence of mollusca life. But this can only account in part for the absence of fossils, because the superjacent beds, lithologically identical with those nearer the ancient shore, are equally or almost as barren. Among the large collections of these objects made during the progress of our work, almost the only ones obtained north of the valley were a few corals and mollusca from the hill of Monte Cristi and from the little adjoining island of Cayo Publico. I found a few very imperfect fragments of small crustaceans in the shale near Limon; but elsewhere over the more than a thousand square miles examined, no other fossils were discovered by either my assistants or myself.

Fortunately the rocks retain their general lithological characters so well preserved that there is no difficulty in identifying any part of the formation, and the structure of the chain is so simple that the labor of deciphering the various sections is comparatively trifling. Although there is no heavy folding or great disturbance in the range, there is a marked difference in all the sections I have been able to make out across it. There is no one well-defined anticlinal axis or single line of upheaval. The elevating force seems to have acted simultaneously under the entire mass, but with various degrees of intensity in the middle or at either margin. Monte Cristi is raised vertically almost a thousand feet. Thirty or forty miles east all of the force was expended on the northern margin; north of Santiago it acted most markedly near the middle, while north of Moca the southern edge alone is disturbed; and again north of Macoris, the greatest upheaval took place north of the summit of the range. West of Puerto Plata the metamorphosed cretaceous slates reach the surface, lifting the entire thickness of the formation undisturbed on their upturned edges. Most of this has since been denuded away, but Isabella de Torres still remains, an ancient beach-mark, its level top of white limestone 2,530 feet above the sea. This is the only case where the entire thickness of the Miocene can be estimated by a vertical section. But unfortunately the flanks of Isabella are so covered up by talus that the only rock accessible in place is the cap of hard limestone. Deducting the probable elevation of the cretaceous base, the thickness is approximately 2,000 feet, or a trifle over my estimate in the theoretical section given elsewhere. If, however, we were to take the thickness of every member of the formation where it is most freely developed, we could run up the figures much higher than 2,000 feet. My object was rather to give a reasonable average.

The above deductions will, I believe, be found to be fully warranted by a consideration of the details of the range as developed by the half dozen sections which I have made across it. For the accuracy of my observations, where my statements differ from those of my predecessor, whether in this case or in my preceding description of the adjoining valley, I must simply beg the indulgence of the reader, reminding him that I can have no object in disparaging the labors of a dead man whom I never saw, and that I commenced my work and carried it on with a full knowledge of his published account of the region. A due regard for truth and for my own reputation as a geological observer oblige me occasionally to contradict his assertions but I do so in no spirit of antagonism—rather with a feeling of regret that so inexperienced an observer should have been tempted to "rush into print." I make this statement to clear myself of any unfair imputations and to avoid future discussion of the subject with any of his surviving friends, should such exist.

Monte Cristi, the extreme western point of the northern range, is a narrow flat-topped hill a trifle over 800 feet high, entirely isolated from its neighbors by a broad belt of salt marsh cut through by tidal creeks communicating with the sea. Its summit is capped with a hard limestone containing foraminifera, and which has impeded to some extent the action of the denuding agencies which separated it from the main ridge. This limestone has so completely resisted atmospheric influences that its surface is nearly naked. Possibly its purity is so great that it is all soluble, and unlike the coast limestone, it contains too little aluminous matter to leave any soil after the lime is dissolved by the rains. Whatever be the reason, the dense crest of thorny bushes which it bears finds nourishment only in the crevices where a soil so scanty as hardly to merit the name has accumulated. Below the limestone the Guayubin shales come in, their upper part pebbly like near Santiago and Angostura. These gradually shade into the bluish shales of the valley in exactly the same manner as the change takes place in the centre of the valley, and the lower part of these blue shales bear occasional beds of sandstone, probably on the same horizon as those near the mouth of the cañon north of Moca, or those near Limon on the road to Puerto Plata. The mountain gives on a small scale, that is, with all of the members considerably thinned out, a section from the top, nearly three-fourths of the way to the base of the formation. The little island lying in front of the bay of Monte Cristi, called Cayo Publico, is made up of the upper part of the shale series, and both there and in the mountain itself we collected casts of corals and a few familiar mollusca, but all in a poor state of preservation.

The barren character of the Monte Cristi chain and the almost entire absence of human occupation, with the consequent scarcity of roads, combined with the fact that in this part of the range no results of economic value could possibly be hoped for, prevented me from devoting any further attention to it than sending through it a topographical party to make a hasty reconnoisance. Mr. Runnebaum obtained its principal features by a rapid triangulation, and reported to me that the only rocks he encountered were the shales and limestones of the upper part of the Miocene series. His limited experience, however, did not permit him to make observations of the details of structure sufficiently accurate to record here.

I myself followed its southern base in the valley several times, studying it from a distance, and have examined its northern face in the same manner from the prominent point at the mouth of the Isabella, which commands a view almost to Monte Cristi. Judging from the very imperfect data thus furnished, from its diminished height and width as well as from the structure of the hill of Monte Cristi and from what information Mr. Runnebaum was able to give me, it is probable that only the upper members of the formation occur there, and that the amount of disturbance has been comparatively limited. Mr. Runnebaum found it in the main a dry barren series of hills badly watered, but with a few little fertile spots where the natural irrigation supplied the deficiency of rain. The coast is almost impassable on account of thickets, mangrove-swamps, and quicksands, and he was obliged to go from Monte Cristi to Estero Balsa in a boat in consequence of his inability to force his way through the thorny brush over the hills. The bad trail from Guayubin to Estero Balsa is the only road across the range between Monte Cristi and the Isabella Pass. From this another trail branches off at Tiburcio in a central valley and runs east, uniting with the latter route, and is sometimes used by the people of Guayubin in going to or from Puerto Plata.

The Isabella or Bahabonito River rises near the centre of the range north of Santiago in the vicinity of Alta Mira, and its upper branches cross the pass that runs through that place. Thence it flows northwest along a valley in the middle of the range, and empties into the sea about twenty-five miles in a direct line west of Puerto Plata. At its mouth is a little bay, a mere rectangular indentation in the coast, opening to the northwest. The southern shore of the bay, a nearly east and west line, is bordered by a sand-beach and mangrove-swamps, behind which rise the yellow barren Tertiary hills scantily covered with cactus and acacias. Among the latter, one species, the "divi-divi," abounds. This tree yields a seed very rich in tannin, which is collected extensively for export, and might be made with industry an important article of commerce. Further back in the hills satin-wood and Guayacan (lignumvitæ) are not rare, and the little settlement near the mouth of the river, owes its existence, I dare not say its prosperity, to the export of these two woods. The eastern side of the bay is formed by a high bluff of horizontal coast limestone, the top forming a table, running back with some trifling undulations a couple of miles to the low miocene hills of the range. The surface of this table-land is strewn with blocks of the same limestone and fragments of corals weathered out, and is covered with a scanty layer of the characteristic red soil always found over this formation. It supports a tangled "monte" or brush-growth of nearly all the species of cactus found in the Island, interspersed with acacia and thorny vines, as forbidding a thicket as it was ever my unhappy duty to force my way through. To the geologist one look at the place would suffice; but the temptation to visit the spot where Columbus made his first settlement was too great to be resisted, and I yielded, to the great risk of torn clothes, scratched face, and ruffled temper. He must have an angelic disposition who can walk a mile through bushes covered with the "cat's-claw" or "wait-a-bit" vine and emerge in a serene frame of mind. In the heart of such a tract Columbus founded the first colony.

The valley of the Isabella is, as compared with that part of the Santiago Valley immediately south of it, comparatively fertile. There is a succession of houses for several miles from its mouth and, while there is nothing very attractive in the beauty of the little "conucos" along the road, they show an amount of fertility in the soil and a rich green of their crops which indicate that the dews must here supply in part the scarcity of rain. The further back one goes into the mountains the better is the appearance of things, and the thick carpet of grass at Laguna and the good size of the plantain trees prove that in this part moisture is not deficient. From Laguna the road divides—one part runs up the valley joining the Alta Mira Pass, while the other continuing south commences at once to ascend the hill. For some distance it continues over rolling ground, past one or two groups of houses, and then suddenly climbs a steep ascent to the summit of the range. At the base of the hills where the trail first leaves the valley there is a little exposure in the bed of a rivulet where the sandstone beds near the bottom of the series stand vertically. On ascending the hill we find more modern strata coming in, although the shale is but poorly represented, its place being taken by their bedded sandstones. These first dip at very high angles to the south, but gradually assume lower dips, and the higher one climbs the hill the lower he finds the dip of the strata, until near the summit the limestone is found capping the hill and dipping southward at low angles. I was not able to measure it with certainty, but it is not far from 20°. The limestone shows only its *edge* on the north face of the mountain, and although it is unusually compact, differs in no other important respect from the same beds elsewhere. On the south face of the range it is cut through by the stream along which the road runs, and near the base it is seen to be underlaid again by the same rocks as on the north side.* Beyond the base of the hill a long gradual slope of gravel, the wash from the arroyo, borders the valley and is, as usual in this region, densely overgrown with cactus and acacias. The high angle to which the sandstones are uptilted on the north side of the mountain, while unusual in this range, is not entirely peculiar; nor does the disturbance necessarily extend to a great distance. A similar upheaval will be described north of Moca which not only does not affect either side of the range greatly, but is actually reversed in both the adjoining sections.

The next pass east of the one just described is the one most travelled in crossing the mountains. It begins nine miles west of Santiago, at Limon, crosses the range west of the high peak of Diego Campo, and passing Alta Mira and the head-waters of the Isabella River, crosses the lower spur on which is perched Mount Isabella de Torres, and descends to the plain near Puerto Plata. Its entire length, including the nine miles in the valley, is forty-one miles, and the thirty miles of mountain section is one of the most interesting in the chain. Near the base of the mountain in the cañon of the Limon Creek it is evident that there has been some disturbance even where the surface configuration does not indicate it. While the shales in the valley are usually undulated, dipping in all directions at angles of from 5° to 10°; here they suddenly pitch northward as high as from 30° to 50°, and bring to the surface the

* I desire particularly to call the attention of the reader to my section along this route and then to the section (*Quart. Journ. Geol. Soc.* 1853, *p.* 119, *fig.* 3) of Mount Murass which immediately adjoins the road or its east side, and which of necessity must have identically the same structure. Beds No. 10 and No. 1 of that section are in reality identical; Nos. 2 and 3 are the equivalents of No. 9, which shall be under instead of over No. 10; Nos. 4 and 5 equal No. 11; and the No. 10 on the north flank does not exist!

gray shales with intercalated strata of sandstone belonging to the lower part of the blue shale series. This upheaval is not extensive and the base of the outcrop near Piedra Gorda shows a marked curve, the beginning of a synclinal axis. Near Lima I found a dark gray conglomerate with broken fragments of shell very similar to the conglomerate bed of the Angostura of the Yaqui; but directly on commencing the ascent of the hill the brown shale of Guayubin appears, and dipping to the south extends to the top of the pass. Near the summit the higher hills on both sides are seen to be capped with the usual white limestone, apparently nearly horizontal; but it is not encountered anywhere on this part of the road. In the shale ascending the south side of the hill near the summit, although fossils were nowhere seen, I found white earthy concretions rarely more than an inch or two in length, very irregular in form, and usually more or less botryoidal. They seem to be a little more calcareous than the surrounding mass. On breaking them open I could not detect any fossil around which they might have segregated, as is sometimes the case in these bodies. They are perfectly homogeneous in structure. East of the road the sharp peak of Diego Campo rises, according to barometrical measurement made by Mr. Pennell, 3,855 feet above the sea, the highest point in the Monte Cristi range. That gentleman reports its summit to be of limestone.

From Alta Mira to the little streams which form the head of the Isabella the road runs along a very muddy clay ridge, where nothing can be seen of the geology; but further on, the shales with occasional sandstone beds are seen to have dipped northward again, and only pebbles of these sandstones are found in the beds of the watercourses. A little further along a coarse, soft, grayish-brown sandstone occurs, dipping at a very low angle northward, and full of the characteristic foraminifera, especially *Orbitoides*, which have so often proved useful in identifying the formation. Still further north on the summit of the last ridge the limestone occurs capping the ridge as a brown or coarse-grained gray or even white rock, in almost every case full of foraminifera. In one place it is of a pinkish white and without these fossils.

On descending the north face of the ridge about four or five miles back of Puerto Plata a marked change takes place in the rocks. The absence of good outcrops here makes it difficult to be very certain about this part of the section. A series of metamorphic sandstones, some of them micaceous, crop out on the road. They are nearly horizontal, dipping slightly to the north. A more extensive study of the surrounding region leads us to believe that these are the base of the Tertiary, altered by contact with the Cretaceous, which has pushed them up and which crops out very near here. Their dip and even their lithological structure help to corroborate this theory; and thus we have here a repetition of the state of affairs at Tabera, on the

Yaqui. No outcrops occur on the plain, but the bluffs about Puerto Plata are made up of the ordinary coast limestone.

Although where the road crosses the ridge which forms the base of Mount Isabella the oldest rock found is the metamorphic sandstone just described, a little west of the town where this ridge reaches to the coast a very different condition of affairs is discovered. It is here found to be made up of the magnesian slate of the Sierra, lithologically identical with the typical localities in the central chain. Its most usual character is the light greenish-gray semi-talc similar to that in the ridge between Vega and Jarabacoa, or to that of many of the localities around the peak of the Gallo. Its metamorphism is so complete that no stratification is discernible, though the semi-lenticular flakes into which it usually breaks are more generally "on edge" than horizontal in position, as if the dip was probably vertical or nearly so. As is intimated in the preceding paragraph, the presence of this intrusion of Cretaceous under the nearly horizontal Miocene is sufficient to account for the alteration of the latter, when we bear in mind that similar causes have produced like effects at Tabera, and that in going east from the locality in question on the Palo Quemado route the metamorphism gradually dies out. Mount Isabella de Torres, the best landmark on the north coast, after losing sight of the headlands of Samaná on one side or Monte Cristi on the other, is a flat mountain which gave to Mr. Pennell a height of 2,530 feet. Schomburgk marks it in round numbers at 700 metres. One or the other is evidently in error. The latter, in his account of his visit to Constanza, in the *Athenæum Journal*, speaks of his having used on that trip an aneroid barometer, and it is not improbable that in this case his measurement may have been made with an equally unreliable instrument. Mr. Pennell's observations were made with one of Green's best mountain barometers of the Smithsonian pattern, an instrument which the extensive mountain work of the Californian Geological Survey has proven to be without a superior. By comparison with my office standard it was proven to be in perfect condition both before and after the observation, so I can hardly imagine the possibility of an error. There is certainly none in the computation of his observations. This mountain is capped with a thick bed of white limestone, below the edge of which the talus covers up all outcrops, so that the details of its structure are not accessible; but we are bound to infer that the highest member of the formation being found at its summit and the oldest being seen at the level of its base, the intermediate strata are in all probability represented at their various levels in its interior. We have thus a pretty good criterion for judging of the thickness of the formation at this point, as stated in the preliminary observations on the range.

West of Puerto Plata a narrow strip of coast limestone borders the sea, making bluffs of from forty to sixty feet high, in some cases forming bold headlands. Nowhere is it very wide, and the encroachment of the sea is slowly but surely undermining and wearing away the little remainder. I traced it as far as I went, to Isabella; but from the contour of the surface beyond that, as seen from that point, I do not think it makes a notable feature in the geology.

While the Alta Mira Pass crosses the head of the Isabella River and skirts around the west side of Mount Diego Campo, the Palo Quemado Pass running around the east side of the same mountain, crosses the upper part of the Yasica River. The upper part of the yellow shales, occasionally calcareous, are seen in the valley before reaching the hills, rolling with a general east and west strike and dipping north or south indifferently. The trail runs up a long spur of the Palo Quemado mountain, showing first the yellow shales with a little limestone dipping towards the valley and exhibiting their edges on the crest of the ridge. At the summit of Palo Quemado Mountain a little yellowish limestone remains; but on descending on the north side the rocks are encountered in a regularly descending series to the bed of the Yasica River, here a stream of half a foot deep and twenty to thirty feet wide. In its bed gray shales with a little sandstone form nearly flat ledges, with little dip in any direction. Mixed with the pebbles of these sandstones are very numerous boulders, some of them over a foot in diameter, of a tough coarse-grained syenite, undistinguishable in any of its characters from similar rock in the Cibao range. This syenite was not seen here in place, and I might have been tempted to have considered it as derived secondarily from a conglomerate had I not seen it elsewhere forming large dykes cutting through the Tertiary rocks. The large size of the boulders and their great number, not less than the comparatively short course of the river, prove that the dyke from which they were derived is not far off. A little settlement, called Yasica Arriba, of four or five houses occupies a pretty little open spot, comparatively level, bordering the river. The people, as is usual among these mountaineers, earn a scanty livelihood from the herds of half-wild pigs that roam through the woods; a not very remunerative occupation, but one that involves plenty of healthy out-of-door exercise in capturing their property when they desire to avail themselves of it. From the crossing of the Yasica the trail crosses another high ridge composed of similar shales and sandstones with a constant east and west strike and with a low but marked northern dip. Towards the northern base the rocks become entirely sandstone and show evident marks of metamorphism, though not so strong as those near Puerto Plata. About four miles from the town I found a brown sandstone with minute specks of mica, as it were an intermediate stage between the unaltered sandstone and the fine-grained silver gray mica slate of Corozal, which is doubtless derived from the same formation.

The coast limestone of Puerto Plata extends eastward along the sea, nowhere, however, so important a formation as it becomes on the south side of the Island. Instead of forming a great rocky bluff hiding everything under it, it modestly skirts little patches, sometimes barely shows itself through the sand of the beach, or is covered up under the high sand dunes, or again appears as broad shelving reefs extending far out to sea with an almost imperceptible seaward dip. In some cases, however, as near the little River Susua, it makes low hills of limited extent, being pushed up alone with the older Tertiary that forms their bases. It also most probably underlies the numerous little "flats" and valleys which border the north side of the range, and which make some of the prettiest farming sites in the country. Among these may be named as pre-eminent Batei and Caberete. West of the latter place there is a peculiar spot, different from any other I have seen on the Island. The low-lying coast and the constant beating of the winds and waters of the Atlantic render the north side much more liable to be covered by sands drifting up from the beach than the south side. Sand-dunes are the exception rather than the rule where the forest does not reach to the water's edge. On the other hand, the greater exuberance of vegetation in this tropical region acts as a partial check to the drifting sand, and the forest crawls seaward about as fast as the sand dips inland. From this never-ending struggle there results many small dunes, their windward face smooth from the renewing influence of the wind, while the leaward side is almost always covered with brush, whose growth keeps pace with the growth of the hill, and by opposing a wall to the wind, eddies back a large part of the sand that would otherwise creep inland. But at the Palmal tens of thousands of the Canna palm, young, form a grove of two or three miles in extent, with but little undergrowth except trees of the same species, their roots firmly knit into the crevices of the underlying limestone, and the soil a shifting layer of beach sand which drifts into the grove, but with the force of the wind so broken by the innumerable tree trunks that it is spread out evenly instead of being piled up in the familiar ridges. The sand is as loose and shifting as a dry beach, and so barren that hardly a blade of grass or a bush can find nourishment in it; but the palms thrive admirably.

The next opportunity for the study of the range that exists east of the Palo Quemado route, is the road from Moca, by way of Jamao to Batei. This pass ascends the side of a cañon in which the dark gray shales and beds of sandstone of the lower part of the shale series dip first as high as 50° north. Great exposures, some of them two hundred feet high on the hill sides, show beautifully the bedding of the strata, and prove that in the spaces between the edge of the hills and the present site of the town of Moca the upheaving forces must have had full play. But the limited extent of their influence is proven alike by the nearly undisturbed condition of the formation between Moca and Santiago, and by the southern dip of the beds on the south flank of Palo Quemado Mountain, hardly a dozen miles distant to the west, and on the Macoris Pass, barely more than twenty miles east. Ascending the mountain the dip continues to the north, gradually becoming lower, while the rocks are passed in the usual ascending series until near the top, instead of the white limestone heretofore found capping the ridges, we find a white highly calcareous marl with casts of foraminifera and a few very rare mollusca of species abundant in the blue shales of the valley and more common still in the brown shales of Guayubin. Here the dip is so low as to seem horizontal, though from finding the same rock further north at lower levels it is probably at very low angles northward.

Descending the hill to Jamao we again descend in the section and find sandstones and brown shale cropping out in the valley. After crossing the river there is a low ridge of the same brown sandstones and shales with very low northern dips, succeeded by a nearly horizontal very thick bed of cream-colored limestone forming the outermost foot-hills at Batei. In this, I found a fragment of a badly preserved *Pecten*, too imperfect for specific determination. Here this limestone is worn into a well-marked ancient terrace apparently of the era of the coast limestones which abut against its base.

At Batei I picked up in the soil a whitish granitoid rock composed of white quartz and feldspar, and small but remarkably distinct crystals of a silver-gray mica. It was but slightly rounded on the angles as if not transported very far. But I have never seen a similar rock on the Island. It is probably from same small dyke in the mountains.

From Batei to the Rio Jobo is a continuous sand beach after leaving the vicinity of the houses of the former place. But on the east side of the Jobo a new style of coast begins and continues almost uninterruptedly to Samaná. The hills come down to the coast and the trail runs along strips of sand, then over a hill through bushes and over rocks to repeat again the same story of sand, bushes and rocks, until the weary traveller is heartily glad to reach the miserable little hamlet of Matanzas. The last route eastward where a trail crosses the range and consequently where a section can be obtained is from the north of the Jobo River, up its cañon and across to Macoris. The trail from Macoris to Matanzas is of no geological value since it runs almost exactly along the strike of the rocks, and further, except crossing a very low ridge almost its whole length is in the bed of a creek, which it crosses, stumbling among sandstone boulders so many times that one gives up counting in despair.

The rocks on the Jobo trail while striking as usual about east and west, show a more than ordinary amount of disturbance. Near the mouth of the river, heavy bedded sandstones and conglomerates are found which continue to and beyond the little settlement of two or three houses called Blanco. The resemblance of some of these coarse-grained sandstones to those near Puerto Plata, which are more or less metamorphosed, is so striking that I could not resist the impression that they are the same beds. Nowhere else, beyond the north face of this range, unless it be on the south edge of the formation on the Bao and Yaqui, have I observed the peculiar appearance possessed by them. It is one of those intangible characteristics that one recognizes but cannot describe. It is nothing remarkable; nothing more than a similarity in "grain" and in general appearance. The dip changes constantly; sometimes it is north, sometimes south, and its angles are also sometimes quite high. At Blanco, which is but a short distance north of the summit, there are thick beds of sandstone studded full of large pebbles which dip about 25° south. Above this point, the more recent members of the formation appear regularly with gradually decreasing southern dips until at the summit we find the white earthy limestone capping the range and nearly horizontal. Further south, descending towards Macoris, the brown shale is again met under the limestone dipping south and passing under the valley.

About five miles south of Blanco, on the trail, is a dyke of syenite about 200 yards wide, cutting directly across the road. The exposures at its sides were so small and so covered up by the soil that I was not able to ascertain whether its presence produced a local metamorphism of the adjacent shale. Like the boulders in the Yasica, it bears a remarkable resemblance to the intrusive rocks of the Cibao range. Where I crossed it, it was coarse-grained and composed of white feldspar, but little quartz with black hornblende, and contained a green mineral resembling augite. A mile or two east it is cut by a stream running down to Macoris, from the bed of which I collected specimens much finer-grained and without the green mineral. If these specimens were mixed with the Sierra series they would defy the most expert petrologist to find a distinguishing character. And yet the Sierra slates were upheaved by these intrusive rocks, and the Tertiary deposited indiscriminately over them and over the upheaved edges of the slates. If further proof of the pre-Tertiary, or rather pre-Miocene age of the Sierra syenites is required, the presence of pebbles of these rocks in the conglomerates at or near the base of that formation furnishes it. And here we have similar syenites cutting through these very beds of conglomerate.

From old Cape Frances the extreme northeastern corner of this range, which I have never visited, Mr. Pennell brought me a rock identical with that which occurs on the point of Cape Cabron, and which indicates the probable existence of the Sierra group in that neighborhood. Some of the Sierra limestones of Samaná are of a peculiar dark blue, semi-crystalline in structure, like an imperfect marble. At both of these places such a rock has been broken down into small splinters and angular fragments and re-cemented by a yellowish stalactitic deposit, making a coarse breccia with numerous cavities.. The resemblance between specimens from these two localities is perfect, and since the blue rock from which the fragments are derived at Cape Cabron is in place, the deposit being a sort of talus, I infer that a similar condition of affairs exist at Cape Frances. How much of this part of the range may consist of this formation we do not know. This is one of the problems for future geologists to solve. Mr. Pennell found it at all of the points from Punta Laguna Gringrisa to Cape Amaras. It must be understood that all of this region goes by the name of "Old Cape Frances," which is not applied to any one particular point. From the topographical structure, and from the fact of the rock being only found on this one spur, it is probable that it will not be found to extend much beyond a line drawn from Cape Amaras to the north of the San Juan. But he is not to be envied who shall settle the question. The interior region is entirely uninhabited, there is not a road or trail through it, and it is practially impenetrable. It consists of a broad mass of low, heavily wooded hills, never visited except by a few pig-hunters.

CHAPTER XI.

GEOLOGY OF SAMANA.

In studying the geology of Samaná we find a repetition of all the phenomena of the larger island, with the exception of the eruptive rocks. I call it island rather than peninsula since it is separated from the mainland by the Gran Estero, formerly a navigable stream, now partially closed. Cretaceous rocks highly metamorphosed and uptilted; Miocene Tertiary deposited on their edges or flanks, these elevated horizontally almost to the highest summits of the hills, and the whole flanked by Post Pliocene coast formations consisting of limestones and gravels constitute the summary of the geology. No syenites whatever have been found either in place or even in the coast gravels.

The elevation of Samaná is unimportant, resembling in this respect the eastern end of the main chain, to which it also bears a greater resemblance in the details of its structure than to the more central portions. The highest points and the region of greatest disturbance are alike at and near its eastern end, and the fact of the Cretaceous strata approaching a more nearly horizontal position towards the west, together with the greater development of the Tertiary in the same direction, seem to indicate that in the yet unexplored eastern end of the Monte Cristi range at most but a trifling amount of the older formation will be discovered.

Immediately adjoining the Gran Estero the land is low, much of it is marshy, and the rocks are covered with river alluvium; but approaching Port Jackson, Tertiary hills came in, and the only rock found is a very compact limestone more or less nearly white, usually with a pinkish tinge, and containing *Orbitoides*. It is nearly horizontal, with a trifling northern dip. Only in the higher hills between this point and Canitas are any of the older rocks discovered, and here they form but a narrow belt. East of Port Jackson this limestone gradually narrows and finally runs out to a point on the coast underlaid by the uptilted Cretaceous; but in the interior it forms a series of basins more or less interrupted and flanking the northern face of the highest ridge. It is there horizontal and occasionally fossiliferous. Along the south coast the formation is continued around the west end of the hills and borders their southern base, past Canitas and los Robalos almost to Punta Mangle. Here it is represented by a narrow strip, but instead of the limestone, an older member makes its appearance. The Guayubin shales with all of their ordinary characteristics form all of the flat or low rolling land between the base of the hills and the shore of the bay.

Owing to the roughness of the surface and the scanty population there is no road across the island between the Canitas trail and one which crosses from the mouth of the Limon nearly south to los Robalos. At the former point the rock is a dark blue limestone, semi-crystalline, and dips north about 30°. Unlike the Cibao range, the greater part of Samaná is made up of limestone and mica slate, both of which rocks are rare elsewhere and the latter is especially exceptional. Abundant proof exists that the mica slate is always sedimentary in origin. It is always interstratified with rocks of that class, and one curious instance occurs east of Santa Barbara where in the same block the transition occurs from this to limestone within a couple of feet. But to return to the section. In following up the ridge parallel with the river the dip of the strata becomes higher and beds of sandstone and mica slate appear, gradually becoming vertical and then assuming a southern dip. Passing the anticlinal, a dip of 35° south is seen, and directly afterwards the horizontal edges of the white Miocene limestone present themselves, the beds containing occasional corals of well-known species. This continues to the base of the high range. Ascending the ridge, Cretaceous limestones again appear with low southern dips. These form the whole range, and are seen cropping out continuously along the cañon down which the road descends towards the bay. Near the base they lie as low as 10° and finally dip under the horizontal Miocene shale. This is less than half a mile wide at los Robalos and contains some seams of lignite which from time to time have induced explorations for coal. During the last Spanish occupation of the country, before 1866, an attempt was made to open a mine in the bed of a stream near this point. The water course was deflected and a pit sunk, which resulted in the exposure of a five inch vein; but nothing more was found. Still more recently, in 1870, a Mr. Kell, an English mining engineer, spent considerable time and money in opening a pit at another spot. Although he jealously refilled his excavation, enough signs remained there and at outcrops in the vicinity to show that his success had been no better than that of his Spanish predecessors. The "coal" differs in no important respect from that at the Angostura of the Yaqui or that of the Yaguajal near Savaneta. It is a very impure soft material, of a dull earthy black, and shrinks, cracks and eventually crumbles on exposure to the atmosphere. From the number of outcrops known it probably extends continuously along the whole of the western half of the north shore of Samaná Bay.

East of the Limon is the Arroyo Salado, or salt creek, which rises in a spring near the middle of the Island. About twenty yards below the head, the stream is fifteen feet wide and a foot deep in the middle. The water can hardly be called salt, but is decidedly brackish. It empties into the sea midway between the Limon and the Cañas. From the Salado to the San Juan the coast is an almost continuous sand beach; the hills retiring a little inland. But the trail from Limon parallel with the sea to the Salado is one of the roughest and rockiest so-called horse-trails in the country. Nothing but a mountain horse or a goat would dare to cross it without risk of broken legs. It is over the usual blue limestones such as that found at the mouths and along the courses of either the Limon or the San Juan Rivers.

The sand beach reaches to the mouth of the latter stream, ending there abruptly against a high wall of nearly black limestone, which dips about 40° to the north. Following up the river the same rock is observed in the hills on both sides with a regular east and west strike, but with a constantly diminishing northern dip, becoming almost horizontal on the summit. Mixed with the limestone is a little mica slate and four or five miles northwest of Santa Barbara a bed of white limestone of the same age occurs. On descending from the top of the pass and entering the lower hills, they are found to be composed of horizontal strata of gravel, apparently of the coast formation, made up entirely of debris of the limestones, mica slates and talcose slates which form the higher range. This gravel, like the Miocene to the west of it, makes a belt adjoining the coast and extends about a dozen miles east and west, forming in some places high bluffs with nearly vertical faces overhanging the bay. It also constitutes the little islands that lie in the neighborhood of Santa Barbara. Although a comparatively modern formation it is so solid as almost to merit the name of a conglomerate; and it resists the encroachment of the waves almost as well as the neighboring points of limerock. To the west it extends as far as Los Corosos, where it first appears as a steep hill.

Between the San Juan and the Arroyo Salado, on the Arroyo Cañas, in addition to the limestone so common in this region, there is a peculiar yellowish-gray talcose slate. It is very fissile and is nearly pure talc. The deposit is quite limited and is almost the only one in Samaná. In the same neighborhood, on the Rio Pito, a branch of the San Juan, but further south, there is a gray mica slate cut up by numerous milky-white quartz veins. Both these rocks have low northern dips.

The gravel beds continue for two miles east of Santa Barbara, where the limestones and mica slates of the interior first come down to the coast. At this point occurs the curious mixture of lime with mica referred to above. A series of gray limestones crop out on the beach, striking about due east and west, and dipping north from 65° to 80°. Interstratified with these are beds of mica slate; but one stratum of two or three feet thick particularly struck my attention. On examining a block of it on the beach, fallen from the bed, I found one side pure limestone; further in there were little scales of mica regularly disposed in layers, the lines of deposition; and this mineral became regularly more abundant until the opposite side of the same block was a pure mica slate, showing no sign of lime to the eye. East of this point the rocks become vertical; still further east, a high northern dip returns, but at La Flecha they fall almost to a horizontal and become more micaceous. Near Punta Caçao, the rock is a silver-gray very fissile mica slate. Similar rocks and some clay slates continue past Punta Balandra, where with a northeast dip they disappear under the horizontal Tertiary which forms a little basin back of Puerto Frances. This is an isolated deposit of horizontal rocks, limestone and sandstone, always white, although in some places, the former has a pinkish tinge. The omnipresent *Orbitoides* fortunately appear in some places and thus saves us from the uncertainty that might hang around the age of so exceptional a group of rocks. Until its discovery, I was inclined to consider the beds as belonging to the coast limestone. This basin extends from Point Grapin to the base of Cape Samana, and runs back forming almost a plain to within a couple of miles of Rincon Bay. Here it abuts against the edges of the Cretaceous shales which are elevated nearly vertically and which are represented in this ridge by brown and gray clay slates, dipping at very high angles to the northwest. These slates run out to the eastward and constitute the bold headland of Cape Samana; while Cape Cabron, running north on the west side of Rincon Bay is made up of the mica slates and dark blue limestones such as have been described from the San Juan and Limon. On Cape Cabron, on the trail crossing the ridge, the dark blue limestone is broken into a coarse angular breccia and recemented by a yellowish calcareous infiltration sometimes leaving cavities unfilled. I cannot determine whether this is a recent deposit or whether it dates back as far as the coast limestone.

Although the gravels about Santa Barbara have been referred to the "coast formation," I have detected no other locality of this group except a trifling little outline, bordering the coast at and near Puerto Frances. Here it makes bluffs about twenty to twenty-five feet high, worn into the most irregular forms by the action of the sea, which beats against it with more than usual violence. The deposit is very small, extending a mile or two along the coast and perhaps nowhere more than half a mile inland.

CHAPTER XII.

GEOLOGY OF THE REGION SOUTH OF THE MAIN RANGE.

The southern slope of the Island divides itself naturally into two distinct and well-marked portions—the mountainous or hilly region and the plains. The latter extends east from the vicinity of the Ozama and its tributaries, or more properly it may be said to include all the country east of the Jaina, while the former comprises all to the west of that river, including the region about the upper half of its course.

Although the district east of the Jaina covers an area of over 1,500 square miles, it furnishes but very few items of interest for the geologist. It has already been described in the chapter on its topography as a plain, nearly level, or at most gently rolling, in part open grassy savanas varied by long lines of trees bordering the water-courses, or in clumps scattered over their surface and covering every depression.

The portion adjoining the coast, whether on the southern or eastern margin, is a dense forest. These peculiarities of the vegetation are strictly dependent upon and conformable with the subjacent geological structure. The coast limestone forms a belt varying from five to fifteen miles wide, its sea side ending invariably in a steep rocky bluff usually vertical and not seldom deeply undermined by the waves—a pitiless wall, with hardly an opening or a harbor, nearly a hundred and fifty miles long, without a lighthouse or a buoy, the scene of many a shipwreck. The little bays sparsely scattered along this coast are barely better than roadsteads, available only for the smaller class of coasting vessels. The bluff is usually forty or fifty feet high, though in some cases higher points run out to the coast. A line of terraces borders the beach and occasionally the sea-margin is a little piece of sand-beach with a low line of rocks but a few feet above high tide. This is especially the case west of Santo Domingo City, where, however, the limestone begins to thin out. East of the mouth of the Ozama as well as directly west of it, although the bluff is in places forty feet high, there is a long terrace, parallel with the sea, bordering the regular level of the plain and over 100 feet high. Immediately back of the capital the plain is perfectly level and about 150 to 160 feet above tide level. This elevation is almost always attained by a varying number of these terraces. At the southeastern corner of the Island, in front of the little island of Saona, three of these terraces exist one behind another, the first far back from the sea. An additional elevation equal to the average height of one of these terraces would unite Saona and Catalinita Islands with the mainland, and bring the neighboring reefs to the surface.

The limestone contains numerous caverns. One or two of considerable size extend under the City of Santo Domingo, while the caves of Sta. Ana a couple of miles from the city, now occupied as a goat-pen, are of historic interest as the scene of the unprovoked massacre of the last remnant of the Indians inhabiting the vicinity under the pretext that they were clandestinely celebrating some heathenish religious rite.

Having already described the causes which produced the differences between the coast limestone and the gravel and sand deposits of the savanas, it is not necessary to recur to that question again. At the eastern end of the mountain range the streams are so small, and during the era of the deposition of these strata must have carried seaward such a small quantity of *debris*, that their influence is entirely lost in the region east of Higuey. There the limestone as a consequence reaches up to the old coast-line, the present base of the hills, where the local earthy modifications are too unimportant and too limited in extent to be taken into account; but about Higuey and thence westward the absence of forest adjoining the hills indicates even to the casual traveller that the limestones have disappeared, and the nearly continuous savanas are a sure index of the presence underneath of the more porous earths, sands, and gravels. In a formation thus varying in its lithological characters, of course the transition from one form to the other must be gradual, and an equally easy gradation between pure forest and pure prairie is to be seen along the line of junction. The pure limestone bears a continuous forest; the uninterrupted grass region is as strictly confined to the sands; and where the underlying beds vary from an earthy limestone to a calcareous sand or earth, there the country is clothed with a beautiful succession of open glades separated by lines and clumps of trees. The boundary separating the Savana from the coast deposit, may be defined as running, more or less, midway between the coast and hills bending north around Higuey. The pretty little town of San Antonio de Guerra, or Guerra as it is more generally known, lies in this line in one of the innumerable prairies, the view cut off in every direction by the clumps and "tongues" of timber which surround it. The softer impure limestone of this part of the plain seems to be better adapted to the retention of surface water than either the more compact but fissured coast rock on the one hand or the porous sand and gravel on the other. This results in the existence of innumerable little ponds and lakes, scattered in every direction, never large, but many of them perennial. They add greatly to the value of the region for grazing purposes, because the streams though reasonably abundant, are still widely separated, and many tracts would be otherwise without water. The drainage of the hills unites into a few comparatively large rivers which cross the plain in very direct lines to the sea, and the local rainfall either sinks into the soil or drains off immediately through usually dry channels.

Adjoining the hills occasionally little outcrops of the Sierra slates peep up through the soil, but they belong rather to the mountain region already described than to the plains under consideration. In some cases, however, the rolling ground continues miles from the base of the range proper, and usually more or less of the slates are found wherever the surface is at all uneven. Five miles south of Monte Plata, I found a little exposure in the bed of a rain-water channel, where the rock was a black and green serpentinoid shale breaking into semi-lenticular masses by oblique cross-cleavages and with all of the surfaces polished, resembling somewhat "slicken-sides." West of this on the San Pedro road clay slates crop out in numerous places, alternating with the often-mentioned red and white semi-talcose shales which never show a positive stratification. The former, however, as well as could be determined from the very small exposures, seem to always have a high southern dip. The same rocks occur around and south of Yamasa, and the latter is not infrequently seamed with little veins of white opaque quartz. I examined in detail several of the streams in this vicinity, washing the sand in the usual manner, but found no trace of gold anywhere. A fact that can be fully explained by the distance to the nearest locality of eruptive rocks.* Between San Pedro and Yamasa there is a long tongue of hills ending at the Ozama River at a place called La Luisa, and which separates the narrow valley of Yamasa from the broad plain to the eastward. San Pedro is on the outermost of the little elevations at the base of this range, a spot that has every facility required for the establishment of a large grazing farm, and one where the beauty of the surrounding scenery would almost compensate for the want of neighbors. It overlooks mile after mile of a tree-dotted prairie shut in by the haze of distance on one side and on the other by an evergreen range of high mountains. Perennial pastures and never-failing streams insure cattle against risk of either famine or drought; while its midway position on the best road between Santo Domingo and the towns of the Cibao would secure it an ample market for all its surplus stock. It is now occupied by an aged couple and their children, who earn a scanty livelihood by selling a few eggs, a chicken, or a bundle of fodder to an occasional traveller. I do not mention this spot because of any pre-eminent advantages it possesses. Innumerable other sites occur, scattered all over the valley, many of them possibly better. But in the frequent journeys I have made across the Island I have become familiar with it, and I cannot avoid regretting to see such an opportunity neglected.

Sierra Prieta is a not very high but from its semi-isolated position is a very prominent hill jutting out into the plain between the Isabella and Ozama Rivers, the terminal point of a low range. Its regularly sloping sides render it easily recognizable, and it forms an excellent topographical station for triangulations. It is made up of clay and talcose slates, with a little earthy iron ore, too impure to be of economic value. The same iron ore of every degree of purity, or rather of impurity, down to simply highly ferruginous shale extends over the savana as far east as the San Pedro trail, crossing the road to Yamasa above Savana Grande, and cropping out wherever a little rain-gully cuts through the soil and even sometimes lying scattered over the surface.

The Sierra Prieta ridge is a spur from the high mountains lying directly east of the Jaina River, starting off in the vicinity of the two high peaks of Mariana Chico and Siete Picos. The intermediate region is so closely connected in its geology with the Jaina country that it is most convenient to consider them as a whole.

In the description of the route across the mountains by the Laguneta Pass I left the subject just before reaching the Jaina River. The route was described across

*See pp. 89 and 127.

the mountains as passing entirely over slates which also extend down the Guananitos Creek. The heavy river deposit in the Jaina and its valley covers up whatever rocks may exist at this part of its course; but its head, which lies far to the northwest of the mouth of the Guananitos, is up a steep, narrow, and exceedingly rough cañon, and entirely in syenite of constantly changing lithological characters. This is the broad mass which is alike encountered on the Maimon River east of Mount Vanilejo, on the Majoma, the Upper Nigua, and even sends dykes across the Nizao almost to Maniel.

The exact point where the pass enters the syenite on the river is not certain on account of the river deposit above mentioned, and which consists of gravel and boulders of intrusive rocks exclusively. Near los Matas Mr. Speare found two rocks, the more peculiar because of the large amount of hornblende in most of the syenite of the Jaina. They were not in place, although fragments of them were so abundant as to imply that their source, most probably a dyke, was not far distant. One is a soft yellow mica slate, the mica which makes the greater part of the mass being of a light brownish-yellow color; the other is a compound of white quartz and yellow feldspar, in which I am unable, with the glass, to detect any other mineral. Southwest of this, five miles above Cataré to the west of the road, and northwest of Mount Basimo, he obtained a dark-colored actinolite slate. This is not far from the syenite. In this same region a little gray limestone is found dipping northeast, and just north of Mount Bassimo a brown earthy shale occurs seamed with calc spar. This mountain, which is a western spur of the Mariana Chica ridge, is traversed by a heavy dyke of syenite, some of which is made up of white quartz, white glassy feldspar, and little black specks of hornblende, while other parts seem to approach a porphyritic structure, consisting of large crystals of glassy feldspar and large grains of quartz imbedded in a matrix of a finer material of smaller quartz grains mixed with minute specks of hornblende. A similar material was found on Upper Nigua, where the feldspar is of a flesh-color. It differs from a true porphyry in that the matrix is resolvable even to the naked eye into its component minerals, and the included crystals are both quartz and feldspar. The high range east of Bassimo which separates the waters of the Jaina from those of the Ozama and its tributaries and which give rise on its eastern side to the Isabella, is made up of clay slates rarely talcose and sometimes jaspery. They are much traversed by quartz veins, some at least of which are auriferous. A little gold has been found in the bed of the Isabella, though not enough to be of importance. In the latter river a greenish-gray fissile claystone is the prevailing rock. On the summit of Mariana Chica the same rock is jaspery, while at its western base, at Novillero, it is brownish, much cracked, and with the surfaces stained with oxide of iron. Further south, at Arbol Gordo, it is sometimes a little magnesian and is usually much more slatey. A little further south still, in the woods of Monte Pueblo and on Madrigal Creek, it varies from a clay to a talcose slate covered with a heavy red soil, the rock traversed by innumerable little quartz veins rich in gold. The whole surface of Monte Pueblo is auriferous—the greater part if not all the soil would "pay" for washing—but unfortunately the deposit is too shallow to warrant the expensive ditching necessary to carry water from the Jaina to a height of perhaps forty feet above its level, opposite that point, to reach the required level. The aggregate quantity of gold is probably not sufficient to cover the expense of a ditch of two or three miles long that would be necessary. I have obtained from an average of a dozen to a maximum of forty "colors" or specks of gold from a single panful of dirt over the greater part of this area. Up the Madrigal Creek, on the eastern margin of this tract, I found jaspers, clay-slates, sandstone, and a peculiar serpentinoid rock in place. The latter, a dark gray, contained little concretionary grains scattered through it of a lighter color and a little harder; so that weathered surfaces took on an appearance, except in color, similar to that presented by mica slate studded with garnets. The rocks on the west side of the Jaina, above the mouth of Madrigal Creek, differ but little from those already described, the most common form being claystones varying from brown or gray to nearly black.

At the mouth of the Madrigal, on the southern edge of the Monte Pueblo or "Buenaventura" tract, the slates are all highly jaspery and are here penetrated in every direction by syenitic dykes of all sizes, often less than an inch in width and occasionally many feet. The syenite here is composed of nearly equal parts of the three usual constituents and is of a light gray color, sometimes containing little masses of the same material of a finer grain, and not rarely pieces of the enclosing jasper. It is perfectly cemented at its walls, so that no amount of force or blows will separate the two rocks along the line of juncture; fractures crossing from one material to the other perfectly. I collected numerous hand specimens here and elsewhere, in part green or blackish jaspery slate, the remainder syenite.

While at Madrigal I availed myself of the rich assortment of boulders in the bed of the river to collect a characteristic series of those syenites in which the hornblende predominated. This form of the rock seems to be peculiar to the Upper Jaina. I never saw it in place, but from the fact that it forms perhaps ten per cent. of all the pebbles in the river, it is not probable that it owes its origin to a single dyke. In some of the specimens the hornblende exists as rather isolated crystals sparsely scattered through a gray mass, while in others there is hardly enough quartz and feldspar together mixed through the mass of black hornblende crystals to separate them one from another. In some cases the crystals are over an inch long and a third of an inch thick, while the white minerals are in grains hardly coarser than sand.

In the savana of Arbol Gordo and among the ruins of the old town of Buenaventura I found pieces of bog iron ore in the form of a granular limonite. At the former place I found it as loose pieces in the soil, especially in a narrow strip of woods on the northern edge of the savana. Among the ruins I encountered squared blocks of a cubic foot and a-half, which had been used in building one of the principal walls. Although my party was camped in this vicinity for weeks, and all were specially charged to search for the original deposit, we failed to find it. It must be of considerable extent to have yielded the above blocks, but it is probably hidden by surface soil. The absence of limestone in this vicinity would act as a serious drawback to its exploration, should it be discovered even were the inducements for working it otherwise good.

The Mano River, the largest branch of the Jaina, enters that stream from the west a short distance above Madrigal. Except near its mouth its whole course is through a solid mass of syenite, the pebbles from which form a broad shingly bed. In time of unusually heavy freshets the water spreads over the whole width, but at other seasons it is confined to a narrow crooked channel. It adds no new facts to our knowledge of the region, except the one that the great intrusive belt which sends so many dykes across the Jaina at this part of its course and through which the upper part of the main river runs approaches bodily very near it, although it does not quite reach it. Below the mouth of the Mano the Jaina channel divides; one portion carries all the water of the river in ordinary seasons, while the other runs on the west side of an island and is only filled in times of extraordinarily high water. On excavating two or three feet deep into this bed, water is reached at all times percolating through the gravel. Here there is a little piece of flat river bottom made up of sand and pebbles, and in 1869, Mr. Ohle "prospected" it thoroughly with a view to beginning mining operations. He found gold in almost all of his pits, but did not seem to discover sufficient in any one place to warrant further proceedings.

South of the Madrigal on the eastern side of the river, although the hills still retain for some distance a height of two or three hundred feet above the river, the grassy surface of the savanas begins to encroach on the forest. The slates continue cropping out to the surface in a few places for four or five miles here with a recognizable high southern dip, until in the Porto Rico Savana, they are finally hidden by the gradually thickening margin of the savana gravels made up entirely of debris of the rocks of the Upper Jaina. Still further south in the savana of Santa Rosa these gravels with their red sand, angular fragments of quartz and the little streaks of black iron sand in every little rain-wash remind a Californian irresistibly of the foot-hills of the Sierra Nevada. They are in places slightly auriferous, and though not probable, it is yet not impossible, that here if any where spots may be found where "hydraulic mining" might be prosecuted with success. I say not probable, because the small amount of gold in the present bed of the river seems to indicate that the quantity would be proportionately still less when spread over so wide an area. And yet the "black sand" although often found by itself, nevertheless the invariable accompaniment of placer gold, is by no means scarce.

South of the savana of Santa Rosa the red sandy matrix of the gravel becomes gradually calcareous and though pebbles are yet occasionally found they are more and more isolated until they also finally disappear, and the coast limestone is reached just below the savana of La Venta or south of Managuallaba Creek.

West of the Jaina, below the mouth of the Mano, is a hilly region of slates, bounded on the west by the syenites which extend across to the Upper Nigua. These hills are traversed by numerous dykes and are full of quartz veins. The slates are an inextricable mixture of green, gray, brown and black claystones variously colored jaspery slates and some more or less talcose. Among the first I found a couple of miles below the mouth of the Madrigal, a black rock slightly arenaceous, very compact and full of white grains. This is certainly a metamorphic shale, and yet, from its appearance in hard specimens, might be mistaken for a porphyritic rock. A similar material was found not rare on the Nigua River. The quartz veins are usually very small, hardly ever over a few inches in width and seem to be limited also in horizontal and vertical extent. A few however can be measured by feet rather than inches, and Mr. Spear spent some weeks in making an experimental opening on one of nearly three feet wide to ascertain its character. The result of his excavation was to disclose a vertical vein with well-defined margins intercalated in the shale. The quartz yielded a little gold by the ordinary miner's test of grinding in a mortar and washing the powder. It is doubtful, however, whether the quantity would have been sufficient to warrant earnest mining.

On the ridge overlooking the mouth of the Mano at the head of two streams, called the Anones and Caballo, which unite and run into the Jaina a mile or more below the mouth of the Madrigal, is the largest quartz vein I have seen on the Island. It crops out on the top of the ridge and its down-hill side is so covered with soil and great blocks of quartz that it is impossible to ascertain its exact width from a mere surface inspection. It is certainly from twenty to thirty feet thick and may be much more. Fragments of the quartz are found the whole length of both streams. Gold is found in every eddy in their cañons and I obtained it by washing even the dirt from the hill sides. The quartz as it appears on the surfaces is more or less cavernous, the cavities lined or filled with peroxide of iron. On crushing it in a mortar and washing it I obtained bright gold in little flakes. I caused an assay to be made in New York of a portion which I took with me in 1869, but the returns of the chemist were so high that I shall not record them here, preferring to believe that either my specimens were accidentally an unfair sample or that the chemist made some mistake. Apart from this enough is known to prove that the vein is gold-bearing, and I believe sufficiently promising to warrant further examination.

Not only is this vein auriferous but many of the smaller ones must contain their share of the precious metal. Over an area of several square miles of this vicinity not only do the streams yield gold but the earth on the hill sides, and even on their summits contains it. About La Horca we found gold everywhere, and throughout the woods are innumerable pits often twenty or thirty feet in circumference and many feet deep whence the Indians mined the clay and gravel, and carrying it to the nearest stream washed it. It is doubtful however if placer mining could be made profitable on a modern scale. Not but that the "dirt" is rich enough, but its quantity in any one place is not sufficient to warrant the construction of expensive ditches, and the slow process of carrying the earth to the water in the Indian style is too laborious and costly to be thought of. Although innumerable little streams intersect the hills, none carry sufficient water for sluices. Possibly some of the larger creeks like the Caballo, Anones, Jiraná, &c., might pay moderately to wash their channels but they would be exhausted too quickly to make them an object of attention alone. The women constantly wash gold in the creek beds and also in those of their tributaries, using the well known "batea" or wooden bowl. But they are content with a return of three or four reals ($37\frac{1}{2}$ to 50 cents) a day. I have myself obtained in the Jivaná grains worth as much as ten cents in the ordinary gold pan, and I have seen lumps weighing a quarter of an ounce obtained by women in the same manner.

There can be no doubt as to the sources of this gold. It is true that it is usually more or less rounded, but a very little transportation among hard stones will suffice to produce this appearance. It is never found far away from or up-stream above the quartz veins. Where quartz is most abundant the gold is also found in the greatest quantities, and where the one is absent the other does not occur. On the hill sides the auriferous earth is clearly derived from the decomposition of the underlying slates; and finally gold is nowhere found in those parts of the streams running only in the eruptive rocks, unless a belt of slate crosses still higher up. Nor is it ever found in the earth overlying the syenites. Throughout this region syenitic dykes are constantly encountered, and the upper half of the Jivaná runs through the parent mass, while veins of the same rock crop out in several places in lower part of its course as well as at the mouth of the Anones, and in the bed of the neighboring part of the Jaina. We have thus a further proof of the theory already enunciated* that the proximity of eruptive masses, is the cause of the presence of gold in the quartz veins of this country.

On the Jivaná there is a more than usual variety in the appearance of the syenite. In every place I found it flesh colored owing to a pinkish feldspar; in another it is dark gray and very fine-grained; and in still another it is white with acicular crystals of hornblende. Near there in the Jaina near the mouth of the Anones, there is a little dyke made up of white quartz, white and pink feldspar and with little isolated grains of a black mineral which I could not determine with certainty; and between the Anones and the river is another in which the materials are very unevenly distributed, hornblende occurring both in irregular masses and in isolated crystals.

South of this region the quartz veins still occur in the slates and on the Susua and Medina Creeks some gold is found, but the eruptive dykes here disappear and the quantity of gold rapidly dimishes. It is said to be found as far south as the Cuallo but this requires corroboration. If it does occur there it is in very small quantities.

This range of hills terminates to the southeast in a prominent point running out into the savanas on the nearly flat summit of which is a little cluster of houses. Here the rocks are more than usually metamorphosed, some of the beds being a black mica slate in which occasionally there can be seen small white grains of quartz. Throughout this rock are stains and an occasional little thread of copper ore. I discovered green and blue carbonate, a little silicate and some purple sulphuret. Nothing approaching a vein structure has ever been detected, but Mr. Heneken, who seems to have been possessed with a mania for copper mining commenced operations here, dug innumerable little pits all over the hills and founded a settlement to which he gave the name of Cobre. Since his time one or two other but less energetic attempts to develop the "mines" have been made, but with no better success than he attained. He also made similar essays at copper mining on the Arroyo de las Platanas, a little tributary of the Nigua west of Cobre. Here he found more copper but no veins.

* See pp. 89, 127.

In one of his excavations I found an approach to a vein structure, in a seam of quartz and slate, the vein swelling and narrowing very irregularly. In the quartz are nests of purple sulphuret of copper, some of them as large as one's fist, and little streaks and threads of the mineral are not rare. On crushing and washing a sample of this quartz I found a minute trace of gold. The country rock is a greenish gray claystone often much cross-fissured and in places slightly talcose. In one place it is dark gray and is spotted with small yellowish grains. It is about on the strike so far as can be determined between Cobre and the copper deposits of the Nigua at Monte Mateo.

Although the slates on the Nigua are so highly metamorphosed that it is next to impossible to discover their dips over a great part of the distance, yet from the almost continuous exposures along the cañon of the river the section is one of the best that occurs through these rocks. I have traversed the entire width of the metamorphic belt many times and while the main features are easily distinguishable have almost always arrived at different conclusions about the dips of the jaspery slates between Tablasas and Pomiel. There is no question but that they all dip more or less southward, but in one or two places the strike twists around to the north and south and the dip is nearly vertical. My main conclusions are confirmed by the limestones which retain their bedding well marked, and in a few places between the two above named points I believe I have found the true position of the slates, though I have been obliged to reject the greater part of my observations as based on too uncertain data. The slates have regular systems of fissures often extending entirely throughout an outcrop, and frequently so regular as to appear certainly the stratification; but others equally well-marked cross these in entirely different directions, and not rarely several of these systems occur together. Another source of confusion exists in the coloration of the rock. It is usually a dark brown or green, but bands of color, a foot or more wide, often extend entirely across an exposure. This looks as if it originated in some trifling difference in the original constitution of the beds, now consolidated into a homogenous mass, but closer examination develops the fact that these bands are not of uniform width, they sometimes end abruptly, taper out, or widen and enclose masses of the predominant color of the surrounding rock; in short they possess all of the irregularity of mineral veins. At first I was misled by them, but on measuring a great number I found that they must have had their origin in some other cause than the original stratification.

The eruptive rocks extend southward to just below the mouth of Jamei Creek, their eastern margin, a nearly north and south line, cutting across the heads of most of the tributaries of the Jaina. On the southern margin they are often of unusually fine grain and dark in color. At the mouth of the Jamei I observed spots where the quartz was unusually clear and glassy; in another place I found a little mica. Sometimes the syenite is flesh-colored or salmon-colored, owing to a more or less pinkish feldspar; but usually it is some shade of gray or even nearly white. In the river I found a gray rock resembling the peculiar porphyry-looking syenite already described from Mount Basimo, on the Jaina, but differing in the smaller size of the enclosed crystals of feldspar and quartz. The Majagual Creek, which empties into the Nigua a mile below the Jamei, also runs through these rocks, there usually of a dark color, though sometimes almost pure white. About a mile from its mouth there is a fall, at the line of juncture between the slates and syenites, where excellent examples of the contact can be obtained. Here, as on the Jaina, the two materials are completely fused together so that they cannot be separated by the hammer. In ascending the hill from this point the sedimentary rocks are found overlying the eruptive, limestone capping the summit, with a low southern dip. Fragments of the latter are very abundant both on the hill side and in the cañon, as well as parallel with this point in the Nigua, and although I obtained fossils abundantly here and in the *debris* in the main river, I could never find the fossiliferous bed in place on the latter stream. For a mile or more below the line of contact dykes cut through the jaspery slates, which are here very much disturbed and seem to be more or less vertical. Approaching Monte Mateo the limestones are found to dip northward at high angles, forming a narrow synclinal. They are here all highly altered and vary in color from dark gray to pure white; a sure criterion of the amount of alteration of this rock on the Nigua is to be found in its color. When nearest its original condition and full of fossils it is brick-red, and breaks with an earthy fracture. The fossils, it is true, are so far changed that they are reduced to a highly crystallized spar, rendering it next to impossible to extract them; but the rock shows no signs of change. But as the metamorphism progresses, the material becomes lighter in color and more compact and varies through dark flesh-color to all the shades of pink or gray, and the most thoroughly altered specimens are perfectly white and even traversed by little seams, like threads, of calc-spar. In no case, however, are they granular, or do they approach even remotely to the structure of marble.

In this vicinity there are numerous signs of minerals. A little gold, hardly worth mentioning, is found above Monte Mateo. On the Majagual, near the syenite a little vein of magnetic iron ore, containing a small quantity of copper and some gold, was opened a few years ago under the belief that the iron was gray copper! Several little copper veins crop out in the bluffs of the river above the mouth of that creek, and at Monte Mateo there is a good-sized vein, which five or six years ago was opened quite extensively as compared with any other mining operations ever undertaken in the country. The mineral shows itself on the face of a high bluff on the margin of the river where the slates are discolored by oxide of iron for a width of 120 feet. Throughout this surface considerable quantities of iron pyrites are found, and in one place some copper stains can be detected. An excavation of about fifty feet was made in the most promising spot, which had afterwards closed up by the rotting of the timbers and the fall of *debris*. Mr. Speare, who was employed at the mine, informs us that towards the surface the streaks of ore, a yellow pyrites, were comparatively small, but as the works increased in depth these streaks converged and promised to unite. He considers that there was a fair prospect of eventually finding a compact vein. His experience in copper mining elsewhere entitles his opinion to respect. Unfortunately, before the character of the deposit could be thoroughly proven, failure of funds and the bankruptcy of the company put a stop to the operations, which have never since been resumed. Numerous assays of the ore were made, and General Cazneau, in whose possession they were, exhibited to us the certificates of the chemists. Some of them are here given. The names of Secor, Swan & Co., of Baltimore, and Adelberg, Raymond* & Co., of New York, are sufficient guarantees for the accuracy of the analyses, which were however made doubtless from the choicest specimens found in the mine. Adelberg, Raymond & Co. give—

	1st.	2d.	3d.	average of five others.
Copper	26.73	26.03	15.5	21.17
Gold	trace		$23.60 per ton.	
Silver	trace			
Sulphur	33.16			

Secor, Swan & Co. found—

	1st.	2d (100 lbs.)	3d.	4th (9 tons).
Copper	20.5	19.0	20.50	12.5 per cent.
Gold	$12.80	$10 00		$5.00 per ton.
Silver	$10.40	$13.03		$1.23 per ton.
Sulphur			25.60 per cent.	

An examination of the above results show that while the hand specimens and even the 100 lbs. lot gave usually very good results, the fairer working test of nine tons brings the character of the ore down to a doubtfully profitable grade. So much for the mine in the abstract. Its position is very unfavorable for successful working, even if the vein and the ore should eventually prove good. It is nine miles up the Nigua above San Cristobal, following the ordinary horse-trail, or six miles to the nearest point

* Dr. R. Raymond, now United States Commissioner of Mining Statistics.

whence a practicable outlet can be obtained from the cañon towards Santo Domingo, and that over a high hill, Loma Cristina, fifteen miles from the city. This, which is the shortest route to an available shipping point, would necessitate twenty-one miles of land-carriage at least; or, in case of the very improbable contingency of a railroad being built to San Cristobal, the ore would have to be carried nine miles on horse or mule-back before it could reach the nearest point of the road.

At the mine the country rock, which is a semi-jasper, strikes N. 30° W. with a northeast dip of 54° nearly conformable with the position of the limestone further up the river; but very soon there is an anticlinal, and the strata towards Tablasas dips to the southward. The jaspers are various shades of dark green and brown, and wherever not too much fissured break with broad conchoidal fractures, but with earthy, never perfectly smooth surfaces. In some parts they present peculiar appearances, resembling porphyry. One green specimen before me is mottled with minute black shining specks; others show similar marks, but gray, yellow or white in color. These are certainly altered sedimentary rocks, although hand specimens might be mistaken for eruptive in origin. Except in these colored grains they differ in no respect from the other jaspers. It seems that a similar character is exhibited by some of the metamorphic rocks of Jamaica. The geologists found that near the dykes some of the beds were "converted into semi-crystalline masses resembling porphyry and sometimes trachyte." These changes are also accompanied by an incipient development of crystalline minerals."* I found one loose piece of gray jaspery slate in the bed of the Nigua, of which nearly a fourth of the surface was made up of flesh-colored grains, apparently feldspar crystals, averaging over an eighth of an inch across. Barrett describes from the southeastern part of Jamaica "porphyries and hornblende rocks interbedded" with cretaceous strata, and compares them with Darwin's account of localities in the Andes, "where porphyries which had flowed as submarine lavas alternate with conglomerates composed of the same rocks, and are overlaid with beds containing cretaceous fossils."† No such condition of affairs exists in Santo Domingo.

At Tablasas the limestone is again encountered striking east and west and dipping on its southern margin south 25°. At its base it is divided into recognizable beds, from which I obtained the measurement; further south it becomes so massive that no stratification can be detected either in the bed of the river or on the hill sides. For several hundred yards it makes the bed and banks of the river in great masses, their bases, usually so surrounded with sand that it is not possible to determine

* Jamaica Geological Report., p. 27.

† Quart. Journ. Geol. Soc., vol. xvi. p. 324.

whether they are in place or fallen from the overhanging precipices. Some of these are doubtless derived from the cliffs, but an occasional ledge or little waterfall shows the rock to be in place. The sides of the cañon are usually so overgrown with brakes, trees, and vines, that though very steep the stratification could not be deciphered even if there were lines between the heavy beds; but at the southern edge the top of the deposit crops out in a low bluff, the strike remaining the same but the dip only 15° south. Throughout, this rock is nearly or quite white and shows no signs of fossils, although at this point I obtained from some boulders derived from the beds further up some of my most perfect specimens. South of the limestone the same jaspery slates come in again with varying strikes from east and west to N. 35° W., and with all dips up to 80° south. At the base of the hill of Pomiel the dip is south 50°, while at the summit there is another outcrop of limestone. I have tried ineffectually to connect this with the rock of Tablasas, but its dip is southwest 30°. Between the two exposures there is no corresponding northern dip of limestone, and all of the exposures at the latter place show southern dips, as well as do all of the localities intervening where a reliable measure can be obtained in the slates; nor could I find any spot where a probable fault by causing a dislocation of the strata again brought the lower beds to the surface. It seems therefore that this is possibly a second deposit and more modern than that of Tablasas, although the rocks of the two localities resemble each other so closely in every respect, that I would prefer considering one a repetition of the other, could I find any reasonable pretext for doing so. The only one would be an enormous fault, but I have examined the interesting space very carefully without finding any trace of it. Another explanation might suggest itself theoretically, but I can find nothing to warrant such a supposition. A reverse folding of the beds would not be incompatible with the appearance of the slates; but it would imply an amount of elevating force, exercised to the south of this point, which the configuration of the surface does not permit us to consider probable. There has been an unusual amount of disturbance at and immediately south of Pomiel, but directly beyond that, the Cretaceous finally disappears, hidden by the Tertiary. On top of the hill the strike is N. 45° W., with a southwestern dip of 30°. In the adjoining low hill of Latoma the limestone strikes N. 40° E., and dips 45° southeast; while, within a quarter of a mile northeast of this point, it strikes directly north and south, and stands vertically. This is on the edge of the river, and the rock thus forms as it were, a rounded cap, covering a good part of the southern face of the high hill, of which Latoma is only a small spur. Directly across the river in the hill of Calaboso, a little outlier of the limestone again occurs, after which all finally disappears under beds of the Miocene and coast formations. A little deposit of Miocene also forms the extreme point of Latoma hill, covering the tract known as Yerba Buena. This is an outlier of Loma Cristina, and strikes about north and south, dipping west 25°.

Near the summit of Pomiel are numerous caves in the limestone, some of them of considerable extent. The one most visited consists of a succession of chambers, perhaps 200 yards or more in length. Its floor is nearly level and is covered with little or no deposit of any kind. Adjoining it is another of nearly equal extent, inhabited by myriads of bats, very few of which are found in the first. Their dung forms a layer over the floor varying from a few inches to several feet in depth, mixed only with a few elytra of insects on which they feed. Other caves, but smaller than these, occur in Calaboso. At Latoma is a beautiful spring welling out from the base of a limestone bluff, probably through a similar cave. The water of the Nigua for a mile or two above this hill disappears under the sand of the river bed, and doubtless, on reaching the limestone percolates through fissures to find vent finally at this point. The quantity of water issuing here is about equivalent to that in the river bed at Tablasas.

A little Miocene Tertiary is found above this spring on the south flank of Pomiel, more occurs on Calaboso, but the whole of Loma Cristina is made up of beds of conglomerate, sandstone and calcareous claystone. The dip varies at low angles from west to south; the most prevalent being about 15° southwest. The base of this deposit is everywhere a coarse conglomerate covered by sandstone while the earthy and calcareous beds form the upper part. I found but few fossils and these in very imperfect condition but sufficient to prove the synchronism of this with the rocks of the Cibao Valley.

In the flat land south of Calaboso and just east of San Cristobal, one or two very small outcrops of the conglomerate occurs, and over these are beds of coast limestone which extend to the sea. In one spot I found the phenomenon of coast limestone so full of pebbles as to form a true conglomerate, and with pieces of branched corals, not water-worn, mingled with the stones. But the explanation of the circumstance exhibits itself in a bed of Miocene conglomerate, underlying the limestone in an adjoining little hill side. The pebbles were washed out of one formation to be immediately re-imbedded in the other. While the Isabella, Jaina, Nizao, and other streams brought down large deposits of gravel during the Post Pliocene period, the quantity carried seaward by the Nigua must have been very small. All of these rivers deposited their loads at and east of their mouths. But east of the mouth of the Nigua, the gravel mass is very inconsiderable, both in area and thickness, and the limestones come up almost to the ancient coast line. It was probably then, as now, a nearly dry stream.

West of its mouth the limestones, while they continue almost to the Nizao, become gradually more earthy, and begin to show signs of the coast influences which acted so strongly to the eastward of the mouths of the (southern) Yaqui, Cuevas and Ocoa. The Nizao bore its part in the work, but deposited most of its debris further north, to the west and even northwest of San Cristobal behind the Miocene hills, then probably low islands, barely if at all elevated above the water. The limestone belt consequently is quite narrow about here, and instead of being a tough rock on the surface, loses the property of hardening on exposure. It gradually merges into a gravel, and beyond the Nizao towards Bani, loses all of its calcareous character. In one place near the mouth of the Nigua, I found in it a bed of small oysters.

The Miocene rocks of which Loma Christina may be taken as a type make a little range of hills west of San Cristobal, extending nearly to the Nizao. Wherever I have examined them, they have proven to be the same earthy, brown beds of an intermediate character between clay and limestone, alternating with beds of sandstone. In the more calcareous strata corals are not rare. These are almost always of the massive form, and occur abundantly as pebbles in all the streams running down from the hills. The strata are a little disturbed, but the dips are, while low very variable. Little outliers of the same formation, remains of probably a much larger deposit now denuded away, are found in the hills further west. I have discovered rolled pebbles of Miocene corals in the Paya Creek, four miles east of Bani, and Mr. Speare obtained another rolled fragment of well-known form in the neighborhood of Savaña Bucy. Back of these hills between them and the base of the main range, the Post Pliocene shingle of the Nizao covers all of the lower land, large rounded pebbles extending to the base of the hill just west of San Cristobal. An excellent opportunity of observing this, exists along the inland road from San Cristobal to Bani, by way of Estancia del Rey, while the coast road shows the parallel transition westward, from the limestone at Don Gregorio, near the mouth of the Nigua through its earthy stage, caused by the finer debris of the Nizao, to the similar shingly product of the Ocoa on the plains of Bani.

Parallel with this outer belt there is a high range of mountains, bearing several peaks nearly as prominent as those of the main chain. But one of these lies east of the Nizao River, Mt. Manaclal over 4,000 feet high. West of it are two others of still greater altitude, Mts. Barbacoa and los Pinos. This mountain mass is visible at a great distance, and forms an excellent landmark at sea. The first of these was visited by Mr. Pennell, who reported it to be made up largely of limestone and granitoid rocks. It lies near the southern edge of the great intrusive mass, and the latter rocks are probably dykes extending from it. I crossed the country behind, or to the north of it to Maniel from the head of the Nigua, a distance by the route followed of about forty miles, although the entire distance in a direct line is hardly more than half that. The eruptive rocks extend uninterruptedly from the mouth of the Jamei across the ridge to the Majoma, and crossing that stream at its mouth, continue across the Nizao for a short distance, when their margin suddenly bends northward, running along the ridge which divides the tributaries of the Majoma from the Nizao, and continues to Mt. Vanilejo previously described. Beyond this western margin as on the eastern side of the mass, dykes run out into green and brown jaspery slates, making a perfect repetition of the condition of affairs on the Upper Nigua and Jaina. The syenites have been so thoroughly described already, that it is hardly necessary to say more than that they show no new features. On the Arroyo Botiguela, a little branch of the Nizao, dykes exactly like those at Madrigal on the Jaina were encountered, and specimens from the one place, showing the contact between syenite and slate, are undistinguishable from those from the other. At this place there is a beautiful fall over the green jasper, the water giving a clear leap of eighty feet. The country is entirely uninhabited, and except on its margins is never penetrated even by the pig hunters. It is entirely without trails, and we were obliged to chop our road through the primeval forest, with its dense undergrowth all of the way. The settlements on its western margin extend but a mile or two east of Maniel; while the last houses on the Nigua are at Jamei. Rancho Arriba further north is the only spot in all the tract where there is any kind of a house; and that is about one-half ruined, and used only occasionally by hunters, or as a stopping place by the very few persons who cross the mountains by the Vanilejo route.

Maniel is a thriving little town on the west bank of the Ocoa, the centre of a good sized settlement in a valley 1,554 feet above the sea, according to the measurements of Mr. Pennell. Around it there is an unusually great variety in the rocks. Ten miles above on the river we found drab-colored argillaceous limestone, with other beds of a darker color with seams of white calc-spar. There is also much clay slate and coarse sandstone, and near the town we found the same rocks repeated and associated with conglomerates. Some of this is barely more than a very coarse sandstone, the grains being almost uniformly of from an eighth to a quarter of an inch in diameter. In other places it is similar to specimens found near la Veja, a green highly metamorphosed rock with small pebbles; while again to the east of the town, towards the Loma de los Ranchos, it is a coarse sandy limestone, very full of pebbles and resembling some of the fossiliferous limestone of the Nigua in this respect, though differing in the absence of organic remains. In the whole region there is but little of the talcose slate so common on the north side and in the eastern half of the range.

South of Maniel along the cañon of the Ocoa River, the hills show a succession of broad, rounded undulations of dark-colored strata of shale and thin bedded sandstones. They are so little metamorphosed that I searched them carefully in hopes of finding fossils. I do not consider my total want of success as proof that they do not exist. With more time to devote to the search I might have been more fortunate. Just before the river emerges from the hills on the east side, there is a little creek called the Arroyo Salado, the water of which is so saline that when it evaporates in the dry season it leaves little incrustations of salt in the rocky basins. The rock which yields the salt is a red shale, the same as that found further north in the hills, differing only in color. I found in it a few concretions of nearly black, semi-crystalline calcareous matter. At the lower part of the same creek, the shales crop out with beds of sandstone, the latter forming long reef-like ridges, projecting above the softer material. Here a few springs similarly but less saline trickle down the banks, and leave a white incrustation over the surface. All of the rocks of this vicinity about Honduras, and even out in the plain about Savana Buey, dip at moderately low angles southward. At the latter place argillaceous and sandy shales of a brown color crop out through the soil of the plain, and on the margins of a high terrace bordering the Ocoa River. But in the Loma de las Tablas, a nearly isolated hill, a little east of the line of the section, heavy bedded sandstones but slightly altered seem to be locally upheaved and striking nearly north and south dip east as high as 50°.

A similar local upheaval occurs just west of Bani in the Loma del Pueblo, but here the rock is a cream-colored limestone with siliceous streaks. I did not attempt the ascent of either Mount Barbacoa or los Pinos, but ascending the cañon of the Bani River approached near to the south base of the former. Far up this stream there is a little collection of houses called Recol, perched on the hill sides and straggling along the cañon. The people cultivate a little coffee, for which the soil is unusually well adapted. At Recol I found a very solid black claystone, and a dark greenish porous shale, both of them characterized by minute white grains scattered through the mass. They are highly metamorphosed forms of the same shales as those seen on the Ocoa, having a corresponding east and west strike.

Further down the cañon a few small streaks of pyrites have given rise to the opinion of the existence of copper deposits. I found nothing beyond a little sulphuret of iron.

I have stated elsewhere that with a single exception all of the eruptive rocks of Santo Domingo are granitoid, and usually well-defined syenites. That exception was found in the Bani River in the form of a few pebbles of an unmistakable porphyry. It is apparently from a small dyke, judging from the few pieces found. I was not fortunate enough to detect it in place. It is a nearly black matrix of fine grain, filled with tabular crystals of white feldspar an inch across.

The plains about Bani have been referred to above as being covered with the usual Post Pliocene formation in the shape of a deposit of coast gravel. Although this extends uninterruptedly to the westward, the greater part in this region was probably derived from the Ocoa River. At Honduras where the river first issues from the hills, it is very coarse and contains great quantities of large boulders, some of which are but partially rounded; but further out on the plains, both south and east there are fewer and smaller, and the preponderance of sand greater. Between the hills of the Pueblo and las Tablas the deposit forms a broad gravelly plain, covered with grass and overgrown with thickets of acacia and cactus. Scattered over it are a few lagoons, or rather small ponds which furnish a perennial supply of water for animals. On the margin of two of these are collections of houses known respectively as Caña Fistula and Matanzas, while near the foot of the hill of las Tablas is another settlement of the same name. The latter is on a small stream running down from Honduras. Three roads connect this region with that to the west. One crosses the Ocoa River at Savana Buey and follows the coast to Azua. The second passes through las Tablas and crosses a high hill called the Numero, uniting with the first a few miles east of Azua, while the last runs southwest across the mountains from Maniel.

The coast road after crossing the broad shingly bed of the Ocoa and a few low gravel hills, traverses some salt mashes adjoining the beach, and then follows the coast around the east side of the Bay of Ocoa. On passing some low hilly points it shows slate cropping out on the beach with southern dips, but most of the way is either on the sea beach or immediately inland on the drifted sea sand.

Approaching Azua the Post Pliocene gravel is soon encountered, but there is nothing to distinguish it from that now in process of deposition. In fact, there is little doubt, but that its formation has gone on uninterruptedly; and if it could be examined, that of yesterday would be found continuous and conformable with the most ancient portions inland.

The road over the Numero runs around the north side of the Tablas hill, crosses the river, and then mounts the slope of the hill. The rocks are coarse sandstones and sandy shales not much altered, but more so than those about Savana Buey or on the Upper Ocoa.

The region towards Azua suffers from the same deficiency of rain, as occurs in the western part of the Santiago Valley, and the nearly bare soil of the Numero, with its thin growth of cactus and thorn bushes, fully attests the great influence that moisture exercises over the fertility of the tropics. On reaching the plain, but little raised above the sea level there is a greater proportion of moisture in the soil, though no more in the atmosphere; and even here a notable difference is to be seen. Larger trees among which the Guayacan or Lignum-vitæ is not rare form forests near the coast; and further inland, although various species of acacia and cactus make up the thickets, their denser growth and more flourishing appearance attest more favorable conditions.

I know the pass west from Maniel only from the report of Mr. Pennell, who represents it as very similar to that of the Numero, except that the vegetation is more dense owing to its greater proximity to the high mountains and consequent greater rain-fall. He brought in hand specimens of a coarse sandstone and of a red highly metamorphosed shale, both identical with rocks about Maniel. He obtained them near the summit of the pass.

West of the junction of these roads, and just east of Azua, the coast gravels are somewhat disturbed, being elevated into two or three low hills; but along the road there is no outcrop of older formations. Near the town, however, on the Rio Bia, the same coarse sandstone found near Maniel on the pass, and in Loma de las Tablas crops out in the bed of the stream, and further up a gray limestone with white calcareous seams forms low falls. Associated with these is a little red jaspery claystone, the whole having a southern dip. North of the town, and west of the river, the sandstone and limestone are again encountered at Higuereta. Near this place, and near the upper edge of the gravel is a stream almost always dry called the Agua Hedeondo or stinking water. About its upper part there is a group of little petroleum springs which make their way to the surface through the gravel. The underlying rock is nowhere visible, but the material probably originates in the Cretaceous shales or sandstones below, and which cannot be very far from the surface. A few little pools occur in the nearly flat ground near the arroyo, and the earth and sand in its bed are cemented by the bituminous matter into a compact mass, in the same manner as occurs in a hundred places in California. A few years ago an attempt was made to work the deposit. Some pits were sunk now filled with water, on the surface of which there floats a thin scum of viscid oil. Besides these an artesian well was commenced, but soon abandoned, and the rusting tools and a broken engine lie scattered around. The tube of the well is filled with oil and water through which an inodorous and non-inflammable gas bubbles to the surface. Near the well there is a shallow depression on the hill side entirely bare, probably from the escape of the same gas, which seems to be deleterious to vegetation. It, however, does not affect the surface beyond the margin of the depression, which is simply a little basin a few feet deep and a dozen yards across. The spot is interesting, mainly because it is the only one where this mineral occurs in Santo Domingo. The Jamaican geologists do not mention it, while Taylor,* as quoted by the geologists of Trinidad, says "the entire chain of the West India and Windward Islands present similar phenomena of petroleum springs, beds or veins of asphaltum and accumulations of mineral pitch," mentioning particularly Cuba and Barbadoes. The last-named authors also quote deposits in New Grenada, while the extensive outflows of Trinidad are perhaps without a parallel. Schomburgk† also describes in detail the petroleum springs of Barbadoes, which although not numerous seem to be of large size.

Beyond Azua our knowledge of the geology is necessarily very limited. Both Mr. Pennell and I made excursions as far to the northwest as Tubanos on the Constanza trail, and that gentleman penetrated eastward from this route some distance up the river of las Cuevas, and made a boat excursion to the southwest along the coast to the boundary at the north of the Rio Pedernales.

I have already described the sierra slates as extending to Tubanos, where they finally disappear under the Post Pliocene beach deposit. Further back in the hills, however, just below las Lagunas, these gravels elevated a couple of hundred feet lie horizontally or with an almost imperceptible southern dip, on the upturned edges of the slates and are cut through by the cañon adjoining the road. This portion of the deposit contains boulders often more than a foot in diameter, derived from the Neyba or Southern Yaqui River. It spreads all of the width of the San Juan Valley to the base of the mountains on the other side, and must be found at least as far up as the town of San Juan. Just west of this town there is a little "divide," beyond which the streams run into the Artibonite. My hearsay information in regard to what lies beyond is too unreliable to be recorded here. Suffice it that all evidence unites in representing the valley as the best grazing land in the Island, an evergreen plain, a continuous prairie of "Guinea grass" that never suffers from either droughts or floods. What underlies it we do not know. From Tubano the same gravels extend southeast, reinforced by the supplies derived from the Rio de las Cuevas, and cover

* Statistics of Coal, p. 247.

† History of Barbadoes, pp. 553 and 571.

the plain to, and beyond Azua. In some spots near Azua there are small, very local patches of coast limestone more impure than that deposited further seaward, and overlaid not by the usual red earth but by a dazzling whitish calcareous soil.

In the mountains on the river Cuevas Mr. Pennell found the gray sandstones of Maniel, Higuereta and las Tablas, gray clay shales similar to those on the Ocoa below Maniel, interstratified with limestone, a brownish serpentinoid rock and a pinkish, scoriaceous-looking shale with dark grains. He took no notes on the positions of the strata. A similar sandstone to the first mentioned was also brought from the mountain of Higueros, in the same vicinity. From the mountain of el Curo west of Azua, the same gentleman obtained a white limestone apparently identical with that from the Nigua, indicating the cretaceous age of that range also.

We know of the existence of a large deposit of mineral salt in the hills fifteen or twenty miles northwest of Barahona, but the disturbed condition of the region has never permitted us to visit it. Specimens brought in from time to time are not rare. The mineral is as clear as glass and cleaves into large blocks. The mine is said to be on a high hill side where it could be mined with perfect facility, while from the base of the hill, a gently descending plain, a natural railroad grade extends to the coast, terminating in a good port. It must be understood that I obtain my information from interested parties, although it is pretty well confirmed by common report.

The results of Mr. Pennell's excursion along the southwestern coast are a corrected map of the coast line, and the information that all of the southern peninsula is a nearly level plain of coast limestone, apparently extending back to the Baburuco mountains. It is densely wooded, and resembles in every respect the coast east of Santo Domingo City. Beata Island off its extreme point is an outlier of the same rock, nearly level, but with a trifling elevation in the interior.

The island of Alta Vela is doubtless interesting, from the presence there of the large phosphatic deposit now being mined by an English company. I am unable to say anything about it, however, on account of the jealous policy exercised by the parties. Their agent informed me soon after they began operations, that he would be pleased to extend to me their hospitality, an offer that has been repeatedly made since; but he then made the condition that I must pledge myself not to publish anything about it. Being thus bound in honor not to avail myself of such facts as I might obtain, and having my time fully occupied in obtaining data that I could use with propriety, I have never felt warranted in accepting the otherwise kind invitation. Mr. Pennell touched at the island during his last trip, but the restriction applies with equal force to my assistants as to myself.

PART IV.

PALÆONTOLOGY.

CHAPTER XIII.

DESCRIPTIVE CATALOGUE OF THE FOSSIL MOLLUSCA.

PTEROPODA.

DIACRIA. Gray.

D. bisulcata. Gabb, n. s.

Shell allied to *D. trispinosa*, Lesueur in general form; lateral spines broader and shorter; apex straight, broad, compressed vertically, lateral margins carinate; body sub-compressed; aperture short, upper lip much more curved than the lower, producing a rather gaping mouth; both lips bordered by a reflected margin. Surface of both upper and lower sides marked by two long longitudinal depressions, which converge towards the base of the apical spine, producing a broad elevated median portion.

This shell is less gibbous than *D. trispinosa*, and more so than *D. mecronata*. From the former it differs also in the shape, and from the latter in the direction of its lateral spines. The sulcation on the back also leaves the median space wider than in Quoy and Gaimard's species, and the reflexed lips of the aperture are different from any described species.

BALANTIUM. Leach.

B. undulatum. Gabb, n. s.

Shell sub-cylindrical, tapering convexly towards the apex which is slightly arched downwards. Transverse section elliptical; aperture as wide as the shell, but slightly compressed vertically. Under surface broadly undulated by a few transverse wrinkles; marked on each side near the apex by a faint marginal groove.

Nearest to *B. australe*, d'Orb., as figured in *Amer. Merid.* but without the lateral ridges. It also differs in being distinctly curved instead of straight. The figure given by Chenu in his Manual is entirely unlike that of d'Orbigny.

STYLIOLA. Lesueur.

S. sulcifera. Gabb, n. s.

Shell minute, regularly conical, straight; marked on one side by a longitudinal groove.

This species can be at once distinguished by its groove. It is not unlike *S. striata*, Rong., in the width of its apical angle, but differs from that species in not possessing its curve nor its transverse striations.

PLANORBELLA. Gabb, n. gen.

Shell minute, vitreous, sinistral, apex sunken as in *Planorbis*.

This genus from its distinctly sinistral character is evidently allied to *Limacina*, from which its planorbiform mode of growth distinctly separates it.

P. imitans. Gabb, n. s.

Shell minute, resembling a broad *Planorbis;* apex sunken, whorls two or two and a-half, partially enveloped.

Except for its sinistral character this pretty little shell might readily be mistaken for a very young specimen of the common *Planorbis trivolvus*, so nearly does it copy the external form of that species.

ATLANTA. Lesueur.

A. rotundata. Gabb, n. s.

Shell minute, dextral; spine minute, sub-globular and obliquely imbedded, nearly enveloped and hidden by the the last whorl; body volution showing a very minute trace of a keel, barely amounting to more than an obscure angulation on the median dorsal line. Umbilicus very shallow and showing but a single volution; aperture transversely elongate; one end being emarginate by the encroachment of the preceding whorl.

Its rounded form will serve to distinguish this from all other known species, and seems to necessitate a probable extension of the generic definition, as given in the books, so as to include round-backed, as well as angular or carinated forms. The present species is not absolutely round on the dorsum, but the keel being rudimentary, shows that such a transition may be expected, and that a generic division on this character alone would not be valid.

A. cordiformis. Gabb, n. s.

Shell minute, compressed, sharply angulated on the dorsum and with a thin elevated keel. Apex depressed, not projecting above the body volution. Whorls three; one and a half being visible in the broad flat umbilicus; aperture heart-shaped; dorsal fissure deep. Sides of the mouth arched forwards in the middle, retreating backwards with a regular curve to the outer margin.

Not unlike *A. Perronii*, L. but with a distinctly heart-shaped aperture; broad on the inner and acute on the outer margins. From *A. Kerandrenii*, L. it differs in ~~being~~ a similarly shaped, but much smaller mouth, and in wanting the lateral angles; the lines of growth being regularly curved.

MUREX. Linn.

M. domingensis. Sby. Quart. Jour. Geol. Soc. 18.

A species approaching *Haustellum* in its almost entirely non-spinous varices. It can be recognized by its comparatively short and crooked canal.

M. recurvirostris. Brod. Proc. Zool. Soc., 1832.

Living on the West Coast from Mazatlan to Central America. Its straight canal, larger than the preceding, and the few spines on the varices serve to distinguish it from the preceding.

M. antillarum. Gabb, n. s.

Shell broadly fusiform, whorls eight, rounded, varices three, small, having small, sharp spines variable in number; body whorl inflated, rounding in broadly to the suture, without any marked angle above, below tapering convexly to a nearly straight, short canal; spire elevated, about as long as the mouth, less the canal. Surface ornamented by numerous, more or less alternating, acute, revolving ribs, with concave outer spaces; crossing these are rather indistinct longitudinal ribs, four or five between each pair of varices. These ribs are better marked where they cross the revolving lines, than in the interspaces. Nuclear whorls polished, rounded and without ornament. Aperture ovate, constricted in advance, canal about equal in length to that of the mouth proper. Inner lip expanded, showing transverse striations; outer lip more strongly striate internally. Length 1.15 in.; width .75 in.

A rare shell whose rounded form, thinner structure, more delicate varices and sculpture, and smaller size will all serve to distinguish it from the two preceding.

M. (Chicoreus) megacerus. Sby. Proc. Zool. Soc., 1845. Rve. No. 24.

Living on the coast of Santo Domingo.

M. (Pteronotus) textilis. Gabb. n. s.

Shell compressed triangular; whorls eight, the first nuclear, the next three cancellate and showing little or no trace of varices, which show themselves on the next (fifth) distinctly for the first time, suture deep, caused by the great convexity of the whorls. Body whorl broad and flat above, then very convex near the top and tapering very gradually in advance. The three varices are thick at their bases, broad, acute and slightly recurved on the margin. Between each pair of varices there is one large prominent node, placed longitudinally, too broad to be called a rib. The entire surface is covered by about a dozen revolving ribs, except on the faces of the varices, where corresponding grooves take their places. Crossing these, the lines of growth are developed into minute erect plates, placed at equal distances and arching over all the ribs and intermediate, alternating lines, so as to produce under a lens, the effect of a lace, or loosely woven web. Aperture small, ovate; inner lip acute; outer lip faintly grooved internally; canal about twice as long as mouth and nearly, or entirely arched over. Length 1.4 in.; width .8 in.

M. (Pteronotus) compactus. Gabb. n. s.

Shell short, thick, robust; spire about two-thirds as long as body whorl. Whorls eight; the first two nuclear, suture impressed. Body whorl broad above, tapering in advance, top sloping, very slightly concave. Varices three, short, robust, fimbriated or toothed on the margins, but bearing no spines or other elongate processes. Between each pair of varices, on the shoulder of the whorl, is a broad, blunt node. Surface ornamented by numerous large revolving ribs, between which are many smaller lines, all crossed by distinct, subsquamose lines of growth. Aperture small, sub-oval, inner lip with a faint tooth posteriorly; outer lip internally striate; canal short, blunt. Length 2.3 in.; width 1.4 in.

The spire is much higher in the preceding species, and this is altogether a much heavier and more compact shell.

TROPHON. Montf.

T. dominicensis. Gabb, n. s.

Shell small, broadly fusiform, thin; spire three-fifths the length of the mouth, turriculated; whorls eight, the first three nuclear, round and increasing very little in width, the other five widening more rapidly and angulated. Body whorl truncated above, with a rounded rib on the angle; above this the surface sinuous, convex nearest the suture and concave adjoining the angle; below the angle it is convex in the middle and rounds concavely into a moderate canal. Surface marked by from six to seven blunt varices, each bearing a single spire on the angle of the whorl. Between the varices the surface is shallowly excavated. Crossing both the varices and interspaces, below the angle, there are a few small revolving ribs. Aperture bi-angular posteriorly, narrowed gradually in advance; canal moderate in length, open; outer lip denticulated internally. Length .8 inch.

A very rare shell. But two specimens were found.

MURICIDEA. Swains.

M. corrugata. Gabb, n. s.

Shell short, broad, robust; spire about equal in length to the mouth. Whorls, including the nucleus, seven; rounded and increasing rapidly in diameter; suture well marked; eight large rounded longitudinal ribs, with broad regularly concave interspaces. These are crossed by numerous revolving lines, sometimes alternating in size. Aperture broad, canal short and recurved; inner lip slightly encrusted and strongly ribbed transversely, especially in advance; outer rib also strongly ribbed internally. This character of the mouth will distinguish the species from the following. Length .65 inch, width .4 inch.

M. lata. Gabb, n. s.

Shell short, broad, and robust; spire and aperture about equal. Whorls seven (?) (the apex is corroded away); broad, angulated, obliquely truncated above. Body whorl very short and sloping with nearly straight lines to its anterior end. Surface bearing nine broadly-rounded longitudinal ribs, crossed by numerous closely-placed and rather large elevated revolving lines. Aperture broad and rounded behind, narrowing regularly in advance; canal short and nearly straight; columella slightly encrusted, polished, and with no teeth or ribs on either inner or outer lips. Length .45 inch, width .3 inch.

From the preceding species this shell can be distinguished not only by the inside of the mouth, as stated above, but also by its sub-angular form, sloping tops to the whorls, and nearly straight converging anterior end, and by the closer-placed revolving sculpture and straighter canal.

M. striata. Gabb, n. s.

Thinner and proportionally longer than either of the two preceding. Spire elevated about equal to the aperture; whorls eight, including the nucleus; angulated. Body whorl sloping nearly straight above, convex below, the angle constricted in advance. Surface ornamented by seven large ribs on the widest part of the whorls, which become obsolete above and below. Crossing these below the angle are half a dozen linear ribs with broad smooth interspaces. These latter ribs are well developed where they cross the others, but are much smaller in the concave spaces. Mouth subovate, constricted in advance. Incrustation of the inner lip heavy, smooth, and with a projecting free edge; outer lip faintly striate internally. Canal twisted, with a broad imperforate umbilicus.

Although about the same size as the two preceding species, this shell can be at once recognized by its thinner structure, its more slender shape, its more twisted canal, and by the paucity of its spiral ornaments.

TYPHIS. Montf.

T. alatus. Sby. Quart. Jour., Vol. VI. p. 48, pl. 10, fig. 4.

Very rare. Close to, but distinct from *T. acuticosta*, Con. of the Vicksburg Eocene.

T. obesus. Gabb, n. s.

Shell short, broad; spire very low; whorls eight, sharply angulated; concave above the suture, sloping convexly below; varices four to each whorl, acute-angular on their margins, and ending in a blunt process on the upper angle of the whorl; tubes moderate, pointed laterally, below each tube the surface of the shell is greatly swollen, and two lines pass anteriorly, one being the margin of the old mouth, the other, in advance of the tube, being similar in character and indicating another arrest in growth. Surface polished, marked by faint lines of growth, and crossed below the angle by a few irregular transverse lines, not ribs. Aperture small, oval, bordered by a prominent, acute raised margin; canal closed, short, recurved; front face of terminal varix marked by five small ribs radiating from the outer lip. Length 1. inch, width .75 inch.

With the same general surface ornaments and the same number of whorls and varices, the shell has a very much lower spire and the body whorl is a third wider than Sowerby's species. The great ~~variety~~ of both species prevents a comparison of a series, but I can hardly believe, despite their similarity in some respects, that two shells of such different form can be specifically related. *T. alatus* is a long slender fusiform shell, with a long straight canal and a slender spire. At the same time the resemblance in the ornaments, number of the varices, and of the whorls, and in size render it possible that they are only varieties of one species. My only specimen of *T. alatus* has not the aperture perfect, so in that respect I am compelled to use Sowerby's figure for comparison. The mouth of my *obesus* is much more elongated than Sowerby makes it, and it is sub-angulated instead of being round in advance.

FUSUS. Lam.

F. Henekeni. Sby. Quart. Jour. Vol. VI. p. 49.

Common.

F. quadratus. Gabb, n. s.

Shell very small, elongate-fusiform, spire nearly twice as long as the aperture; whorls eight, the first two, nuclear, round and plain; the next three bearing a number of tubercles which diminishes on each succeeding whorl; suture linear, impressed; body whorl most prominent in the middle, sloping up with but slightly converging sides to the suture. Canal short, broad. Aperture broad, columella slightly curved, outer lip simple. Surface of the body whorl marked by four very large rounded longitudinal ribs, with nearly flat interspaces, making an irregular quadrangular prism. On the next two whorls the ribs, which are not perfectly coincident from one volution across the suture to the other, become more numerous, so that in the middle of the spire there are five, and still further up, on the first ornamented whorl below the nucleus, there are eight or nine little tubercles. Length .35 inch, width about .15 inch.

This peculiar little shell, of which I have seen but a single specimen, has somewhat the surface characters of *Mangelia*, but its straight lines of growth show that it cannot belong to that family. It is a *Fusus* in all of its characters except its unusually short canal.

F. Haitensis. Sby. Quart. Jour. Vol. VI. p. 49.

Among the many thousands of shells collected I have found nothing corresponding with the above quoted description. May it not be only an individual variation of *F. Henekeni?*

HEMIFUSUS. Swains.

H. Antillarum. Gabb, n. s.

Shell short fusiform, moderately broad; spire about half as high as the length of the aperture; whorls eight, angulated, sloping, and slightly concave on the upper surface, bearing about ten rounded nodes on the angle, slightly convex below; suture impressed. Surface ornamented by numerous revolving lines. Aperture broad; outer lip internally striate; canal moderately produced, slightly twisted. Length about four inches.

Allied to *H. colosseus*, Lam., but proportionally broader, with a lower spire, less sloping on the shoulder of the whorl, and the nodes are larger and rounder.

MELONGENA. Schum.

M. melongena. Linn, sp.

Murex melongena, Linn.
Pyrula melongena, Lam. An. S. V.
Cassidulus melongena, H. and A. Ad. Gen. Rec. Moll. p. 81.
Pyrula patula, Brod. and Sby. Proc. Zool. Soc. Vol. IV. p. 377.
C. patulus, H. and A. Ad., *loc. cit.*
Pyrula consors, Sby. Quart. Jour. Vol. VI. p. 49.

No further proof of the above synonymy is needed than an examination of the series of over a hundred specimens collected in the Santo Domingo Tertiary. The fact that *M. patula* is from the Pacific, while *M. melongena* is West Indian, loses all weight when we study the common Miocene ancestors of the two. The two figures, 18 and 20, of Reeve in Icon. Conch. do not exhibit the extreme variations traceable among our fossils. The thickening of the body whorl adjoining the suture varies, sometimes amounting to the deformity observable in *Clavella*, and sometimes being entirely absent. The rows of tubercles on the shoulder as well as those in advance also vary greatly. The normal or most common condition is one row in each series, but two are not rare behind; three occur occasionally, and in some cases, especially up to middle size, the shell is entirely devoid of any signs of prominences. The anterior row may be entirely wanting, or the tubercles, always large when present, may be close to each other or distant. One or two half-grown specimens occur in the series entirely devoid of tubercles, while a small shell before me, undoubtedly of this species, is squamose adjoining the suture, has two rows of tubercles above, a large row below, and is covered with strong revolving lines.

This species is not rare in the European Miocene, where it has received a series of specific names. For a list of half a dozen, see Hörnes, Foss. Moll. Tert. Wien. in the Abhandlungen der K. K. Geol. Reichsanstalt, p. 274, plates 29 and 30.

METULA. H. and A. Ad.

M. cancellata. Gabb, n. s.

Shell long, regularly curved-fusiform; spire a very little shorter than the mouth; whorls eight, body whorl long, slender, sides gently curved; suture bordered by a thickened rib. Mouth long, narrow, peristome continuous posteriorly; inner lip covered with a thick smooth callus, outer lip thickened, sub-acute, and faintly reflexed on the margin, faintly denticulated internally. Surface marked by small but equal longitudinal and revolving ribs. One or two of the latter nearest the suture are a little larger than the others.

About the same size as *M. clathrata*, but has finer sculpture and is more slender. My specimens resemble more nearly the figure of that species in Gen. Recent Moll., than the original in the "Voyage of the Samarang." It also has one more whorl than is attributed to that species in the description.

METULELLA. Gabb, n. gen.

Shell fusiform, canal more or less produced; inner lip covered with a thickened plate, continuous posteriorly with the outer lip. Interior of both inner and outer lips strongly denticulated or transversely striated. Surface cancellated or costate.

This genus is more distinctly fusiform than *Metula*, and has the additional character that the thickened inner lip is covered throughout its length by a series of prominent denticles *not* corresponding with the covered-up surface ribs.

M. venusta. Sby., sp.

Columbella venusta. Sby. Quart. Jour. Vol. VI. p. 46, pl. 9, fig. 6.

The absence of all trace of a notch in the lip proves that Sowerby's reference of this shell to *Columbella* was incorrect. Its fusiform shape, its canal, and the straight lines of growth place it in the *Fusinæ*, and I have been obliged to institute the genus to receive it and the following species.

M. fusiformis. Gabb, n. s.

Shell fusiform, spire high, slender, a third longer than the mouth; whorls nine to ten, rounded. Surface regularly cancellate, except on the canal, by equal longitudinal and revolving ribs. On the canal the former are absent. Aperture long and narrow; canal produced, slightly recurved; inner lip covered by a thin callus posteriorly, thickened in the middle, denticles as prominent as the external ribs and placed transversely. Outer lip thick with an acute margin with eight or ten teeth on the inner face. Length .7 inch, width .25 inch.

Not common.

TURRIS. Bolt.

T. (Surcula) virgo. Lam., sp.

Pleurotoma virgo, Lam.

Turris virgo, H. and A. Ad. Gen. Rec. Moll.

Pleurotoma virgo, Moore. Quart. Jour. Geol. Soc. Vol. IX. pp. 129, 130.

P. Haitensis, Sby. *Id.*, Vol. VI. p. 50.

P. Barretti, Guppy. *Id.*, Vol. XXII., 290, pl. 17, fig. 6.

P. Jelskii, Crosse. Jour. Conch. 1865, p. 34, pl. 1, fig. 8.

P. Antillarum, Crosse. (Nat. d'Orb.) Loc. cit. fig. 6, 7.

A common shell, found living in the West Indies and on the coast of Mexico, and one of the most abundant fossils throughout the Dominican beds, occurring over their whole extent both stratigraphically and geographically. It varies very much in the number, relative size, and arrangement of the ribs, although the general form is quite constant. While Mr. Guppy's figure represents a not infrequent variety, those of Mr. Crosse are not less characteristic. In some cases the ribs are all of the same size, or they are alternate, or even have three or four fine thread-like lines in the interspaces. In one specimen the whole surface is covered by large ribs only separated by acute channels, from which form a regular gradation can be traced to the other extreme, in which the body of the last whorl has but one very prominent ridge on the angle and but one or two below. The identity of all of these forms is amply proven by a study of over 500 specimens collected and a comparison with recent shells. There is one constant character, apart from the form. The notch of the outer lip is broadly sub-angular and is only coincident with the most prominent of the ribs when they differ in size. This rib occupies the posterior angle of the body whorl. Mr. Guppy's figure of *P. Barretti* represents the size of the largest specimen found by Mr. Bonaczy.

T. (Surcula) Henekeni. Sby. sp.

Pleurotoma. Id., Sby. Quart. Jour. Vol. VI., p. 50, pl. 10, fig. 6.

T. (Surcula) *Jaquensis.* Sby. sp.

P. Jaquensis. Sby. Loc. cit. p. 51.

Not a very common species but easily distinguished by its robust fusiform shape and unusually heavy longitudinal ribs. In the young stage it is proportionally more slender. I have before me a few smaller specimens, so nearly like the typical form that I dare not separate them, though they show some small points of difference. The longitudinal ribs are a little more oblique and the revolving ribs are smaller and more numerous, but my experience with *T. virgo* renders me timid in attaching great importance to these characters, unless proven by a larger series than I yet possess.

T. (Surcula) rara. Gabb, n. s.

Shell elongated fusiform; spire high, whorls numerous (number unknown), slightly convex on the sides; body whorl rounded in the middle, sloping upwards nearly straight to the suture, concavely tapering in advance; suture impressed. Surface marked by a large number of equal revolving ribs, crossed by well-marked, irregular lines of growth. Mouth long, narrow; canal long; inner lip smoothly encrusted; outer lip acute. Sinus distant from the suture, broadly sub-angular. Length between 2 and 3 inches.

A single specimen which has lost both the apex and the end of the canal. It is most nearly allied to *T. Carpenteriana*, Gabb, from the later Tertiaries of California, but is much more slender, with a proportionally longer spire and canal, and the notch of the outer lip is sub-angulated instead of being broadly concave, as in that species.

T. (Surcula) Parkeri. Gabb, n. s.

Shell slender fusiform; spire high, longer than body whorl and canal. Whorls eleven prominent in the middle. slightly concave towards the suture, which is linear and undulated. Surface ornamented by about ten very prominent acute longitudinal ribs, with broad, smooth, concave interspaces. Aperture long, narrow; canal straight; inner lip rather heavily encrusted, sinus broad, rounded, moderately deep and placed near the suture. Length about one inch.

A rare little shell, with ornamentation resembling that of *Mangelia.*

T. (Drillia) militaris. Hds. sp.

Clavatula Id., Hds. Proc. Zool. Soc. 1843, Vog. Sulph., p. 16, pl. 5, fig. 10.

Drillia. Id., H. & A., Ad. Gen. Rec. Moll.

Pleurotoma consors. Sby. Quart. Jour. Vol. VI., p. 50.

Id., Guppy. *Loc. cit.* Vol. XXII., p. 289.

With very similar sculpture to *Drillia venusta*, Sby., this shell can be distinguished at all ages by its more slender form. Described by Hinds as living at Panama.

T. (Surcula) longicaudata. Gabb, n. s.

Shell long, slender fusiform; spire elevated, somewhat shorter than the body whorl; whorls ten, the upper ones prominent in the middle, slightly concave near the suture. Suture impressed, bordered by a thickened margin. Body whorl long, slender, outlines gently sinuous. Canal long, tapering, very slightly recurved; aperture long, narrow; columella slightly tortuous, inner lip encrusted by a very thin callus; sinus small, deep, adjoining the suture. Surface marked by numerous acute, revolving ribs, with concave interspaces and crossed by longitudinal ribs following the direction of the lines of growth which, by their intersection, produce a semi-clathrate appearance. Near the suture, over the space occupied by the sinus, the revolving ribs are replaced by fine lines. Length about an inch.

This species is not unlike *T. consors* in its sculpture; but it differs in form. In this, the spire is shorter than the body whorl; in that, it is much longer; in this, the canal is straighter and the notch is nearer the suture than in that; and, finally, this does not possess the heavy revolving rib just below the suture, which is one of the most constant characters of *T. consors.*

T. (Surcula) humerosa. Gabb, n. s.

Shell elongate fusiform, spire high, turriculated; whorls ten, prominent and angulated on the sides, broadly and deeply concave above. Suture bordered by a thickened line. Body whorl broad in the middle, concave above, convexly narrowing below and suddenly constricted at the base, beyond which projects a long, slender, straight canal. Surface marked by revolving ribs showing more or less tendency to alternation in size; above the angle, these ribs are smaller and more uniform. On the angle is a series of flattened tubercles, about a dozen to a volution. Aperture wide and bi-angular above, narrowed in advance. Inner lip but faintly encrusted. Sinus deep, oblique and placed between the suture and the angle of the whorl. Length about an inch.

A peculiar shell unlike any other *Turris*, in the formation. It looks like a small *Fusus*. One specimen, on account of an injury during its growth, has the body whorl rounded, instead of angulated on the shoulder.

T. (Bela) Dominicensis. Gabb, n. s.

Shell minute, turriculated; spire about twice as long as the mouth; whorls eight, the first two nuclear, the others angulated, straight and sloping above, convex below. Body whorl convex in the middle, concavely tapering below. Suture linear, bordered by a slightly thickened line. Surface ornamented by small, revolving ribs, crossed by minute but distinctly prominent lines of growth. On the angle is a series of tubercles, about eight to a volution, which sometimes extend above and below as broadly rounded ribs or undulations. Aperture moderately broad, regularly tapering in advance. Canal broad, short. Inner lip polished. Sinus very broad and shallow, the deepest part immediately above the angle. Length .2 inch.

T. (Drillia) gibbosa. Chemn., sp.

Pleurotoma gibbosa, Chemn. Conch., Vol. XI. p. 190.

Drillia gibbosa, H. and A. Ad. Gen. Rec. Moll.

T. (Drillia) venusta. Sby., sp.

Pleurotoma venusta, Sby. Quart. Jour. Vol. VI. p. 59, pl. 10, fig. 7, *id.* Guppy, Quart. Jour. Vol. XXII. p. 289.

T. (Drillia) squamosa. Gabb, n. s.

Shell large, heavy, turriculated; spire about $1\frac{1}{2}$ times the length of the mouth. Whorls ten, prominently convex in the middle, concave or laterally flattened immediately below the suture. Suture bordered by a thickening of the succeeding whorl. Surface covered by prominent oblique ribs, about ten to a volution. These ribs are laterally flattened in the young shell, but develope to an elongated tubercle in the adult. The whole surface is transversely striated by minute, broken, elevated, thread-like lines, which are in turn crossed or interrupted by the lines of growth, which in places, especially adjoining the suture and on the large ribs, stand out as squamose plates. Mouth sub-quadrate; canal short, twisted; inner lip covered with a heavy plate, of which the free edge projects somewhat; outer lip heavy, margin acute; sinus large, deep, and adjoining the suture. Length 2.5 inches, width 1 inch.

CLAVATULA. Lam.

C. labiata. Gabb, n. s.

Shell regularly fusiform, spire nearly as long as the aperture; whorls nine, angulated above, concave and sloping from the angle to the suture, bearing about nine or ten broad rounded oblique tubercles on the outer side of the angle. Surface of the upper whorl faintly striate by revolving lines; body whorl marked only by the coronal tubercles and lines of growth in some specimens; in others faintly striate like the spire. Aperture narrow, canal moderately produced, very faintly twisted; inner lip simple; outer lip irregularly rugose internally, prominent in the middle, acute on the margin, and thickened behind; sinus deep, adjoining the body whorl, margin internally thickened. Length .85 inch, width .4 inch.

DEFRANCIA. Millet.

D. gracilis. Gabb, n. s.

Shell elongate slender-fusiform; spire longer than the mouth, whorls eleven, of which three are nuclear, slightly rounded on the sides; suture bordered by a thickened line. Surface marked by numerous rounded longitudinal ribs extending to the suture and crossed by two sets of revolving lines, one series prominent and somewhat distantly placed, the interspaces filled with minute threads. This revolving sculpture varies somewhat in degree. Aperture narrow; canal moderate, broad; columella encrusted, slightly tortuous, a broad low tooth near the sinus; outer lip very thick, with an acute slightly reflexed margin and a faint notch anteriorly; posterior sinus deep, close to the suture. Length 1.2 inch, width .3 inch.

A rare shell, remarkable for its long slender form.

D. fusiformis. Gabb, n. s.

Shell elongate, fusiform, spire a little longer than the mouth; whorls twelve, the first one or one and a half nuclear, the others convex in the middle and strongly carinated; suture bordered by a thickened rib. Surface ornamented by a few large longitudinal ribs (about eight), crossed by prominent revolving ribs with broad interspaces in which are fine revolving lines. There are usually three of these larger revolving ribs on the upper whorl, the upper one of which is generally accompanied by a smaller one placed above and close to it. Mouth broad above, narrowed and produced in a long canal, the end of which is slightly expanded. Inner lip heavily encrusted; outer lip very thick with a thin margin, internally grooved, the grooves corresponding to the external revolving lines. Sinus deep, widened a little at the bottom, placed above the angle. Length 1.5 inch, width .5.

A shell resembling *Fusus* in external form and with the large ribs of *T. Jaquensis* combined with nearly the same revolving ornaments as *D. gracilis*. Its spire is proportionally much higher than *T. Jaquensis*, and its whole form is unlike the other species.

D. paupercula. Gabb, n. s.

Shell small, compact, elongate; sides curved; spire one and a half times the length of the mouth; suture well marked and bordered by a raised line; whorls about seven; sides gently curved, forming a nearly continuous line from the apex to the anterior end. Surface prominently clathrate. Aperture narrow, canal short and broad; columella arched; outer lip thickened, sinus moderate, near the suture. Length .35 inch, width .1 inch.

Very rare. A single specimen found. Distinguished by its small size, its curved sides, and its strongly cancellate sculpture.

GLYPHOSTOMA. Gabb, n. Gen.

Shell like *Defrancia*, but with the entire length of the inner lip strongly crenulated or transversely rugose.

This genus bears the same relation to *Defrancia* that *Metulella* (*ut supra*) bears to *Metula.* The inner lip of the only known species is thickened and is crossed by a number of prominences, intermediate in character between teeth and transverse folds. At the same time they are not like the one fold of *Borsonia* or the two or three of *Cordiera*, which in those genera are very similar to those of *Mitra.* A better comparison would be with the teeth of *Cypræa.*

G. dentifera. Gabb, n. s.

Shell rounded, fusiform; spire elevated, nearly as long as the mouth; whorls eleven, rounded on the sides, slightly excavated near the suture, which is bordered by a little thickening of the succeeding whorl. Body whorl convex, gracefully concave, and prolonged in advance into a straight canal. Surface cancellated by nearly equal longitudinal and revolving ribs. On the upper whorls the former are proportionally larger, giving the spire a slightly nodose appearance. Aperture narrow, rather suddenly constricted in advance. Canal moderate in length; inner and outer lips equally dentate; outer lip very much thickened by a prominent rib, margin acute; sinus deep, narrow, and near the suture. Length 1.35 inch, width .5 inch.

CORDIERA. Rouault.

C. magnifica. Gabb, n. s.

Shell large, elongate, fusiform; spire a little longer than the mouth, turriculated; whorls thirteen, straight on the sides, concave and sloping above; body whorl slender, sides sinuous, angulated above. Surface ornamented by moderately large revolving ribs, somewhat alternate in size; these are smaller above the angle, while below it they are broken or crossed by undulations following the direction of the lines of growth, so as to present a distinctly cancellated appearance. Suture bordered by a small rib. Aperture long and narrow, narrowed but not constricted in advance. Inner lip not thickened, bearing four mitraform folds; outer lip simple, broadly convex in the middle, retreating above; sinus broad, shallow, placed above the angle; canal twisted. Length 2.9 inches, width .6 inch.

Very rare. The sculpture and general form of this species approach *T. consors*, Sby., but it is a larger, thinner and more graceful shell, the cancellation of the surface is more marked than I have ever observed in a series of over 150 specimens of that species and the folds on the columella show that the resemblance is only one of imitation and not of relationship.

C. varicosa. Sby. sp.

This shell has the characteristic notch of the family distinctly developed, coincident with the angle of the whorl.

BORSONIA. Bellardi.

A genus established for a shell from the Miocene of Turin, is represented in our collection by a beautiful little shell with the characteristic fold on the middle of the columella.

B. recurvirostris. Gabb, n. s.

Shell small, fusiform; spire turriculated, as long, or a trifle longer than the mouth; whorls nine, two nuclear, the others angulated, excavated above, suture bordered by a rib. Surface ornamented by a series of tubercles on the angle (about a dozen to the body whorl); below this there are large revolving ribs. Inner lip with a single large nearly transverse fold; outer lip simple; sinus broad, oblique and close to the suture; canal produced, strongly recurved. Length about .4 inch, width about .15 inch.

MANGELIA. Leach.

M. heptagona. Gabb, n. s.

Shell elongate, spire elevated, about three-fourths as long as the mouth; whorls eight, nuclear. Body whorl rounded above the middle, sloping up to the suture and tapering nearly straight in advance. Surface marked by seven angular ribs with shallowly concave interspaces; the whole crossed by minute, impressed lines. Mouth linear, canal straight, outer lip thick, straight, acute on the margin; sinus very small. Length .6 inch, width .25 inch.

The largest of the four species, and easily recognized by its seven prominent ribs.

M. polygona. Gabb, n. s.

Shell a little smaller, but nearly of the same shape as the preceding, slightly more slender; surface marked by about seventeen slightly sinuous, longitudinal ribs, with shallow, concave interspaces, crossed by numerous small closely placed, revolving ribs. Aperture narrow; sinus small with a small internal tubercle in advance.

Distinguished from *M. heptagona* by the numerous ribs and by the revolving sculpture.

M. elevata. Gabb, n. s.

Shell minute, sub-fusiform; spire elevated, a little longer than the mouth; whorls seven, flattened on the sides, sub-truncated above; body whorl tapering sinuously in advance. Surface marked by about nine or ten large longitudinal ribs with deeply concave interspaces and crossed by fine, thread-like revolving, elevated striæ. Aperture large, canal broad; sinus deep, rounded, obliquely placed. Length .25 inch, width .1 inch.

Recognizable by its size, not half as long as the two preceding; by its nearly equal spire and mouth, and by the heavy longitudinal ribs.

M. elongata. Gabb, n. s.

Shell small, very slender, spire twice as long as the mouth; whorls eight, nearly flat on the sides; body whorl broadly convex, slightly narrowed in front. Surface marked by six large longitudinal ribs with broad shallow interspaces. Mouth narrow, canal short. sinus deep, narrow, oblique.

Size about the same as that of *M. elevata*, but distinguished from it by the much higher spire and the smaller number of ribs.

All of these species, except *M. polygona* are very rare, and even that species cannot be called common as compared with many of the other shells in the formation.

TRITONIUM. Link.

T. (Lampusia) lineatum. Brod. Proc. Zool. Soc. 1833, p. 6; *not* T. *lineatum*, Sby. Proc. Zool. Soc. 1833, p. 72.

The Santo Domingo fossils differ only from Galapagos specimens in that one of my shells has larger varices than I find in the recent ones with which I compared it. The two series agree exactly in sculpture, form, size and, in short, all of the details except the individual difference noted.

T. (Cymatium) femorale. Linn. sp.

A few well characterized specimens, the largest about five inches long.

T. commutatum. Dk.

My shell agrees perfectly in all its details with specimens of this species in the Museum of the Academy, marked from the West Indies.

T. (Ranularia) Domingense. Gabb, n. s.

Shell small, spire high, as long or longer than the mouth; apex blunt; whorls eight? (the last nuclear whorls are broken in all my specimens); below the nucleus there are three whorls which are cancellate, but do not bear recognizable varices, while the last three whorls have large varices. Whorls convex, the upper ones distinctly bi-angulated, and sloping above. Surface marked by four large tubercles on the angle of the whorls, between each pair of varices; the whole surface crossed by revolving ribs crossed by more or less strongly marked lines. Aperture oval; lips slightly produced; inner lip rugose; outer lip strongly costate internally; canal moderate. Length 1 inch.

Not unlike *T. antillarum*, d'Orb., but with a much higher spire and shorter canal.

DISTORTIA. Bolt.

D. simillimus. Sby. sp.

Triton, id. Sby. Quart. Jour. Vol. VI, p. 48.

Persona, id. Guppy. loc cit. Vol. XXII, p. 288, pl. 17, fig. 13.

Closely allied to *Triton constrictus* of the West coast, but differs in having more numerous revolving ribs.

BURSA. Bolt.

B. crassa. Desh.

Ranella crassa, Desh., Rve. Icon. Conch., sp. 18.

id. Guppy. Quart. Jour. Geol. Soc. v. 22, p. 228, pl. 18, fig. 9.

PHOS. Montf.

P. Veraguensis. Hds. Am. Nat. Hist., vol. XI, p. 256.

Id, Hds. Voy. Sulph. p. 37, pl. 10, fig. 13, 14.

P. Moorei, Guppy. Quart. Jour. Geol. Soc., Vol XXII, p. 290, pl. 16, fig. 11.

P. elegans. Guppy. loc. cit. fig. 13.

After a careful study of about 130 specimens, I feel forced to differ with both Messrs. Moore and Guppy in regard to this shell. That Guppy's two species are based on different ages only of one I have clear proof; and I can find no character on which to separate this from the shell described by Hinds, and admirably well figured in the report of the voyage of the Sulphur.

P. Guppyi. Gabb, n. s.

Shell elongate, spire high, larger than the aperture; whorls regularly convex on the sides; ten or eleven in number. Surface marked by a few broad longitudinal ribs, prominent on the spire, less distinct and occasionally obsolete on the body whorl, and crossed by numerous very small revolving lines; aperture broad, inner lip with but a single fold in advance; outer lip internally striate.

P. semicostatus. Gabb, n. s.

Shell robust, spire longer than the mouth; whorls nine; suture well marked. Surface ornamented by numerous large rounded longitudinal ribs on the apical whorls, which suddenly become fewer on the penultimate, and are represented by but one, or two at most, on the body volution. These latter are almost as prominent and noticeable as the varices of *Triton*. The whole surface is crossed by numerous prominent revolving ribs with usually a distinct alternation in size. Besides these and replacing the large radiating ribs, or rather placed between them, are more or less distinct longitudinal lines crossing the transverse series. Inner lip thickened posteriorly; outer lip internally striate.

P. costatus. Gabb, n. s.

Shell short, robust, spire longer than the mouth; whorls nine; very convex; suture deep. Surface covered with very prominent longitudinal ribs, about nine to a volution, and very uniform in size, with regularly concave interspaces. These are crossed by small revolving lines, most prominent where they cross the ribs. Aperture broad; inner lip heavily encrusted, the margin of the encrustation rising beyond the surface of the whorl as a stout plate; internally it is strongly rugose in advance. Outer lip internally striate in advance.

It would seem rash to attempt to separate shells so nearly allied as the above four species, were it not that I had in all over 1300 specimens. Of these, the first was represented by 130, the second by about 50, the third by over 600, and the last by over 500. In not a single instance did I find a specimen that I could not assign with certainty to its proper species, so that I feel well convinced of the validity of my determinations.

The diagnostic differences between them may be briefly stated as follows: *P. Veraguensis* is evenly sculptured by small, uniform longitudinal ribs, and crossed by still smaller lines; *P. costatus* has very large round ribs of uniform size throughout, crossed by very small lines; it is also by far the most robust of the four, and is the only one that possesses a rugose columella. *P. semi-costatus* is not markedly unlike *P. costatus* in the upper whorls, except that the cross sculpture is much stronger, in which last character it excels all the others; but in the presence of the few varix-like ribs on the body whorls, it is at once distinguishable. And finally, *P. Guppyi* can be recognized at a glance by its very slender form, the four, large irregular ribs and the delicate cross lines. The last is much the prettiest species of the four, and I dedicate it to Mr. J. M. Guppy, whose name occurs on almost every page of the present paper.

NASSARIA. Link.

Hindsia, H. & A. Ad.

N. brevis. Gabb, n. s.

Shell short, broadly fusiform; spire as long as the mouth; whorls eight, the first nuclear, convex; suture deep; whorls covered by about nine prominent ribs, extending from the suture, and on the last volution ending below the middle. Surface crossed by strong revolving lines with concave interspaces. Aperture broad; inner lip encrusted and transversely rugose, especially in advance; outer lip internally striate; canal short, recurved. Length .8 inch; width .5 inch.

ECTRACHELIZA. Gabb, n. gen.

Shell acuminately oblong, spire elevated (always truncate in the only species known). Surface compressed near the suture; inner lip encrusted, columella sinuous, short, outer lip produced in advance.

This genus seems to be allied in many of its characters to *Cominella* and *Truncaria*. Like them it is compressed adjoining the suture. It shows no trace of umbilicus as is seen in most of the *Buccinidæ*; but its most distinctive character is in its obliquely sub-truncated columella, which does not reach the anterior end of the shell. It differs from *Truncaria* in having no fold on the columella, and in the aperture not being emarginate posteriorly. Whether the truncated apex will be of generic or only of specific value, can only be determined on studying other species, should they be found.

E. truncata. Gabb, n. s.

Shell acuminately oblong, spire high, whorls nine or ten at least; apex always truncated, so that usually not more than two whorls are preserved; surface of whorls broadly rounded, slightly concave near the suture which is linear and distinct. No ornaments except some obscure revolving lines, not always present. Aperture acute behind, inner lip sinuous, encrusted, simple; outer lip simple straight, produced in advance; anterior sinus broad, shallow and oblique. Length of body whorl of an average specimen 1.15 inch; width .8 inch.

The truncation of the apex is not an accidental character, but one of at least specific value. Very young shells, only one-fourth of an inch long show it in the same manner as the adults which, with the spire, would have a length of two inches.

CYCLOPS. Montf.

C. angulatus. Gabb, n. s.

Shell minute, translucent, discoidal, whorls rounded above and below and having an angle or carina in the middle, which becomes obsolete in the adult shell on approaching the aperture. Body whorl enveloping the others above, the suture being carried to the apex, but leaving it in the mature shell, so that the top of the shell shows the suture as a straight line bent at a right angle in the middle, and running from the apex across the body whorl to the margin. Aperture laterally expanded; umbilical callus small and slightly concave. Surface minutely striate by fine revolving lines.

A peculiar shell recognizable by its covered top and carinate body whorl.

C. depressus. Gabb, n. s.

Shell very small, discoidal, spire flat, whorls rounded, increasing rapidly in size; body whorl enveloping the others, the suture running in a straight line from the apex. Aperture large, callus small; surface polished.

It differs from the preceding in the whorls being regularly rounded, instead of carinated, and in their increasing more rapidly in size. The top of the shell also is flatter.

CUMA. Humph.

C. tectum. Kiener, sp.

Pyrula tectum. Kiener.

Buccinum tectum, Gray. Woods. Ind. Test., Supp.

Turbinella tectum, Rve. Icon. Conch. Turbinella, sp. 40.

This well known Panama shell is very common in the Dominican beds, and goes through an astonishing series of variations. I have it with a rounded body, without a tubercle, and varying from that to a broadly angulated and umbilicated form, with six immense tubercles on the angle. Between these, and other extremes, I fortunately possess complete series connecting them without question.

HARPA. Lam.

H. rosea. Lam.

A single nearly full-grown specimen of this African species, has all of the characters possessed by recent shells of corresponding size in the Academy's collection.

OLIVA. Brug.

O. cylindrica. Sby. Quart. Jour. V. VI, p. 45.

O. reticularis, Lam., Guppy. *Id.* V. XXII, p. 288.

After a study of nearly 600 specimens I am decidedly inclined to agree with Mr. Guppy in referring this shell to the Lamarckian species. The only ground for a separation that I can discover is that the fossils are usually heavier than the recent specimens and sometimes acquire a greater size. I have them 2.5 inches long.

With these shells are two specimens isolated by their size and differing from each other in such a manner that, were they more numerous, I should be tempted to name them. As it is, I dare not risk making useless synonymy. One 4 inches long has a comparatively low spire and is decidedly tapering in advance; the other 3.3 inches long, is quite high-spired and unusually slender. They are most probably aberrant forms of this species.

O. oryza. Lam.

Quite abundant and differing in no respect from recent specimens.

O. muticoides. Gabb. n. s.

Shell elongate-ovate, spire elevated; whorls seven; suture deeply channeled; inner lip encrusted with a heavy callus and distinctly transversely plaited; four or five large folds in advance extend over the end of the body whorl.

About the size of large specimens of *O. mutica*, this species is more slender, has a higher spire and differs essentially in the inner lip. While that species has a peculiar thickening, built up, as it were, on the inside margin of the lip and running longitudinally on it, and has very few folds (or even none in some cases), this has no such thickening, and is almost as strongly plaited as *O. reticularis.*

O. gradata. Gabb, n. s.

Shell resembling in size and shape *O. ispidula*, but with a higher spire; whorls seven; deeply channeled; surface marked with a sharp offset or break in the continuity of the surface about a tenth of an inch below the channel. Inner lip but lightly encrusted and marked by a few very prominent transverse folds.

A very rare shell, but one that can be at once distinguished by the break in its surface similar to but stronger than that observed in some species of Ancillaria.

O. brevispira. Gabb, n. s.

Shell elongate-oval, spire very small, body whorl sub-cylindrical, very slightly tapering in advance, convexly tapering in its upper one-third or one-fourth towards the suture; suture channeled; aperture rather heavily encrusted and transversely striate by numerous small teeth; anterior folds large. Length one to one and a-fourth inches.

Distinguishable by its comparatively slender form and by the very small spire.

O. canaliculata. Gabb, n. s.

Shell robust, sub-cylindrical, spire moderately elevated, deeply channeled; whorls seven or eight. Aperture linear; inner lip heavily encrusted, crossed by numerous fine transverse striæ; internal surface excavated (by absorption) so as to produce an angulated ridge. Length .8 inch.

Nearest to *O. fimbriata* from which it can be at once distinguished by its more cylindrical form, lower spire and entirely different aperture.

PLOCHELÆA. Gabb, n. gen.

Shell olivæ-form, suture faint; aperture linear deeply and obliquely notched at the base; outer lip thickened in the middle; inner lip encrusted and bearing several transverse folds of which the upper ones are smallest; columella strongly recurved at the base.

From its form and general appearance I feel inclined to consider this genus to belong to the *Olividæ* although its details of character are strikingly like those of *Dibaphus*. It seems to form in a manner a connecting link between the true *Olives* and the genus *Monoptygma* of Lea (not of H. & A. Adams).*

I have before me specimens of *Dibaphus edentulus* and *Mauritia Barclayi*, the typical species of their respective genera. There is no possible room for doubt that *D. edentulus* is, at least sometimes, supplied with mitra-like folds. My specimen has seven or eight and well-developed. Consequently *Mauritia* is synonymous with *Dibaphus;* and it seems to me that the genus should be placed rather with the *Mitras* than with the *Cones*. The differences between the present genus and *Dibaphus* are small, and it is possible that the two should be placed side by side, although I strongly suspect that the resemblances are rather those of imitation than of true relationship.

P. crassilabrum. Gabb, n. s.

Shell elongate-oval, slightly tapering in advance in old specimens; spire low, acuminate, whorls eight, suture obsolete, its end, at the mouth, bent upwards; body whorl rounded above, nearly straight on the sides. Aperture linear, contracted in the middle by the encroachment of the outer lip, which is very much thickened in the middle; inner lip encrusted, crossed by about eight slightly oblique folds, the most anterior of which are largest; columella strongly recurved, sinus deep and oblique. Length about 1 inch.

On one specimen are faint traces of the color pattern which seems to have been small, more or less triangular light patches on a darker ground.

This shell is unlike either *D. edentula* or *Barclayi* in its low spire, its olive-like shape, in the end of the columella being bent directly backwards instead of laterally, in the folds on the inner lip being arranged in an order the reverse of that of *Mitra*, and in the posterior elongation of the mouth.

FASCIOLARIA. Lam.

F. semistriata. Sby. Quart. Jour. Vol. VI, p. 49.

Id. Guppy, loc cit, Vol. XXII, p. 288, pl. 16, fig. 12.

Differs from both *F. tulipa* and *F. distans* in being intermediate between them in color pattern. It seems nearest to *F. tulipa* in shape, but is more slender and has a

* See Lea, Contributions to Geology. The genus *Monoptygma* is described and figured by Mr. Lea as an olive with a very large single fold on the middle of the columella. The author adds that he has received a little shell from the East Indies which he considers should be added to the genus. Authors of recent conchology have all assumed this little shell as the type of the genus, ignoring alike the generic description and the excellent figures of the typical species. H. & A. Adams have monographed the recent shells of this unnamed genus in the Proc. Zool. Society, referring them incorrectly to Monoptygma of Lea.

much longer canal. At the same time it differs in being more grooved near the suture, making a distinct shoulder whorl. It is not impossible that all of these forms, together with *F. rhomboidea*, Rogers, of the North Carolina Miocene, should all be included under the Linnæan name of *tulipa*.

F. intermedia. Sby. Quart. Jour. 1849, p. 49.

Very close to the young stage of *F. gigantea*, which it resembles much more closely than *F. papillosa*. The papillary apex is simply the single nuclear whorl, which is rather larger than usual.

LATIRUS. Montf.

L. infundibulum. Gmel. Lam. A. S. V. (Desh. Ed.) Vol. IX, p. 386.
Id. Rve. Icon. Sp. 3.
Id. Guppy. Quart Jour. Vol. XXII, p. 288.

L. elongatus. Gabb, n. s.

Shell very elongate, slender-fusiform, spire high, many whorled ; whorls rounded in the sides ; suture distinct. Surface marked by a series of broad, rounded, longitudinal ribs, about nine to a volution, crossed by simple revolving lines, larger on the canal than on the body of the last whorl ; canal very long, straight ; inner lip with four or five small, slightly oblique folds. Length about three inches.

Easily distinguishable by its very elongate fusiform shape, and its long, slender straight canal.

L. exilis. Gabb, n. s.

Small, elongate, slender, spire longer than the aperture and canal ; whorls numerous, suture bordered by a rib ; surface marked by a very few large longitudinal ribs, five or six to a volution. These are crossed by strong revolving lines, of which about three appear on the upper whorls. Mouth small, oval, extended into a long slender, slightly curved canal ; inner lip encrusted, the plate extending so as to make a raised sharp border to the mouth ; internally marked by two strong transverse folds. Length 1.5 inch.

Differs from the preceding by its coarse sculpture, the laterally-bent canal and the details of the mouth.

L. fusiformis. Gabb, n. s.

Shell small, fusiform, spire a very little shorter than the mouth ; whorls nine, subangulated and slightly concave above ; surface marked by about eight or nine longitudinal ribs crossed by revolving lines. Aperture broad ; inner lip with three oblique folds ; canal long, straight. Length 1.7 inches.

In sculpture, this is nearest to *L. infundibulum*, but it differs in being more finely sculptured, and being more regularly fusiform, with a long straight canal, and in not being umbilicated. From *L. elongatus* it differs in being more broadly fusiform, shorter and broader, in being sub-angulated above, and in the columellar plications.

L. angustatus. Gabb, n. s.

Shell elongate, slender-fusiform ; spire many whorled, longer than the aperture ; whorls convex, suture well marked. Surface marked by a dozen long rounded ribs with regularly concave interspaces and crossed by small revolving lines. Aperture elongate ; inner lip with two or three small oblique ribs ; canal moderately elongated, slightly twisted. Length 1.4 inches.

A comparatively small shell, with a rather short canal and distinguishable by its more numerous and nearly straight ribs, and fine cross sculpture.

TURBINELLA. Lam.

T. valida. Sby.

Turbinellus validus, Sby., Quart. Jour. Vol. VI., p. 50.

Differs from *T. scolymus* in its greater number of tubercles. The specimens differ also among themselves somewhat, in the character of the inner lip. In some cases it is hardly encrusted, while in others it is covered with an enormous plate with a free edge.

T. ovoidea. Kiener. Icon. Coq. viv. p. 7, pl. 17, fig. 7.

Not rare. It is reported from the coast of Brazil, and I am not aware that it occurs now in the West Indies.

VASUM. Bolt.

V. Haitensis. Sby., sp.

Turbinellus Haitensis. Sby. Quart. Jour. Vol. VI., p. 50.

Closely allied to *T. muricata*, from which it differs in one constant character. In that species the suture is considerably below the angle of the preceding whorl; in this, the suture always follows the extreme outer angle.

V. tuberculatum. Gabb, n. s.

Shell large, ponderous, broad; spire elevated, half as long as the mouth, whorls about eight or nine; broadly angulated, concave and sloping above, bearing a few very large tubercles on the angle; body whorl tapering rapidly below the angle and strongly ridged in advance. Surface covered with a few revolving lines. Aperture broad behind, narrowed in advance and expanded at the termination of the anterior ridge. Inner lip with four or five large folds. Length 4 inches, width 3 inches.

Allied to *T. caestus*, but differs in having but six very large tubercles on the angle instead of many, as in that species.

V. Dominicensis. Gabb, n. s.

Shell small, very robust; spire about as long as the mouth in old shells, not so long in the younger stages, whorls 10, concave above, angulated; body whorl convex in the middle, concave in advance and broadly umbilicated: surfaces marked by about 7 larger slightly oblique longitudinal ribs, more or less tuberculate on the angle and crossed by numerous revolving ribs, the whole rendered more or less squamose by lines of growth; there is a larger revolving rib or row of tubercles in advance. Aperture elongate-oval; inner lip covered with a heavy plate, with four transverse folds. Length 2.5 inches, width 1.5 inch.

The high spire and small size of this shell render it entirely unlike any other with which I am acquainted in the genus.

LAGENA. Schum.*

L. rhomboidea. Gabb, n. s.

* I have elsewhere expressed my disapproval of the use of names of such authors as Klein, who were only by accident binomial; who only used a single word for a specific name occasionally, and whose names are not seldom a whole phrase or even a sentence. H. and A. Adams use for this genus *Leucozonia* of Gray since Klein had used *Lagena* elsewhere. But if we follow Gray and Adams in adopting Klein's names, we must, with the latter also use those of Aldrovandus; and since he quotes Aristotle, to be consistent we must imitate him. Malacology is sadly in need of an *index expurgatorius* and I am by no means sure that it ought not to contain with these polynomial authors, the anonymous writers of Museum Colonnianum, Museum Boltenianum, *et id omne genus*. Since, however, through the endeavors of Swainson, Gray, Morch and Hermannsen, we now have the names of Humphrey, Bolten and Link (who were binomial though defective) applied to definitely recognized genera, and since conchologists are very generally agreed on their use, they may be retained: but no good argument has yet been adduced to support the use of names, derived from those authors who were habitually polynomial.

Shell short, broadly fusiform; spire and mouth equal; whorls seven, the first nuclear, the other regularly sloping above, obsoletely nodose on the angle and tapering in advance. Surface marked by fine revolving striæ. Aperture broad, contracted in advance; columella bent in the middle, carrying three folds, slightly twisted in advance.

SCAPHA. Gray.

S. striata. Gabb, n. s.

Two very young shells, evidently of this genus, occur in the collection, and I venture to name them despite their immature condition. Although the largest is barely over an inch long, they have both lost their nuclei and have the usual prominent but blunt apices. The larger is elongate, rather slender, the shoulder bears a series of short laterally compressed nodes which form a coronated angle. The suture is well marked and the whole surface is crossed by fine revolving striæ. Below the angle, the sides are nearly straight and narrow sinuously in advance. Columella with the two prominent oblique folds.

I have compared these evidently immature shells with all the known species and cannot identify them as belonging to any one of them.

LYRIA. Gray.

L. pulchella. Sby. sp.

Voluta pulchella. Sby. Quart. Jour., Vol. VI., p. 45, pl. 9, fig. 4.

? *V. soror.* Sby. *loc. cit.*, p. 46.

I have both the varieties of the species mentioned under the first of the above-quoted descriptions, and by an examination of about 200 specimens, which show great variations in the number, size and characters of the ribs and in the height of the spire, I am strongly inclined to suspect that *V. soror* is only another of these variable forms. Among these 7 shells I have one variety almost undistinguishable from *L. Delessertiana.* The strongest difference is that some of the specimens of that species are more slender than our shell.

MITRA. Lam.

M. Heneken i. Sby., Quart. Jour. Vol. III., p. 46, pl. 9, fig. 5.

Id. Guppy. *Loc. cit.*, Vol. XXIII., p. 288.

Distinguished by its slightly convex sides and by the small number of columellar folds; but more especially by the shallow channels, or, more strictly speaking, by the truncation of the upper margin of the whorl, adjoining the suture.

M. longa. Gabb, n. s.

Shell very attenuate, spire as long, and in old specimens much longer than the mouth; whorls about twelve, nearly flat on the sides; body whorl very broadly convex in the middle; suture distinct; surface marked by large and acute revolving ribs, with occasionally smaller ones interposed. In the interspaces, fine longitudinal and revolving lines form a distinct cancellation. Aperture long, slender, narrowing very little in advance. Inner lip with four distinct and one or two faint folds.

Distinguished from the preceding by its very slender form and the greater number of columellar plaits.

M. rudis. Gabb, n. s.

Shell short, broad robust, sides curved; spire about equal to the mouth; upper whorls nearly flat on the side; suture bordered by a slightly thickened margin; surface marked by a few large rounded revolving lines crossed by irregular lines of growth, so as to produce a semi-cancellate appearance. Aperture broad, not contracted in advance; inner lip with four folds of which the most posterior is very prominent and the anterior is very indistinct; outer lip serrate, the notches corresponding to the superficial ribs. Length 1.4 inch, width .6 inch.

The short, thick form and rudely cancellate surface sufficiently distinguish this rare shell.

M. titan. Gabb, n. s.

Shell very large, elongate spire a little shorter than the aperture; whorls about ten or eleven (apex broken), silghtly convex on the sides, suture linear or bordered by a very faint thickening of the margin of the succeeding whorl. Surface nearly smooth, marked only by a few faint revolving impressed lines in the adult. In the young shell these are more marked, and are broken by the traces of the lines of growth which are hardly perceptible except in the depressions. Anteriorly there are sometimes traces of indistinct revolving ribs. Aperture long and narrow, slightly narrowed in advance; columella encrusted, especially in front, where it is gently twisted, carrying one very faint and four distinct folds. Outer lip thick and rounded on the margin, not striate. Length 6 inches, width 1.75 inch.

This shell, which rivals *M. episcopalis* in size, resembles in its younger stages *M. Isabella* in form, but can be distinguished by its smooth surface, which also separates it from all the other fossil Mitras of Santo Domingo.

Not unlike *M. scrobiculata*, Brocc., of the N. Italian miocene, but proportionately more convex, with a larger body whorl and with the columellar folds more transverse.

M. symmetrica. Gabb, n. s.

Shell slender fusiform; spire and mouth about equal; whorls ten, slightly convex on the sides, suture, distinct. Surface marked by numerous, closely placed, flattened revolving ribs, the interspaces crossed by prominent lines of growth which do not appear on the tops of the ribs. Aperture moderate, narrowed slightly in front. Columella with four well marked plaits.

From *M. Henekeni* and *M. longa* this can be readily distinguished by its flat ribs; from the first by its more numerous columellar folds and from the second by its more rounded form. It is not impossible, however, that it may prove to be the young of *M. titan*, from which it differs in having a straight canal, and in its ribs; two characters which are not always unalterable as shells grow older.

M. tortuosa. Gabb, n. s.

Shell elongate, sub-turretted; spire about as long as the aperture; whorls flat on the sides, convexly truncated adjoining the suture; body whorl narrowed in front and produced into a tortuous canal. Surface marked by about a dozen longitudinal ribs, acute on their summits and with concave interspaces. These ribs begin at the suture, and on the body whorl cover all of its convex portion. Between these are revolving impressed lines of variable intensity, which never cross the summits of the ribs. Beyond the termination of the longitudinal ribs, and especially on the canal, these lines are stronger. Aperture long and narrow, contracted into the canal in advance; columella twisted, bearing four prominent folds. Outer lip faintly notched near the suture. Length 1.3 inch, width .45 inch.

This species belongs to the group of *Costellaria*, Sw., but the contraction into an anterior canal is more marked than in any other species known to me. It is nearest in style to *M. semifasciata*, Lam.

MARGINELLA. Lam.

M. coniformis. Sby., Quart. Jour., Vol. VI., p. 45.
Id. Guppy, *loc. cit.* Vol. XXII., p. 288, pl. 17, fig. 2.

A very variable species which I have failed to divide after a careful study of its modifications. It is sometimes broad, sometimes slender; the spire is sometimes elevated, sometimes depressed, and some of the mature shells are twice as large as others. Still, the gradations between all of these variations are so numerous and so complete that I am forced to consider them all one species.

M. (Glabella) Sowerbyi. Gabb, n. s.

Shell volutiform, spire high, whorls five; body whorl regularly tapering in advance. Aperture linear, inner lip with four folds, the last one terminal and all slightly grooved on the summits; outer lip with numerous small teeth, one or two at the posterior end, larger than the others. Length .6 inch, width .45 inch.

Easily recognized by its high spire and by the sulcate columellar folds.

M. chrysomelina. Redf. Am. N. Y. Lyc., N. Hist., Vol. IV, p. 492, pl. 17, fig. 2.
M. pudica. Gaskoin, Proc. Zol. Soc., 1849, p. 18.

Rare—Living in the West Indies.

STROMBINA. Mörch.

S. gradat~~e~~a. Guppy.
Columbella id. Guppy, Quart. Jour., Vol. XXII., p. 288, pl. 16, fig. 10.

In a note Mr. Guppy refers this species to *Strombina* and suggests relationship with *Pleurotoma.* The shell is characterized by two or three prominent tubercles of variable size on the upper part of the body whorl, which give it a triangular form. These are variable; sometimes very prominent, in other cases almost wanting.

S. ambigua. Guppy, loc. cit., p. 288, pl. 16, fig. 8.

Has not been found in Santo Domingo.

S. inflata. Gabb, n. s.

Shell elongate, spire elevated, whorls eight, convex on the sides and truncated adjoining the suture. Surface of the body whorl transversely striate in advance. Aperture narrowed in advance, canal somewhat recurved; inner lip encrusted and transversely striate; outer lip but slightly thickened and interiorly striate, but not denticulated.

In size and general appearance, this shell is not unlike *S. gradata,* but it differs from that species in its much broader body whorl, shorter spire, in the absence of all ornament except a few revolving striæ in advance and in the outer lip being slightly thickened and striate internally instead of being denticulated.

S. Haitensis. Sby., sp.
Columbella Haitensis. Sby., Quart. Jour., Vol. VI., p. 46.

S. Caribæa. Gabb, n. s.

Shell small, robust, spire high, whorls nine, minutely truncated on the upper margin; body whorl marked by a few revolving striæ in advance and with a thickening opposite the lip, making a sub-elliptical cross-section. Aperture broad; outer lip very thick, with a few teeth internally, the internal notch remote from the posterior angle. Inner lip encrusted and with four or five minute teeth. Canal very short and recurved.

About the size of *S. Haitensis*, and not unlike it in general form, but differs in entire absence of longitudinal ribs and in the presence of the ranella-like flattening.

S. exilis. Gabb. n. s.

Shell minute, slender, spire a little longer than the mouth; whorls seven; marked by small longitudinal ribs; anterior end of body whorl crossed by a few revolving lines. Inner lip encrusted; outer lip slightly thickened, with the characteristic internal notch, and with three or four teeth in advance. Length .15 inch.

In size and form this is not unlike the immature shells of *S. Haitensis*, but a dozen or twenty specimens prove it to be mature, independent of the perfect mouth. It also wants the thickened suture margin of that species.

I have two fragmentary specimens, indicating a fourth species larger than S. Haitensis, more regularly gibbous and with strong longitudinal ribs. Unfortunately, in both cases the anterior half of the body whorl is broken away.

CASSIS. Lam.

C. sulcifera. Sby., Quart. Jour., Vol. VI., p. 47, pl. 10, fig. 1.
Id. Guppy, loc. cit., Vol. XXII., p. 286.

Sowerby's specimen, as figured, is an unusually round one. The inner lip is generally expanded far beyond the body whorl, so as to make the under face a rude right-angled triangle. In old specimens there are three rows of tubercles, and the middle one of the upper row is generally very prominent.

CASSIDEA. Brug.

C. granulosa. Brug, Enc. Meth. Vol. I., p. 421.
Buccinum cassideum tesselatum, Chemn. Conch. Cab., p. 76.
B. inflatum, Shaw. Nat. Misc., Vol. XXII., pl. 959.
Cassis monilifera, Guppy. Quart. Jour., Vol. XXII, p. 287, pl. 17, fig. 8.

Reeve says that Shaw's name antedates that of Brugiere ten years; but by a reference to the original authors, it is certain that it should bear a later date than 1795 (that of both Conch. Cab. and Enc. Meth.), since Shaw not only refers to the figure of Chemnitz, but his illustration is evidently from Conchylien Cabinet, very badly made and sinistral.

CYPRÆCASSIS. Stuch.

C. testiculus. Linn.

Not common; half a dozen specimens found.

CASSIDARIA. Lam.

C. laevigata. Sby., Quart. Jour., Vol. VI., p. 47, pl. 10, fig. 2.
C. sublaevigata, Guppy, loc. cit., Vol. XXII., p. 287, pl. 17, fig. 10.

A study of 160 specimens proves that Mr. Guppy's separation of his species is not based on sufficient grounds. The spire varies more than the difference between the two figures, the striation is a pretty constant juvenile character occasionally retained on adult shells, and I have *lævigata* much larger than Guppy's specimen.

This is not the same species as described by Conrad, from Vicksburg, although (Proc. Phil. Acad., 1852, p. 199,) he states that he considers them identical.

MORUM. Bolt.

M. Domigensis. Sby., sp.

Oniscia Domigensis. Sby., Quart. Jour., Vol. VI., p. 47, pl. 10, fig. 3.

Very different from *Oniscia harpula*, Con., from the Vicksburg Eocene, although Mr. Conrad has asserted their indentity.

MALEA. Val.

M. ringens. Swains.

Cassis ringens. Sw., Bligh. Cet.

Malea. *Id.*, H. and H. Ad., Gen. Rec. Moll.

Dolium. *Id.*, Rve. Icon., sp. 5.

Malea latilabris. Val.

M. camura, Guppy. Quart. Jour., Geol. Soc. Vol. XXII, p. 287, pl. 17, fig. 9.

Both the typical form and Valenciennes variety occur fossil in Santo Domingo.

FICUS. Bolt.

F. papyratia. Say.

Pyrula papyratia, Say. Jour. Phil. Acad., 1 ser., Vol. II., p. 228.

Sycotypus papyracea, Stimpson, Sw. Check List.

Id. H. and A. Ad., Gen. Rec. Moll.

A single good and one poor specimen found.

F. Mississippiensis. Con., Jour. Phil. Acad., 2 ser., Vol. I., p. 117.

Ficula Carbasea, Guppy. Quart. Jour., Vol. XVII., p. 580, pl. 26, fig. 7.

I have compared Mr. Guppy's shell with Mr. Conrad's original specimens from Vicksburg, Mississippi, and find them indentical in form and sculpture. I am by no means sure that this should not be considered the same as *F. decussatus* (*F. Ventricosus*) the common west coast Mexican form.

NATICA. Linn.

N. canrena. Linn. Mus.. p. 674.

A common West Indian shell. The callus in the umbilicus seems smaller in the recent specimens, but not sufficiently different to warrant a separation.

N. sulcata. Born., Mus. Cæs., pl. 17, fig. 5, 6.

Id., Guppy. Quart. Jour. Vol. XXII., p. 290, pl. 18, fig. 14, 15.

I have both shell and operculum of this and the preceding species, besides a third species of operculum about which I am in doubt.

MAMMILLA. Schum.

M. mamillaris. Lam. sp.; *Natica id.*, Lam., A. S. V., Vol. VIII., p. 628.

Id., Guppy. Quart. Jour., Vol. XXII., p. 291.

N. subclausa, Sby. Quart. Jour., Vol. VI., p. 51.

I cannot find sufficient grounds for separation of *subclausa* from the Lamarckian species.

AMAURA. Möller.

A. Guppyi. Gabb, n. s.

Natica phasianelloides, Guppy, (not d'Orb.) Quart. Jour., Vol. XXII., p. 219, pl. 47, fig. 1.

Shell subglobular, spire high, two thirds as long as the mouth; whorls rounded, neither flattened nor channeled near the suture. Aperture broad, regularly rounded in advance; inner lip thinly encrusted, thickened and bordered by a carina in advance of the umbilical region. This carina forms a flattened margin to the mouth and unites in advance with the outer lip.

Guppy's figure is a little smaller than the average of the full grown Dominican specimens, but the shell never attains a quarter of the size of the Cuban shell. It is quite common in Santo Domingo.

SCALARIA. Lam.

S. denticulata. Sby.

One or two imperfect specimens of this species were found.

S. minutissima. Gabb, n. s.

Shell elongate, slender, spire high; whorls nine, convex, suture deep; surface marked by prominent plates, about twelve to a volution, denticulated on the upper angle. Between these plates are minute revolving lines. Aperture subcircular with a continuous thickened lip. Length .2 inch.

This species differs from *S. uncinaticosta*, d'Orb., La Sagra's Hist. of Cuba, pl. 11, fig. 25, 27, in having a more slender form and in the interspaces between the ribs being marked by smaller and more numerous revolving lines.

S. ampla. Gabb, n. s.

Shell short, broad, robust; spire a little higher than the body whorl; whorls about seven (apex broken), very convex, and having about ten larger, robust sub-squamose plates, angulated, or sub-denticulated above; body whorl with a few faint impressed lines and a ridge at the lower angle. Mouth circular, bordered by a heavy lip. Length .6 inch, width .45 inch.

Characterized by its short, very broad form and by the varices which are built up of numerous layers and are so thick that they unite at the base. I found but a single specimen weathered out of the brown shale east of Guayubin. It is of the same type as *S. expansa* Con., of the Maryland Miocene, but is hardly a third as long as that species.

TEREBRA. Brug.

T. robusta. Hds. Proc. Zool. Soc., 1843, p. 149.

Id. Rve. Icon. sp. 10.

T. sulcifera, Sby., Quart. Jour., Vol. VI., p. 47.

I can find no difference, on a critical comparison, between the fossils and recent Panama specimens.

T. inæqualis. Sby., Quart. Jour., Vol. VI., p. 47.

Id. Guppy, loc. cit., Vol. XXII., p. 290.

Very similar to the preceding in its young state, this shell continues slender at all ages and retains its sculpture, while *T. robusta* widens more rapidly as its grows older, and the sculpture becomes obsolete.

T. bipartita. Sby., Quart. Jour., Vol. VI., p. 47.

Distinguished by the usually finer sculpture and by the single impressed line.

T. dislocata. Say., sp.

Ceritium, Id. Say., Jour. Phil. Acad., 1 ser., Vol. II., p. 236.

Terebra, Id. Rve., Icon., sp. 32.

T. Petitii. Kiener.

A common shell and agrees perfectly with specimens from the coast of Georgia and South Carolina.

In addition to the typical form, I have another differing from it in being very much more alternate. In sculpture and other details, apart from this, it agrees perfectly.

OBELISCUS. Humph.

O. canaliculattus. Gabb, n. s.

Shell elongate, slender, many whorled, umbilicated; spire high, whorls flat on the sides, truncated on the upper margin adjoining the suture, so as to produce a deep revolving channel; at the lower angle of the whorl there is sometimes a corresponding channel, at other times a mere angle, and in still other cases only a rounded surface. When this channel is present, it always, in the upper whorls, assists in forming the revolving groove. Under surface of body whorl convex with a rib surrounding a minute umbilicus; aperture broad, columella straight, with one transverse fold above and two, more oblique, below; the anterior of these two, borders the internal channel. Outer lip with two or three transverse internal plates. Length .5 inch, width .15 inch.

RINGICULA. Desh.

R. semistriata? d'Orb., LaSagra, pl. 21, fig. 17, 19.

I refer my little shell to d'Orbigny's species, although it seems more elevated than his figures. It has all of the details of the other characters, as well as I can make them out in so minute an object.

TURBONILLA. Risso.

I cannot understand why Herrmannsen and others place the large cretaceous *Chemnitzias* as congeneric with the little polished delicate forms for which Risso proposed the above generic name.

T. Dominicensis. Gabb, n. s.

Shell minute, subulate, whorls numerous, flat on the sides; apex small, placed vertically; surface crossed by numerous fine longitudinal ribs and very minute revolving lines. Inner lip twisted, but without a distinct fold. Length .28 inch.

Distinguished from the others by its broader form and by the revolving sculpture. Nearest to "*Chemnitzia*" *ornata* d'Orb., but more slender.

T. angusta. Gabb, n. s.

Shell small; spire many whorled, whorls flat on the sides; surface ornamented by longitudinal ribs which do not run over the base of the body whorl. Aperture rounded in front, inner lip simple, straight.

About the same size as the preceding, but more slender and without any trace of the revolving lines. It differs also in the mouth.

T. pertenuis. Gabb, n. s.

Shell small, very slender, polished, whorls numerous, nucleus large, vertical; surface of whorls flattened on the sides and with comparatively large ribs; base simple; aperture small sub-quadrate.

Distinguished from both the preceding by its very slender form and more prominent ribs.

T. turritelloides. Gabb, n. s.

Shell minute, slender, elongate, whorls about 14, the first placed vertically, the others regular, flat on the sides and truncated above; suture bordered by the top of the succeeding whorl; base of body whorl sub-angulated on the margin and rounded below; aperture quadrate. Surface polished and marked by microscopic revolving lines. Length .35 inch.

This shell can be distinguished by its form which is exactly like that of a minute Turritella. The sides of each volution are parallel, the top is truncated, and only three or four of the primary whorls show any convexity.

AURICULINA. Gray.

A. alta. Gabb, n. s.

Shell slender, spire elevated, about three times as high as the mouth; whorls six elongate, convex on the sides, curving in abruptly to the suture; surface plain; aperture sub-elliptical, lips simple. Length .1 inch.

A little shell unlike any other in the formation. It can be at once recognized by its few semi-flattened whorls and elongate aperture.

ACLIS. Loven.

A. polita. Gabb, n. s.

Shell minute, polished, subulate; whorls seven, flattened on the sides; suture channeled, sides of spire convex; base of body whorl elongate-convex, aperture small, acute behind, rounded in advance; lips simple; surface without ornament. Length .1 inch.

In its polished surface and channeled suture, this shell is not unlike *Obeliscus canaliculatus*, but its short form, convex sides and simple rounded mouth will distinguish it at a glance.

MENESTHO. Möller.

Pyramis, Couth., not Schum. Bolt., *et al.*

Monoptygma, H. and A. Ad., Sby., *et al.* not I. Lea.

Monotygma, Gray.

See note under *Plochelæa*, with reference to the curious misapprehension under which most of the English authors have labored with reference to the true meaning of Mr. Lea's genus.

If we restrict the name *Menestho* to these species without a columellar fold, as is done by H. and A. Adams, then the *Monoptygma* Ad., &c. (not Lea), is without a name. The present species has a fold, and I agree with the Adams' in making at most but a sub-generic separation.

M. clathrata. Gabb, n. s.

Shell minute, elongate, spire high, whorls eight; the first two polished, the other six marked by regular longitudinal and revolving elevated lines, sides of the whorls rounded, suture strongly marked. Aperture elongate oval, sub-acute behind; columellar fold strongly marked.

The species is most like *M. spirata*, but is not more than a third of its length, is less tapering, and is at once distinguishable by its strongly clathrate sculpture.

EULIMA. Risso.

E. acicularis. Gabb, n, s.

Shell elongate, slender, sides straight, surface polished, whorls numerous, elongate; last whorl produced in advance, mouth long narrow, acute behind. Length .6 inch.

Distinguished by its very elongate form. Not unlike *E. bifasciata*, d'Orbigny, but larger and more slender.

E. robusta. Gabb, n. s.

Shell minute, elongate, widening much more rapidly than the preceding; sides straight, whorls numerous, short; suture very transverse; base of body whorl moderately produced; aperture small. Length .15 inch.

From the preceding, this can be distinguished by its much smaller size, its transverse suture and short mouth. From *E. subcarinata*, d'Orb., it differs in being more slender and in being less angulated at the base.

E. crassilabris. Gabb, n. s.

Shell short, robust, spire elevated, nearly three times as long as the mouth, whorls numerous, surface polished, base of body whorl elongated; mouth long, acute behind, produced in advance, outer lip thickened and very prominent at its anterior lateral margin. Length about .1 inch.

NISO. Risso.

N. grandis. Gabb, n. s.

Shell large, subulate; whorls numerous, short; surface gently convex, polished; suture well marked; body whorl rounded on the basal margin, base sloping, gently convex; umbilicus moderate, bordered by carina on the inner face of the angle. Aperture small, acute behind, rounded in advance.

A single fragment showing the last five ~~fine~~ whorls is .8 inch in length, with the body whorl .5 inch wide. Its unusually short volutions will serve to distinguish it from any other known species.

N. minuta. Gabb, n. s.

Shell minute, broad, spire elevated, whorls numerous, apical angle wide, sides straight, surface polished; base of body whorl sub-angulated, lower surface slightly convex; umbilicus moderate, bordered by an angle. Aperture broad, sub-angulated in advance. Length .07 inch.

It is possible that this may be a young shell, but its specific characters are so marked it cannot well be mistaken.

IOPSIS. Gabb, *n. gen.*

Shell Eulimoid, polished, spire elevated, sutures obsolete, apex dextral, non-umbilicated columella twisted and produced into a short, lip-like canal.

This ivory-like surface, obsolete suture and whole general appearance of this shell prove its close relationship to *Eulima*; while its faintly twisted columella, extended to such degree as to produce a short, (though not notched canal), distinguishes it from the other genera of the family. Named from its resemblance in form to the fresh water genus *Io*.

I. fusiformis. Gabb, n. s.

Shell minute, short-fusiform, spire twice as long as the mouth, whorls seven, flattened on the sides, apical angle wide, suture obsolete, surface polished; body whorl sub-angulated below, slightly convex and produced in advance. Aperture sub-angulated, lips simple, columella slightly twisted, anterior end produced so as to form a small but well marked lip-like canal. Length .08 inch, width .04 inch.

ARCHITECTONICA. Bolt.

A. quadriseriata. Sby., sp.

Solarium, id. Sby., Quart. Jour., Vol. VI, p. 81, pl. 10, fig. 8.

Id. Guppy, Quart. Jour., Vol. XXII., p. 291.

Common.

TORINIA. Gray.

T. rotundata. Gabb, n. s.

Shell moderate in size, spire elevated, apical angle rounded; as also the outer margin; base of body whorl convex; outer margin marked by two large ribs with a smaller one between; upper surface with four ribs, under surface with five or six, of which one forms the umbilical margin and is strongly crenate; umbilicus broad, inner face of the whorl marked with two large and three linear alternating ribs; the whole surface crossed by strong lines of growth breaking the revolving ribs and producing a cancellated appearance. Aperture nearly circular. Diameter .5 inch, height .35 inch.

Rare. In the sculpture of the upper surface, this is not very unlike the preceding species, but its rounder form sufficiently distinguish them.

CONUS. Linn.

It is with decided reluctance that I have taken up the enumeration and separation of the Cones of Santo Domingo. I am safe in asserting that I have never undertaken a more difficult task, and while I have almost suffered under an embarrassment of riches in the great numbers of specimens I have had to study, that same profusion is rather the source of the difficulty than a means of relief. With a few shells, a fictitious division can easily be made; but in series of hundreds, nay thousands, where opportunity exists for the study of all the varieties, this labor is not so easy. I have based the following arrangement on the careful and prolonged examination of over 2,300 good specimens, and believe that, in the main, I am more correct than my predecessors could have had the means of being. Since I have been obliged in most cases to work in this difficult genus without the advantage of the color patterns, and therefore to depend almost entirely on form, my results cannot have that certainty which accompanies the study of recent shells. Still I have had this assistance in part, and have availed myself of it. By comparison of the larger suites at my disposal, I have learned that the apical angle, within certain limits is, of itself of little value; the presence or absence of spiral striæ on the tops of the whorls is not always a safe character, but the most variable one of all is in the surface striæ or grooves on the sides, more especially at the anterior end of the shell. In recent specimens, where the colors are so marked, this latter character is but little noted; but in the fossils it becomes of the greatest importance to ascertain how far it can be depended on. I find that the character of this spiral ornament, *when present*, is of much greater value than the fact of its actual presence or absence. Again, in many species, especially in young specimens, the whole or a part of the surface may be marked by raised ridges or simple striæ. These may be smooth, or they may bear small tubercles. The presence or absence of these tubercles is usually of no importance in specific determination. But raised ridges never widen so as to produce flat ribs; that is to say ribs proper are never interchangeable with regular impressed grooves. In a shell which is sculptured in its young stage and smooth when old, or in a variable species, sometimes sculptured and sometimes plain, it is an invariable rule that the sculpture disappears first from the part nearest the angle, and almost always some trace of it, albeit very faint, is discernible at the anterior end. In the variably sculptured species, there seems to be no connection between the disappearance of the striæ on the side and on the top of the whorl. The latter may be used guardedly; but a determination of cones, without the colors must be rather an adjustment of averages than a dependence on fixed specific characters. Of course there are some marked forms to which this statement will not apply, but it is true with reference to the greater majority of the species.

C. pyriformis. Rve., Icon. Conch. sp. 70.
C. solidus, Sby. Quart. Jour., Vol. VI., p. 45.
C. solidus, Guppy. Quart. Jour., Vol. XXII., p. 287, pl. 16, fig. 1.
C. solidus, Sby. Conch. Ill., fig. 76.
C. recognitus, Guppy. Proc. Sci. Assn. Trinidad, 1867, p. 171.

A very common fossil, found living at Panama. I have compared excellent fossil specimens retaining their color pattern with the recent shell and find them indentical in every respect. The shape is variable, the sides of the spire are always more or less concave, but the elevation of the apex changes greatly as the shell grows older; the young specimens being usually much more elevated than old ones. The species can be distinguished from all of the others by the rounded angle of the body whorl; though in two or three cases a slight angulation could be detected.

C. consobrinus. Sby., Quart. Jour., Vol. VI., p. 45.
C. granozonatus, Guppy. Loc. cit., Vol. XXII., p. 287, pl. 16, fig. 5.

Sowerby notes the variations of this shell. I have young specimens that are crossed over the entire surface with beaded linear ribs, and every intermediate stage to entirely smooth shells. The species can be recognized by its elevated, coronated spire, and the general resemblance of its form to that of *C. cedo-nulli; C. granozonatus*, Guppy, is the young costate form of the species.

C. catenatus. Sby., Quart. Jour., Vol. VI., p. 45, pl. 11, fig. 2.
C. interstinctus, Guppy. Loc. cit., Vol. XXII., p. 288, pl. 16, fig. 3.

Sowerby's description is from a young shell and Guppy's from an adult. I have duplicates of both figures, and a full connecting series. It is not impossible that this may also include the form described by me as *C. Floridanus*, in the American Journal of Conchology, although none of the fossil specimens agree exactly with my recent shell. The points of resemblance are—general form and details of surface, but the only specimen I have seen of *C. Floridanus* is perfectly straight from the angle to the anterior end, while all of the fossils are slightly curved.

C. stenostoma. Sby., Quart. Jour., Vol. VI., p. 44.
Id., Guppy. Loc. cit., Vol. XXII., pl. 287, p. 16, fig. 2.

Approaches *C. tornatus*, Brod. in form.

C. Orbignyi. Audouin, Mag. de Zool., 1831, pl. 20.
C. planicostatus, Sby. Conch , Ill., No. 15.
C. gracilissimus, Guppy. Quart. Jour., Vol. XXII., p. 288, pl. 16, fig. 4.

Varies slightly in proportionate height and width ; young specimens being more slender than older ones. The number of the revolving ribs is also variable; one of my specimens showing nearly twice the usual number, while in a fragmentary specimen, having all of the other characters, of size, shape, elevated and coronated spire, number of whorls, &c., the surface is nearly plain, being only marked by faint revolving ribs, showing a marked beading.

The locality of the recent shell has been heretofore in doubt. Audouin says his specimen probably came from China, and a recent specimen in the Museum of Philadelphia Academy is also without a local label. But finding the species fossil in the West Indies would induce us to look for its living representations either in the Caribbean or Panama region, rather than in the Eastern seas.

C. marginatus. Sby., Quart. Jour., Vol. VI., p. 44.

A well-marked species having no close allies. Its broad short form, deep revolving sculpture and high non-coronate spire at once distinguish it.

C. mus. Huass, Enc. Meth., Vol. I., part 2, p. 630.

Four specimens only were found, but they are unmistakably members of this well known West Indian species.

C. planiliratus. Sby., Quart. Jour., Vol. VI., p. 44.
Id, Guppy. Loc. cit., Vol. XXII., p. 287, pl. 16, fig. 7.
C. Stearnsii, Con. Amer. Jour. Conch., 1869, p. 104, pl. 10, fig. 1.

A long narrow species, characterized by revolving impressed sculpture. The tops of the revolving ribs are smooth, but in the intervening grooves the lines of growth are elevated, producing a tendency to punctate character similar to that observable in some species of Actæon. In some of the specimens the sculpture is faint or wanting near the posterior angle. I have compared my fine series of fossil with Mr. Conrad's type specimens of *C. Stearnsii* from Florida and find no difference except that in his shell, which is very young, the sculpture is only visible on the anterior half. The shape, the angle and character of the spire, the *character* of the sculpture, in short all of the details agree perfectly.

Compare *C. minutus*, Rve. Conch. Icon., No. 259, apparently a very young shell. Reeve describes his species as having entirely different colors from Conrad's, especially in that it has two revolving bands on the middle. The angle of the whorl is dotted with reddish brown as in *C. Stearnsii* and the surface is smooth. The resemblance therefore between *C. minutus* and *C. Stearnsii*, are these of form and of the red spots on the angle; the differences are the general color and the smallness of Reeve's species, while Conrad's is sculptured over half of its surface. But this sculpture is not an essential character since I have a series showing that the whole or only half of the surface may be sculptured, and if this much difference is demonstrated to exist, why may not a very young specimen, the size of Reeve's vary still further. While not prepared to assert their specific identity, I consider their resemblance sufficiently near to warrant a critical examination.

C. Haitensis. Sby., Quart. Jour., Vol. VI., p. 44.
C. symmetricus, Sby. Loc. cit., p. 44, pl. 9, fig. 1.
C. Domingensis, Sby. Loc. cit., p. 45.

I have studied over 700 specimens of species and have tried by every test known to me, to divide it into two or more groups, but without success. Sometimes it is perfectly straight and regularly tapering on the sides, sometimes gently convex; the spire varies from flat to elevated, the whorls being flat or grooved above, and striated or plain, with a rounded or sharp angle; the surface of the body whorl is either smooth or marked over a part or the whole, by ribs which may be in part or in whole, plain or beaded; and the shell varies from thin to massive. I do not wish to be understood that these characters run in groups. On the contrary, they are so intermixed that there is no possibility of separating them. But in this otherwise protean species there is a single character which, when obtainable, is constant. The color pattern is fortunately preserved in a large number of specimens and irrespective of their form, density or surface is invariable. It consists of a dark ground, with light cloudings elongated transversely and more or less connected by dashes and lines. The pattern is not unlike that of *C. testudinaria*, but the shell, in average specimens is more in form like *C. purpurescens*.

? C. proteus. Hwass, Enc. Meth., Vol. I., part 2, p. 682.

I have a series of eight shells before me, having the shape and size of this species, and differing only in color pattern. Seven of the series show more or less traces of color. In two of them the marks are slightly confused, although they are rather closely placed and distinctly spiral; but the other four have dark spots with well-defined margins and arrayed in regular revolving rows. These rows are about seven in number although one specimen shows but five, while another eight.

C. Berghausii. ? Michelotti, Descr. Foss. Terr. Miocene de l'Italie Sept., p. 342, pl. 13, fig. 9.
Id. Hörnes, Foss. Moll. Tert. Wien., p. 19, pl. 1, fig. 3.

I refer this species doubtfully to the Italian form on the strength of a single specimen. My shell seems to have all of the characters of form as figured by both the above authors, except a slightly higher spire. In colors, it agrees with Hörnes' figure in the arrangement of the elongated spots on, and above the angle, but those on the sides of the whorl are much more numerous and smaller.

C. cedo-nulli. Brug. Enc. Meth., Vol. I., part 2, p. 601, pl. 316, fig. 1-9.

I have 847 specimens of this one species, and in only two of the entire series, have I been able to detect the faintest trace of color. In both cases it consists of broad, badly defined longitudinal bands of dark color more or less broken.

C. furvoides. Gabb, n. s.

Shell elongately turbinated, narrow, nearly or quite smooth, striated in some cases anteriorly by a few wavy lines; spire acuminate but not very elevated; the first whorls elevated and sloping on the top, acute-angulated; the later whorls more or less deeply channeled and sometimes striated on top. Aperture linear. Color pattern unknown.

About the size of *C. furvus*, Rve., and similar in the form of the body whorl. The spire, however, is much lower and the tops of whorls are markedly grooved in all the specimens I have seen. An unusually broad specimen before me is not unlike a very narrow example of *C. monilis*, which it also resembles in the concave sides of its spire.

C. strombiformis. Gabb, n. s.

Shell large, rather thin, turbinated, spire elevated, convex; whorls numerous, rounded on the angle, rudely nodose and sloping to the suture, which is sharply cut but irregular. Body whorl curved above, pretty regularly tapering in advance. Surface marked by a few distant revolving ribs, which are most prominent, and most closely placed at the anterior end. Aperture moderate, outer lip broadly, but not deeply, emarginate posteriorly. Length 2.6 inches width 1.5 inch.

In general appearance this shell is not unlike an incomplete *Strombus*, but on close examination it proves to be a true Cone. Its blunt rounded spire and the imperfect tuberculation especially of the upper whorls separate it not only from the fossil cones of Santo Domingo, but from all the species of the genus, with which I am acquainted.

C. aratus. Gabb, n. s.

Shell turbinated, apex acuminate, spire varying from nearly flat to elevated; the angle of the elevated apical volutions minutely crenulated; top of whorls flat or very slightly sloping, covered by well-marked striæ; outer edge sharply angulated. Body whorl straight on the sides or very faintly convex near the angle. Surface covered by distant, well marked impressed lines. At the anterior end these lines become confused and the shell marked by a series of wavy ribs. Aperture linear.

Nearest to *C. sulcatus*, but differs in the straighter sides and more regular sulcation. In size and general form this shell is so like *C. Haytensis* that in view of the variable nature of that species, I could not have dared to separate it, were it not that I find the sulcation very constant in 19 specimens before me, and have *not* found it in the hundreds of examples of *Haytensis*. This seems to be a good distinguishing character.

C. Bonaczyi. Gabb, n. s.

Shell small, convexly turbinated, sides curved, tapering gradually in advance; posterior angle rounded, spire low, apex acute, side of spire concave; surface marked by a variable number of revolving grooves, which are distinctly interrupted by lines of growth; the intervening ribs are flat, or faintly sulcated and show no traces of the growth lines. Top of the whorls very slightly concave, not striated. Length .9 inch, with .5 inch.

This shell has almost exactly the sculpture of *C. planiliratus*, the ribs being somewhat more numerous. But unlike that species it is a short, broad shell with curved sides. Its proportions of length and width are not unlike those of *C. mercator*.

C. Yaquensis. Gabb, n. s.

Shell robust, broad, turbinated, spire low, angle rounded, top of whorls grooved, sides convex below the suture and regularly tapering in advance. Color a dark ground regularly tessellated by light spots arranged in close revolving series.

In size and form, this species is almost identical with *C. cedo-nulli*, but its colors are so entirely different from anything I have ever seen in that species that I have ventured to name it.

STROMBUS. Linn.

S. bituberculatus. Lam., A. S. V., (Desh. Ed.), Vol. IX, p. 690.

S. Haitensis. Sby., Quart. Jour., Vol. VI., p. 48, pl. 9, fig. 7.

An examination of over 100 specimens proves that the tubercles, on which Sowerby depended to distinguish this shell from *S. inermis*, Sw. (= S. accipitrinus, Lam.), are not only variable in disposition, but as sometimes entirely absent. The surface is sometimes marked by broad, flat, revolving ribs alternating with fine lines. In other cases only seven or eight broad low ridges occur. The smallest specimens are usually the most close ribbed.

S. pugilis. Linn., Syst. Nat. (12 Ed.) p. 1209.

S. ambiguus. Sby., Quart. Jour., Vol. VI, p. 49.

S. proximus. Sby., loc. cit., p. 49, pl. 9, fig. 8.

S. bifrons. Sby., loc. cit., p. 49. pl. 9, fig. 9.

S. pugilis. Guppy, loc. cit., Vol. XXII, p. 287.

I admit myself a little surprised that Mr. Sowerby should have been betrayed into making three synonyms for the best known shell of the West Indies.

S. gigas. Linn., Syst. Nat. (12 Ed.) p. 1210.

Two or three good characteristic specimens found.

ORTHAULAX. Gabb, *n. gen.*

Shell rounded-fusiform, canal moderate, straight and regularly tapering, adult shell enveloped over the whole spire by an extension of the inner lip, posterior canal fissure-like, formed by the continued edge of the outer lip and running directly to the apex. Outer lip apparently sharp and simple, anterior notch oblique and broad.

The discovery of this genus fills an important break in the Rostellarias, uniting the true genus, *Rostellaria* with Conrad's *Calyptrophorus.* Unlike both of these genera the canal is not styliform, but robust and comparatively short, and its terminal notch is formed by an almost rectangular truncation of the anterior portion of the outer lip. Like *Rostellaria,* it has a straight posterior canal, prolonged however, further than is common in that genus. The canal is similar in structure to that of *Calyptrophorus,* being formed by a squamose plate; but in the latter genus it curves over backwards, behind the spire, which it ascends to about half its height and then bends down to near the suture of the body whorl. Unlike the first, and like the second of its congeners, it has the whole spire enveloped in a plate which should more properly be described as a posterior extension of the body whorl, carrying the suture to the extreme apex. The lines of growth run from the top of the spire to anterior end of the shell. It carries none of the tubercles seen in *Calyptrophorus* and *Tessarolax,* and seems, unlike most of the other genera of the family, to have had a simple outer lip, neither digitate nor notched.

O. inornatus. Gabb, n. s.

Shell broadly rounded-fusiform. Young shell with the spire a little shorter than the aperture, suture impressed, whorls numerous, nuclear whorls three, the subsequent ones showing faint traces of occasional thickenings disposed like the varices of *Triton;* surface smooth; anterior end of body whorl marked by a few faint revolving lines, no posterior canal. Adult shell more distinctly fusiform, the spire covered by a longitudinally striated incrustation covering the sutures and extending to the extreme apex. Aperture elongated, acute behind and prolonged into a very narrow posterior canal running straight to the apex; in advance it is gradually narrowed, the anterior notch broad and shallow; inner lip thinly encrusted; outer lip thin in all my specimens, and apparently thin, straight and entire in the perfect adult. Size of largest specimen, length 3.75 inch, width 1.5 inch.

DOLOPHANES. Gabb, *n. gen.*

Shell elongate oval, spire elevated; showing a minute imperforate umbilicus; aperture semi-oval; inner lip slightly encrusted, outer lip acute, sinuous; anterior end of the aperture terminating in a short, not emarginate canal.

The first impression produced on looking at this little shell is that it is probably a *Melania;* but apart from all of its three hundred associates being marine, which would render such a reference improbable, it has a grouping of characters which ally it so closely to *Struthiolaria,* that I am convinced that it is most probably a nearly related genus. Its spire is very like that of many species of *Strombidæ* and, in the details of its mouth it differs from *Struthiolaria* in having a thinly encrusted inner lip, an acute outer lip and an obsolete umbilicus, instead of the thickened margins and no umbilicus of that genus.

D. melanioides. Gabb, n. s.

Shell oval, spire elevated, whorls ten, the first three nuclear, the others rounded on the sides, angulated above and flattened and a little sloping near the suture. Surface marked by numerous minute longitudinal ribs reaching over the angle to the suture and becoming obsolete on the middle and anterior portions of the body whorl. On some specimens there are very minute revolving striæ. Umbilicus minute, imperforate and bordered by a small ridge or angle. Aperture sub-oval; inner lip thinly encrusted, continuous behind with the outer lip which is acute and slightly sinuous, most prominent in the middle. Canal very short, not emarginate.

I have tried to identify this species with the shell described by Guppy as *Melanopsis capula*,* which it seems to resemble somewhat in form and size. But that author gives his shell but seven whorls, and does not describe or figure the flattened tops of the volutions, which are a marked character of the present species. There are also other differences which, however, might be explained by want of care in the artist, but which, nevertheless, lead me to believe that, while there may be a generic relation between the two shells, they are most probably different species.

CYPRÆA. Linn.

C. Henikeni. Sby., Quart. Jour., Vol. VI., p. 45, pl. 9, fig. 3.

A very variable species; sometimes the tubercles are entirely wanting, and distorted specimens are occasionally found. The colors are light spots on a dark ground, similar to those of *C. reticulata* and *C. cervus*, but proportionately larger, contracting the dark parts to the net-work of thick lines.

C. Isabella. Linn., Syst. Nat., (12 Ed.), p. 1177.

A few specimens were found which, in the absence of color, I cannot separate from this well known species. They agree in all the details of form, teeth, &c.

C. spurca. Linn.. Syst. Nat., (12 Ed.), p. 1179.

My shells agree perfectly in form, size and detail with the recent forms, but two of them show a color pattern which may possibly warrant a separation. They are covered with round spots of different sizes, about as numerous and as variable in size as those of *C. argus*

C. spurcoides. Gabb, n. s.

Shell similar in form to *C. spurca*, but somewhat broader and more narrowed in advance. Callous broad, convex below, and slightly expanded laterally, not crenulated above as in *C. spurca*. Crenulations of both lips well defined, more numerous on the inner than on the outer lip. Color pattern mottled irregularly.

In color and size, this not unlike *C. bicallosa*, but it differs from it in form and in the absence of the two callosities. It wants entirely the marginal pittings of *C. spurca*, which it approaches nearest in form.

* Quart. Jour., Geol. Soc., Vol. XXII, p. 580, pl. 26, fig. 14.

C. Dominicensis. Gabb, n. s.

Shell very similar to *C. lurida* in form, sides sub-parallel, anterior end tapering more than the posterior, base slightly flattened; inner lip flexuous in advance; teeth small, very numerous and not extended over the base.

This shell is closely allied to *C. lurida* and *C. pulchra*, but differs from both in that its teeth are small, regular, uniform and end abruptly along a straight line. This last character at once separates it from the latter, while the size of the crenulations equally distinguish it from the former. The largest specimen is 1.5 inch long.

PUSTULARIA. Swains.

P. nucleus. Linn., sp.

Cypræa, id., Linn., Syst., (12 Ed.), p. 1181.

Four good specimens were found.

CANCELLARIA. Lam.

C. reticulata, Linn., sp., Syst. Nat., (12 Ed.), p. 1190.

C. Barretti, Guppy, Quart. Jour., Vol. XXII., p. 289, pl. 17, fig, 11,

C. Moorei. Guppy, Quart. Jour., Vol. XXII., p. 289, pl. 17, fig. 11.

C. lævescens. Guppy, Quart. Jour., Vol. XXII., p. 289, pl. 17, fig. 12.

C. brevis. Sby., Proc. Zool. Sec., 1832, p. 52.

C. tessellata. Sby., Proc. Zool. Soc., 1832, p. 51.

C. Guppyi. Gabb, n. s.

Shell sub-globose, spire elevated, about three fifths as long as the aperture; whorls eight, the first two nuclear; suture slightly channeled. Surface finely cancellated by nearly equal revolving and longitudinal ribs; umbilicus small. Inner lip covered with a strong plate bearing three prominent folds, the lower terminal. These folds are distinctly grooved on top.

Allied to the *C. reticulata*, this shell can be at once distinguished by its short sub-globose form its channeled suture, its finely sculptured surface and by the columellar plates being broad and grooved on top, instead of being thin and acute.

All of the above species of *Cancellaria* are rare; *C. Moorei* being the only one of which a really good series has been found.

CERITHIUM. Brug.

C. prismaticum. Gabb, *n.* s.

Shell large, robust, elevated, whorls numerous, suture deeply impressed; surface marked by a deeply square-cut groove below the suture, and one less distinct adjoining the suture; below these there are a few very large tubercles, five or six to a volution, the whole crossed by a few revolving lines, most marked on the upper whorls. Aperture with a single large fold on the pillar lip.

I have but a single fragmentary specimen of this species. It is 2.3 inches long and possesses but five volutions. Originally it must have been considerably over 3 inches in length. Its immense tubercles and the deep groove below the suture are unlike any other known species.

C. microlineatum. Gabb, n. s.

Shell large, turreted, many whorled, sides of whorls flattened, suture linear undulated; surface marked by a row of indistinct nodes adjoining the suture, and a large number of very fine, closely placed revolving lines covering the entire surface. On the body whorl there is a single obsolete varix. Aperture broad, canal slightly twisted, inner lip without folds, but bearing a tubercle posteriorly.

About the size and shape of *C. fasciatum*, but distinguished by its different surface, by the absence of columellar folds and by the less deflected canal.

C. dentilabrum. Gabb, n. s.

Shell large, heavy, spire elevated, suture distinct, whorls flattened on the sides, bearing a few very faint varices. Surface marked by not very strong longitudinal ribs or undulations; these are crossed by four or five strong revolving ribs, flat on top and with concave interspaces, giving the surface a coarse but pretty regularly cancellate appearance. Aperture sub-quadrate, with two strong folds on the columella, one in the middle, the other behind; outer lip with one large tubercular tooth in the middle and one in advance. These folds and teeth are absent in the young shell. Length 2 inches width 0.7 inch.

Easily distinguished by its coarse cancellated appearance and its dentate mouth.

C. suprasulcatum. Gabb, n. s.

Shell broad, spire moderately elevated, whorls numerous, increasing rapidly in width flat on the sides; suture channeled. Surface plain or marked by a few lines in advance and by a deep revolving groove a short distance below the suture. Aperture sub-quadrate, canal very small, no folds; outer lip strongly produced on the base, adjoining the canal. Length about 1.5 inch, width .7 inch.

Easily recognizable by its broad form and its smooth sides with a single groove near the suture.

C. obesum. Gabb, n. s.

Shell short, broad, spire about one and a half times as long as the aperture, apical angle very variable, suture linear. Surface very variable. The most usual character is a series of tubercles near the suture. In some cases these form an angle, in others they are obsolete or entirely wanting while in one specimen they are prolonged into short ribs, with a secondary series adjoining the suture. The entire surface is always covered with minute revolving lines. Aperture sub-ovate, canal very short, not reflexed, a tubercle on the inner lip behind; outer lip effuse, internally thickened. Length 1. inch, diameter .5 inch.

The short robust form with rounded outlines of this shell, its revolving thread-like striæ and its expanded lip, are unlike any other species I have ever seen. In the great majority of cases it bears a series of small rounded prominences a short distance below the suture.

C. uniseriale. Sby., Quart. Jour., Vol. VI., p. 51.

I have studied Sowerby's description of this species carefully and am not certain whether I have been successful in fixing the name to the proper shell. It might apply with some propriety to the immediately preceding species, but seems to agree more nearly with the one before me. This is much more slender, with an elongated spire, bearing a series of small tubercles on the angle, and crossed by pretty strong, and somewhat alternated revolving lines. The canal is elongate, moderately twisted, with the ordinary terminal fold and with a posterior tubercle. Length about one inch.

C. turriculum. Gabb, n. s.

Shell elongate, slender, spire high, whorls numerous, with their sides almost parallel, ornamented by a series of elongate tubercles, laterally compressed and not so wide as the intervening spaces. These tubercles reach the suture and are shouldered, producing a more or less marked superior angle to the whorl which however does not exist in the interspaces. Crossing the whole surface is a series of small revolving lines. Canal moderately long, but slightly twisted. Length about an inch.

From the preceding species, this can be distinguished by the rib-like tubercle and the entire want of convexity in the whorls, as well as by the peculiar "shouldered" appearance of the tubercle.

C. Dominicense. Gabb, n. s.

Shell robust, turreted, spire high, whorls numerous, the upper ones cancellated, the last two or three with a row of large round tubercles on the angle and revolving lines, usually alternating in size. In some specimens, three or four of the largest of these on the body whorl, are granular. Aperture small, canal moderately twisted. Length about one inch.

Distinguished by the cancellate upper whorls and the round tubercles on the last two or three volutions. One or two of my specimens retain traces of brown color and look like bleached beach shells.

C. plebium. Sby., Quart. Jour., Vol. VI., p. 51.

Id. Guppy, loc. cit., Vol. XXII., p. 290, pl. 16, fig. 9.

A well-marked species, easily recognized by its straight ribs, usually alternating with an equal number of thread-like ribs in the interspaces. I have a shorter and broader form with the same sculpture which I consider a variety of the same species.

? C. venustum. Gabb, n. s.

Shell slender, very elongate, whorls numerous, flat on the sides; suture linear, bordered both above and below by a thread-like ridge surface bearing a few obscure, rounded varices and ornamented by obscure longitudinal ribs crossed by about four revolving ribs making a small tubercle at each intersection. Between the latter ribs are a few minute lines. Aperture unknown, Length nearly 1.5 inch.

The shape of this shell is not unlike *Turritella* while its sculpture and the faint varices seem to ally it to Cerithium. I have seen but a single specimen.

C. simplex. Gabb, n. s.

Shell broad, spire elevated, whorls eleven, rounded; suture linear. Surface ornamented only by fine revolving impressed lines. On some, especially of the upper whorls, faint traces of varices can be detected. Aperture broad, sub-oval, canal short, slightly twisted, inner lip not encrusted; outer lip simple, nearly straight. Length 1 inch, width .5 inch.

The round whorls, almost without ornament, and the naked inner lip and nearly straight outer lip show this to be a decidedly aberrant form in the genus, while its columella and canal forbid a generic separation.

C. Yaquensis. Gabb, n. s.

Shell minute, spire elevated, whorls numerous, rounded, bearing occasional rounded varices or irregular ribs; upper whorls most expanded on the lower side near the suture, narrowing gradually upwards. Surface marked by a few large ribs extending from the suture to the base and crossed by fine revolving lines. Canal short, curved, wide; outer lip internally striated. Length .35 inch, width .1 inch.

A very small shell, recognizable by the rounded body whorl and slightly angular upper volutions, and by the short, open canal.

C. Maoënsis. Gabb, n. s.

Shell minute, whorls rounded, with a few obsolete rounded varices; upper whorls smooth, others crossed by fine regular revolving lines; aperture broad, canal very short, columellar twisted, outer lip prominent in front, simple. Length .6 inch.

Most nearly allied to *C. simplex*, of which I was at one time inclined to consider it the young. But its more slender form forbids such a reference. The apical angle of that species is double that of the present, and both are very constant.

CERITHIDEA. Swains.

C. minuta. Gabb, n. s.

Shell minute, stout, spire about twice as long as the aperture, whorls seven or eight, very slightly convex on the sides, suture linear. Surface marked by numerous fine longitudinal ribs covering the spire and extending to the middle of the body whorl. These are crossed by finer revolving lines, most marked in advance. Canal nearly obsolete, not emarginate, inner lip encrusted, outer lip thickened and produced in advance. Aperture acute behind. Length .2 inch.

Very rare; but a single example found.

TRIPHORIS. Desh.

T. nigrocinctus? Adams, sp.

Cerithium, id. Adams, Best. Jour., N. Hist., Vol. II., p. 286, pl. 4, fig. 11.

Triforis, id. Stimp., Sm. Check List.

I am by no means sure of my identification of this species; my only specimen being immature and barely more than .05 inch in length. But it seems to agree as nearly with that, as with any other species; and I should not venture on more than a provisional determination with such imperfect material.

BITTIUM. Leach.

B. asperoides. Gabb, n. s.

Shell elongate, slender, whorls convex, marked by numerous longitudinal ribs, crossed by from three to five sharp filiform ribs, sometimes with finer lines interposed; base striate; aperture sub-quadrate.

Close to *B. asperum* of the coast and late Tertiaries of California, but more robust, with more longitudinal ribs and with a shorter mouth.

B. canaliculatum. Gabb, n. s.

Shell elongate, slender, spire high, whorls eleven, slightly convex, suture channeled, surface marked by numerous, fine closely-placed longitudinal ribs, crossed by obsolete revolving lines. Aperture rounded sub-quadrate. Length .2 inch.

Differs from the preceding by its channeled suture and by the absence of cancellation on the surface. From the following species it is distinguished by its smaller size, more delicate structure, by the presence of the channel and by the much more numerous whorls.

B. costatum. Gabb, n. s.

Shell minute, robust, whorls seven or eight, flattened on the sides, suture linear. Body whorl produced in advance. Surface marked by numerous large longitudinal ribs which begin at the suture and cover the whole surface, extending even over the base of the body whorl. Aperture elongated and rounded in advance. Length about .15 inch.

A very solid species recognizable by its uniform, large ribs and produced aperture.

LACUNA. Turt.

L. punctata. Gabb, n. s.

Shell small, spire elevated, variable in height, as long, or longer than the mouth; whorls six, convex, widening towards the base; base rounded, umbilical groove bordered by a sharp margin; aperture nearly round. Surface smooth, covered by minute colored spots, arranged in pretty regular quincunx.

The original color seems to have been more or less a light brown or reddish, with dark spots; but usually in the fossil the dark spots are preserved as an opaque white or a semi-translucent ground.

This shell is living in the West Indies, but I cannot find it described.

TURRITELLA. Lam.

T. tornata. Guppy, Quart. Jour., Vol. XXII., p. 580, pl. 26, fig. 12.

A very slender species, recognizable by its beaded ribs. Mr. Guppy's description applies very well to a single variety. Besides it, there is one form, with the same large ribs, but beaded all over; another with the upper rib double; and still a third with the lower rib much the more prominent of the two. In addition to these, there are several less marked variations.

T. planigyrata. Guppy, Proc. Sci. Soc. Trinidad, 1867, p. 169.

Shell elongate, many whorled; whorls convex, the nearer ones flattened in the middle, marked with three or four larger, and a great many smaller ribs covering all of the sides and base. Aperture sub-quadrate, inner lip encrusted and reflexed.

With a much wider apical angle than *T. tornata*, and convex sides. This species differs from both of the preceding by the nearly uniform size of the ribs which are all nearly thread-like and cover alike the sides and base of the shell. It is not unlike *T. ungulina* in its surface, but differs in having a quadrate mouth, instead of its being elongate.

T. exoleta. Linn., sp.

I have the specimens of this species, showing quite distinctly the squamose lines of growth.

VERMETUS. Cuv.

V. decussatus. Gruel. sp., p. 3745.

V. decussatus. Mörch. Vermet., p. 26.

I have a single specimen of only the regular part of this shell. It seems to agree with the figures and descriptions, as well as with labeled specimens in the museum of the Philadelphia Academy.

PETALOCONCHUS. Lea.

P. sculpturatus. H. C. Lea. Trans. Am. Phil. Soc., Vol. IX, p. 230.

P. Domingensis, Sby. Quart. Jour., Vol. VI., p. 51, pl. 10, fig. 9.

A comparison of extensive suites from both localities, proves beyond a doubt, the identity of the species.

I have specimens which correspond with the description, though not with the figure of *Vermetus papulosus*, Guppy, loc. cit., Vol. XXII., p. 292, pl. 17, fig. 6. The illustration does not show the tubercles arranged "in regular longitudinal rows" nor does it exhibit the striæ. My specimens do, however, and I believe them to be the large terminal end of the tubes of *P. sculpturatus.*

The internal plates of *Petaloconchus* are by no means constant in either the straight or the spiral portions of the shell. In fact I find them to occur rather in a minority of my specimens. May they not have rather a sexual value? The genus can always be distinguished from *Vermetus* by the irregularity of its spiral. In the latter genus, the spire is as regular as that of *Turritella;* in the present one it is never uniform.

CÆCUM. Flem.

C. annulatum. Gabb, n. s.

Shell minute, arcuated, rather thick, covered by transverse ribs, becoming finer and more closely placed near the aperture. In the interspaces between the ribs are minute longitudinal lines.

More robust and less arcuated than *C. trachea*, and differs from it in the details of sculpture.

C. constrictum. Gabb, n. s.

Shell minute, slightly curved, tapering slightly toward the truncated apex; septum prominently convex; aperture distinctly narrowed. Surface smooth.

With the smooth surface of *C. glabrum,* this little shell differs in the constricted aperture.

ONUSTUS. Humph.

O. imperforatus. Gabb, n. s.

Shell broad, trochiform, moderately elevated, whorls seven, convex above, margins squamose, suture minute, not undulated; upper surface covered by fine oblique irregular lines, sometimes dichotomous; under surface marked only by lines of growth. Umbilicus small, almost entirely covered by an expansion of the inner lip, its margin regularly rounded. Aperture sub-elliptical, outer edge acute.

About the size of *O. exustus*, but differs in its markedly smaller umbilicus with rounded margins, and in the non-stellate character of the squamose plate.

PHORUS. Montf.

P. agglutinans. Lam., sp.

P. onustus, Rve. Icon. Conch., No. 3.

Trochus agglutinans, Lam.

Seventeen specimens were found, and on the largest, which is nearly naked, are several fragments of *Petaloconchus.*

CRUCIBULUM. Schum.

C. spinosum. Sby., sp.

Calyptræa spinosa. Sby., Gen. of shells, sp. 6.

Crucibulum spinosum. Rve., Icon. sp. 10.

Very rare, but shows several varieties, as is usual elsewhere. I have it spinous, striate, smooth; very high, nearly flat; thin and thick, round, oval, and irregular.

TROCHITA. Schum.

T. Sp. indet.

A single young specimen, smooth and rather high.

CRYPTA. Humph.

C. fornicata. Linn., sp.

Petella, id. Linn. Syst., p. 1257

Crypta, id. H. and Ad. Gen. Rec. Moll.

Rare.

CAPULUS. Montf.

C. inornatus. Gabb, n. s.

Shell thin, expanded, nuclear whorl distinctly incurved; mouth irregularly sub-circular, surface marked by lines of growth and by obsolete radiating lines. Length .6 inch, height .4 inch.

A thin simple shell, with little of tangible characters except its small incurved apex and barely visible radiating lines.

NERITINA. Lam.

N. viridis. Linn., Syst., p. 1254.

A dozen specimens, all showing more or less of their color.

EUTROPIA. Humph.

E. altispira. Gabb, n. s.

Shell small, spire elevated, about as long as the aperture, whorls six, very convex; surface polished, aperture rounded, inner lip slightly encrusted. Length .15 inch.

A beautifully formed little shell, which can be recognized by its very round whorls and nearly circular aperture. My unique specimen shows no trace of color.

TURBO. Linn.

T. Dominicensis. Gabb, n. s.

Shell sub-globular, spire elevated, base imperforate, whorls about six or seven, round; suture bordered by a beaded rib. Entire surface marked by rounded revolving ribs, of which two on the side and one adjoining the suture are generally larger than the others. All of these ribs, but more especially the large ones, are more or less broken up into rows of beads. Mouth round, callous of the inner lip, thick and rounded; outer lip simple. Height and width about 1 inch.

Nearest in general character of the surface to *Senectus Spenglerianus*, but distinguished from it by the closely-placed beaded ribs and the presence of a strong beaded rib adjoining the suture instead of a groove. The inner lip is different, and the aperture is rounder and not expanded in front.

ASTRALIUM. Link.

A. longispinum. Lam., sp.

Trochus longispinus. Lam., A. S. V., Vol. IX., p. 122.

Astralium, id. Adams.

A single mould, fortunately in determinable condition.

CYCLOSTREMA. Marryatt.

C. striata. Gabb, n. s.

Shell small, discoidal, spire depressed, umbilicus broad, perspective; whorls about five, round, slightly flattened near the suture. Aperture nearly circular; surface marked by numerous fine revolving lines.

Nearest to *C. cingulifera*, Ad., but more discoidal and with finer surface striæ.

C. pentagona. Gabb, n. s.

Shell minute, discoidal, spire moderately elevated; umbilicus perspective; whorls five, cross section rudely pentagonal, flat on top, with three keels on the outer surface, one at the upper and one at the lower angle, and the third in the middle; the umbilical margin is faintly angulated; except these keels the surface is polished, and without ornament.

ADEORBIS. S. Wood.

A. carinata. Gabb, n. s.

Shell depressed trochiform, whorls five, rounded above and below with a prominent raised keel in the middle; umbilicus narrow, perspective, margin faintly angulated; aperture elliptical, outer lip produced into a short tongue-like angle in the middle at the end of the rib.

A peculiar little shell, of which the whorls are a little broader than high, and bear a keel in the middle. This is visible only on the body whorl, being coincident with the suture in the upper volutions. This may be the shell figured by d'Orbigny (La Sagra, pl. 18, fig. 26–28) as *Rotella carinata*, but its open umbilicus forbids the reference to that genus or even the family. It is clearly an *Adeorbis.*

UMBONIUM. Link.

U. vitreum. Gabb, n. s.

Shell minute, vitreous, spire moderately elevated, whorls three, round, sutural edge slightly thickened, surface polished, mouth round, inner lip thickened and slightly expanded; callus narrow, surface polished.

Nearest to *U. semistriatum*, d'Orb. (La Sagra, Cuba, pl. 18, fig. 20–22), but with a higher spire, rounder mouth, and without the striæ of that species.

CALLIOSTOMA. Swains.

C. conica. Gabb, n. s.

Shell small, conical, spire high, whorls numerous, sides flattened, so that there is an uninterrupted straight line from the apex to base of the body whorl; sides ornamented by about seven simple, rounded, revolving ribs with narrow interspaces; base covered with ribs smaller than those above. Aperture sub-quadrate.

My single specimen may be young. It is .25 inch in height, but its characters are different from any other species I know. It is nearest *C. zizyphinus*, but differs in the much narrower apical angle and in the uniform size of all of the ribs, wanting the characteristic large rib on the angle. In shape it is very near to *C. jujubinus.*

OMPHALIUS. Philippi.

O. viridulus. Gmel. sp.

Trochus, id. Gmel., p. 3574.

O. viridulus. H. and A. Ad. Geo., P. P. Carp. Mozat. Moll. p. 234.

I have compared the specimens with authentic West Coast shells, and find them identical in all their details.

MARGARITA. Leach.

M. tricarinata. Gabb, n. s.

Shell minute, spire elevated, whorls three or four, the upper ones rounded, body whorl bearing three strong carinations, top of the whorl bearing one or two ribs, and crenulated adjoining the suture, base slightly convex, umbilicus large, margin bordered by a crenulated rib. Aperture rounded, simple.

A very minute shell, about equal in size to *Cyclops depressus* and *Umbonium vitreum*, at once distinguished by its high spire, open umbilicus, and tricarinated whorls.

LUCAPINA. Gray.

L. alternata. Say., sp.

F. alternata. Say., Jour. Phil. Acad., 1 ser., Vol. II., p. 224.

L. alternata. H. and A. Ad., Gen. Rec. Moll.

Half a dozen specimens were found, the largest not quite an inch in length.

DENTALIUM. Linn.

D. dissimile. Guppy, Quart. Jour., Vol. XXII., p. 292, pl. 17, fig. 4.

I have a shell answering to Guppy's description and figure, except that it seems more robust than the latter.

Another form, probably a variety, differs from this in being smooth but with six sharp longitudinal ridges, not, however, like *D. hexagonum.* In apical angle and curve it agrees with the above.

D. affine. Gabb, n. s.

Shell rapidly tapering, gently curved, marked by six or eight large ribs, with a variable number of smaller ribs interposed. Besides these the shell is sculptured by minute longitudinal lines, crossed by equally small lines of growth, giving the surface a finely woven appearance. Length about 1.5 inch.

Differs from *D. dissimile* in the amount of curvature and in widening much more rapidly towards the mouth; also in being sculptured over the entire surface. Nearest to *D. elephantinum*, but smaller, less curved, and with finer sculpture.

The large ribs are not uniform in pattern, sometimes being as few as six, while in other specimens the whole surface is covered with ribs of pretty nearly uniform size.

I have two specimens which seem to indicate a larger species, in which the longitudinal ribs are of uniform size; and while the minute sculpture described above does not occur, it is replaced by the lines of growth being finely squamose. In the absence of more material, I do not feel warranted in naming it.

D. Haytensis. Gabb, n. s.

Shell small, nearly straight, increasing very gradually in size, surface polished.

This little shell differs from the preceding by its straighter form and entirely smooth surface, as well as by the nearly parallel sides.

? D. rudis. Gabb, n. s.

Shell long, straight, slender, massive; widening very gradually. Surface sculptured by longitudinal ribs, coarse, undulated, and sometimes broken by transverse wrinkles. Length 2.5 inches.

This shell has the general form of a straight *Dentalium*, but its thick substance and its rough sculpture seem to indicate a generic difference. Its surface is not unlike that of some species of *Hippurite* in the style of ornament.

D. ponderosum. Gabb, n. s.

Shell elongate, slender, very slightly arcuate, the greater curve being at the tip; surface with a few longitudinal ribs at the apex, which become obsolete as the shell grows older; beyond these there are no ornaments except the faint lines of growth. Internally the shell is thickened by deposition of shelly layers so as to reduce the internal diameter to a fourth of the external.

In external appearance this species approaches *D. dissimile*, Guppy, but its thick walls will distinguish it. It differs in this respect only from other species in the genus.

GADUS. Rang.

G. Dominguensis. D'Orb. sp.

Dentalium Dominguense. D'Orb., La Sagra, pl. 25, fig. 7.

Not rare.

SCURRIA. Gray.

S. mitra. Esch. sp.

Acmæa mitra. Esch. Zool. Atlas, 1833, p. 18, pl. 23, fig. 4.

S. mitra. Gray, Genera 1855.

A few specimens, which I cannot separate from this familiar West Coast form.

NACELLA. Schum.

? N. sp. indet.

A single little shell, which seems to belong to this genus.

ACTÆON. Montf.

A. tornatilis. Linn.

A single specimen.

A. Cubensis. Gabb.

Tornatella punctata. D'Orb., La Sagar, pl. 17, fig. 10–12.

Not *A. punctata*, Lea.

A variable species. In some specimens the sculpture is nearly absent, in others it covers half, and in others the whole of the whorl.

ACTÆONIDEA. Gabb, n. gen.

Shell long oval; aperture narrow, outer lip simple; columella slightly encrusted, bearing one large transverse fold in the middle and truncated in advance. Sculpture revolving ribs.

The genus is an *Actæon*, except that it has a single large fold on the middle of the inner lip and the columella is truncated as in *Achatina.*

A. oryza. Gabb, n. s.

Shell small, slender oval; spire elevated, whorls five, regularly rounded above and below flattened in the middle; surface marked by about 30 flat, revolving ribs with punctate interspaces. Size about equal to a large grain of rice.

CYLICHNA. Loven.

C. sulcata. D'Orb., sp.

Bulla sulcate, d'Orb., La Lagra, Cuba, pl. 4 bis., fig. 9-12.

This species has not the anterior fold of *Cylichna.*

CYLICHNELLA. Gabb, n. gen.

Shell sub-cylindrical, spire sunken, mouth narrow behind, widened in advance. Columella with two folds.

This genus has the external form of *Cylichna*, but it has two distinct folds, the upper one is sharp and prominent like that of *Actæon,* while the lower is more oblique and winds around the collumella in the same manner as that of *Cylichna.*

C. bidentata. D'Orb., sp.
Bulla bidentata, d'Orb., La Sagra, pl. 4, fig. 13-16.
Utriculus bidentata, Chemn. Man. Conch., Vol. I., p. 388.

TOMATINA. A. Ad.

T. recta. D'Orb., sp.
Bulla recta, d'Orb., La Sagra, pl. 4, bis., fig. 17-20.

VOLVULA. A. Ad.

V. cylindrica. Gabb, n. s.

Shell minute, sub-cylindrical, anterior end rounded, posterior produced, acuminate; surface with a few fine revolving striæ in advance; aperture narrow, linear, widening in advance; anterior end of inner lip thickened, reflexed.

Allied to *V.* (*Bulla*) *acuta*, d'Orb., La Sagra's, Cuba, pl. 4, fig. 17-20, but more slender and cylindrical. That species narrows sensibly in advance.

BULLA. Linn.

B. granosa. Sby., Quart. Jour., Vol. VI., p. 51, pl. 10, fig. 10.

B. paupercula. Sby., Quart. Jour., Vol. VI., p. 52.

A shorter, broader and thinner shell than *B. amygdala*, (*striata*), to which it is most nearly allied.

In addition to the above I have about a dozen species of undetermined Gasteropods, mostly minute.

ACEPHALA.

MARTESIA. Leach.

M. *Sp. indet.*

A single imperfect little shell, showing no trace of the accessory valve.

TEREDO. Linn.

? T. *Sp. indet.*

A mass of tubes which may belong to a *Teredo* or to one of the allied genera.

KUPHUS. Guett.

Furcella, *Septaria*. Lam.

K. incrassatus. Gabb, n. s.

Tube large, cylindrical, irregular, surface covered by lines of growth, substance thick; apex often twisted or otherwise distorted; divided by a longitudinal septum into two tubes, often of unequal size.

Fragments of this species are very common in the brown earthy shale east of Guayubin. The largest I have seen is a little over an inch in diameter, and they usually occur in pieces of two or three inches in length. ~~I have never seen it from~~ other localities. The shelly walls are often so thickened that the internal diameter is not over half that of the outside.

ROCELLARIA. Bellev.

R. Sp. ?

A pair of minute valves, nearest to *R. cuneiformis* in shape, found boring a large shell. They are too small for satisfactory specific determination.

SILIQUA. Muhlf.

S. subæqualis. Gabb, n. s.

Shell small, translucent, narrow, beaks central, base straight, ends nearly equal; surface polished; internal rib small, oblique. Length 1 inch.

Differs from *S. costata* in being more slender and in the beak being central.

BOTHROCORBULA. Gabb, n. gen.

Shell like *Corbula* in form and hinge, but differing in having a deep lunular pit in advance of the beaks, penetrating and almost passing through the hinge plate.

I have carefully examined almost all of the living and many fossil species of *Corbula*, and can find in none the slightest trace or rudiment of a lunule; while this shell has it deeper than it occurs in any other form except in *Here* (*Nob.*) of the *Lucinas*.

B. viminea. Guppy, sp.
C. viminea. Guppy, Quart. Jour. Geol. Soc., Vol. XXII., p. 293, pl. 18, fig. 11.

CORBULA. Brug.

C. disparilis. D'Orb., La Sagra, Cuba, pl. 27, fig. 1–4.
C. vieta. Guppy, Quart. Jour., Vol. XXII., p. 580, pl. 26, fig. 8.

C. contracta. Say., Jour. Phil. Acad., 1 Ser., Vol. II., p. 312.

C. Dominicensis. Gabb, n. s.

Shell large, thin, nearly equivalve, beaks central, valves moderately convex, no lunule, posterior end produced into a sharp angle; a narrow flat space running from the beaks to the angle. Surface marked by numerous moderately fine concentric ribs. About the size of *C. viminea*, this species is without the lunular pit, is much more finely sculptured, flatter and more produced posteriorly. In this latter character it also differs from *C. crassa*, which seems to be its nearest ally.

C. Lavaleana. D'Orb, La Sagra, Cuba, pl. 27, fig. 9–12.

Abundant.

NEÆROMYA. Gabb, n. gen.

Shell thin, translucent, in shape approaching *Pholadomya*, ends closed; hinge with a prominent tooth in the right valve, articulating behind a smaller similar one in the left valve. An anterior and posterior lateral tooth in each valve. Mantle margin without a sinus.

This genus, in its thin character and minute hinge, is closely allied to *Pholadomya*, *Thetis* and *Neæra*, but differs from all in the details of the hinge. *Neæra* has no cardinal tooth, but in its place a cartilage pit on each valve. It has a single posterior tooth, while this genus has the anterior equally well developed. In having corresponding teeth in both valves it differs from *Thetis*, while its well specialized hinge and its closed ends distinguish it from *Pholadomya*.

N. quadrata. Gabb, n. s.

Shell small, rounded, sub-quadrate; beaks posterior; anterior end produced, rounded, and slightly narrowed; posterior end broadly rounded; base nearly straight. Surface polished, marked only by minute lines of growth. Length .3 inch, height .23 inch.

A beautiful little translucent shell which looks like a small *Pholadomya*.

NEÆRA. Gray.

N. alternata. D'Orb., sp.

Sphena, id. D'Orb., La Sagra's, Cuba, pl. 27, fig. 17–20.

Neœrea, id. H. and A. Ad. Genera Rec. Moll., p. 369.

N. ornatissima. D'Orb., sp.

Sphena, id. D'Orb. loc. cit., pl. 17, fig. 13–16.

Neœra, id. H. and A. Ad., Gen. p. 369.

Despite the differences in D'Orbigny's figures quoted, I am hardly prepared to admit the validity of the two species. My specimens certainly run into each other, so that although I can lay out the typical forms, it is not so easy to draw the line across the gradation. The more common form is one finely costate behind and with one or two large ribs in advance.

PANDORA. Brug.

P. inconspicua. Gabb. n. s.

Shell small, inequivalve, very inequilateral; beaks small, about one-fourth of the length from the anterior end; cardinal margin gently sloping, straight behind; base broadly convex. Right valve convex, with a sharp angular ridge running posteriorly from the beak, and sometimes a faint groove above it. Left valve concave, angulated on the posterior cardinal margin. Length .3 inch, width one inch.

The smallest species of the genus with which I am acquainted. It is almost always found in a denuded or otherwise injured condition, where the other fossils are remarkable for the beauty of their preservation. It belongs to the true genus *Pandora* as restricted by Carpenter.

MACTRELLA. Gray.

M. alata. Spengl., sp.

Mactra alata. Spengl., Skriv. Nat., Vol. V., part 2, p. 99.

Mactrella, id. Gray, H. and A. Ad.

A few small specimens which agree perfectly with recent shells in the Academy's collection. It is stated by Reeve to be a West Columbian species.

RAETA. Gray.

R. canaliculata. Say. sp.

Lutraria canaliculata. Say., Jour. Phil. Acad., Vol. II., p. 311.

Raeta, id. Gray, Adams.

A single half-grown specimen, which seems rather broader posteriorly than is common in this species.

TELLINA. Linn.

T. (Peronæoderma) punicea. Born, p. 33, pl. 2, fig. 2.

A common shell on both sides of the Isthmus. My specimens are broader and a little more rounded posteriorly than the recent form. It is possible that they may constitute a distinct species. They agree in size and sculpture.

T. (P.) alternata. Say., Jour. Phil. Acad., 2 ser., Vol. II., p. 274.

Agrees perfectly in form, size and sculpture with the recent shell.

T. (P.) minuta. Gabb, n. s.

Shell small, sub-oval; beaks central; anterior end and base broadly rounded; base sloping up behind very slightly sinuous; posterior margin arched and uniting with the base by an angle; surface polished, convex and without a posterior ridge; hinges with two strong lateral teeth in right valve; none in the left; primary teeth small.

About half the size of *T. Guadalupensis*, very much rounder and without the posterior ridge of that species.

T. (Mœra) cuneata. D'Orb., La Sagra, pl. 26, fig. 21-23.

T. (Arcopagia) fausta. Donov., Vol. III., pl. 98.

T. (Macoma) constricta. Brug., Mem. Soc., N. H., 1792, p. 126.

Living from U. S. to Brazil.

STRIGILLA. Turton.

S. pisiformis. Linn., sp.
Tellina, id. Linn., Syst. Nat., p. 1120.

Living in the West Indies.

TELLIDORA. Mörch.

T. crystallina. Chemn., sp.
Tellina, id. Chemn., Vol. XI., 210, fig. 1947, 1948.

Living in the Panama province.

DONAX. Linn.

D. æqualis. Gabb, n. s.

Shell small, triangular, beaks central, the two sides sloping equally to the ends; base broadly and evenly convex; truncation of the anterior end broad, bordered by a rounded angle; surface polished, obsoletely sculptured by radiating lines; inner margin of base and anterior end crenulated, the teeth on the basal margin being larger than those above. Length .25 inch, width .2 inch.

A single valve still more regularly triangular that the larger *D. deltoides*. Its central beaks will distinguish it from all known species.

VENUS. Linn.

V. magnifica. Hanley, Thes. Conch., Venus, p. 704, pl. 153, fig. 5.

I have compared my fossils with authentic recent specimens of the Philippine Island shell, and can find no difference between them.

CHIONE. Megerle.

C. pap~~p~~hia. Linn., sp., Syst. Nat., p. 1129.

C. Guppyana. Gabb, n. s.

Shell sub-circular, swollen beaks anterior, base and extremities regularly rounded; posterior cardinal margin arched and bordered by a narrow flat space; lunule surrounded by an impressed groove; surface sculptured by numerous equal radiating ribs, crossed by rather closely placed concentric waved lamellæ.

The form of this shell is nearest to *V. toreuma*. In its sculpture it resembles *C. Walli*, and *C. Woodwardi* of Guppy, but can be at once distinguished from them by its round form.

C. circinata. Born, sp.

Venus, id. Born, Test. Mus., p. 61, pl. 4, fig. 8.

Cytherea juncea. Guppy, Quart. Jour., Vol. XXII., p. 582, pl. ~~22~~, fig. 13. 26

Reeve is probably incorrect in referring this species to Mazatlan. There are West Indian specimens in the Mus. Phil. Acad., which I have used for comparison.

CALLISTA. Poli.

C. planivieta. Guppy, Quart. Jour., Vol. XXII., p. 292, pl. 18, fig. 3.

C. acuticostata. Gabb, n. s.

Shell rounded sub-triangular, beaks pointed, about a third of the length from the anterior end which is excavated above and prominently rounded below ; base regularly convex ; cardinal margin gently arched ; posterior end narrow ; lunule minute, slightly sunken, internal margin entire. Surface covered with closely placed, acute, erect plates.

In form this shell approaches *M. juncea*, but it is less convex, the lunule is very much smaller, it is more acutely pointed behind and the concentric ribs are more numerous and have not the intermediate striation.

C. Carbasea. Guppy, sp.

Cytherea (Circe) Carbasea. Guppy, Quart. Jour., Vol. XXII., p. 292, pl. 18, fig. 13.

C. Tryoniana. Gabb, n. s.

Shell rounded triangular ; beaks anterior ; cardinal margin arched ; base deeply convex ; anterior end narrowly rounded, straight in the lunular region ; lunule large not sunken, bordered by an impressed line ; surface smooth in the young, in the old covered by numerous small, rounded concentric ribs.

A very little smaller than *M. juncea*, this shell differs markedly in its lunule and surfaces and slightly in outline. It is more produced in front and more narrowly rounded ; in that species the lunular region is concave.

CYCLINA. Desh.

C. cyclica? Guppy, sp.

Dosinia, id. Guppy. Quart. Jour., Vol. XXII., p. 582, pl. 22, fig. 15.

I have a single shell about half the size of the one figured by Guppy, and which differs slightly from his in outline. It is possibly a different species but I do not feel warranted in proposing a new name on such insufficient material, especially since I cannot get at the hinge.

CARDIUM. Linn.

C. (Trachycardium) sub-elongatum. Sby., Proc. Zool. Soc., 1840.

C. sub-elongatum. Rve. Icon., sp., 57.

C. lingua-leonis. Guppy, Quar. Jour., Vol. XXII., p. 293, pl. 18, fig. 7.

The Santo Domingo specimens agree perfectly with living shells from the surrounding waters.

C. (T.) Dominicense. Gabb, n. s.

Shell elongate, cordiform, convex, thin ; umbones prominent ; surface ornamented by nearly 60 small sub-squamose ribs, the lateral ones bearing minute tubercles ; edges serrate.

Of the size and form of *C. sub-elongatum*, this species differs in being much thinner and in having twice as many ribs. It is possible that perfect shells may show tubercles over the entire surface, the middle of my single specimen being somewhat worn.

C. (Serripes) bulla. Gabb, n. s.

Shell sub-circular, thin, compressed, umbones small, posterior side a little more produced than the anterior. Surface marked only by lines of growth. Diameter 1.7 inch.

Not unlike *C.* (*S.*) *Grœnlandicum*, but flatter and more circular.

C. (Lævicardium) venustum. Gabb, n. s.

Shell oblique cordiform, convex; umbones larger; anterior end rounded; posterior obliquely produced; surface marked in the middle by very numerous minute radiating ribs; anterior and posterior ends smooth. Length about 1 inch.

Nearest to *C. oblongum*, but much shorter, more expanded posteriorly and with much finer ribs.

C. (Fragum) Haitense. Sby., Quart. Jour., Vol. VI., p. 52, pl. 10, fig. 11,
C. Haitense. Guppy, Quart. Jour., Vol. XXII., p. 293.

Like *C. media*, but with much fewer ribs.

CHAMA. Brug.

C. macrophylla. Chemn., Conch. Cab., Vol. VII., p. 149, pl. 52, fig. 514, 515.

C. arcinella. Linn., Syst. Nat., (12 Ed.), p. 1139.

The fossil specimens are peculiar in that their spines are always small, amounting hardly to more than tubercles.

LUCINA. Brug.

L. Jamaicensis. Chemn., sp.
Venus, id. Chemn., Conch. Cab., Vol. VII., p. 24, pl. 38, fig. 308, 309.

L. Antillarum. Rve., Icon., sp., 37.

L. tigerina. Linn., Syst. Nat., (Ed. 12), p. 1133.
L. costata. D'Orb, La Sagra, pl. 47, fig. 40, 42.

L. dentata. Wood, Gen. Conch., 195, pl. 46, fig. 7.

For the abundant synonymy of this species, see Tryon., Pr. Phil. Acad., 1872, p. 85.

L. crenulata. Con. Foss. Med. Tert., p. 39, pl. 20, fig. 4.

Fossil in the miocene of Virginia and living on the coast of the United States.

L. Yaquensis. Gabb, n. s.

Shell minute, convex, sub-translucent; beaks central, prominent; hinge line deeply excavated under the beaks, sloping, slightly convex behind; base and ends regularly rounded; hinge thin, teeth well developed; internal margin minutely crenulated. Surface marked by small concentric lines.

About the size of *L. crenulata*, this shell is much thinner and more globose. It is less excavated in front of the beaks, and the internal edge is ornamented by much finer crenulations.

LORIPES. Poli.

L. edentula. Linn., Mus. Ulric., p. 74.

MYSIA. Leach.

M. capuloides. Gabb, n. s.

Shell small, thin, globose, anterior nearly circular, slightly compressed across the hinge margin ; beaks small, incurved ; umbones very large, giving to single valves a form not unlike that of shells of *Capulus*. Surface polished and ornamented by minute concentric striæ. Diameter about .2 inch.

M. sub-quadrata. Gabb, n. s.

Shell small, thin, moderately convex ; outline rounded sub-quadrate, length and width about equal, beaks small, prominent, hinge line sloping equally on both sides. Surface smooth.

About the size of the preceding, but distinguished by its comparatively square form and the absence of the enormous umbones.

ERYCINA. Reel.

E. tensa. Guppy, Quart Jour., Vol. XXII., p. 582, pl. 22, fig. 6.

GOULDIA. Adams.

G. Martinicensis. D'Orb, sp.
Crassatella, id. D'Orb, La Sagra, pl. 27, fig. 21-23.
Gouldia, id. H. and A. Ad., Genera, Vol. II., p. 455.

CRASSATELLA. Lam.

C. Antillarum. Rve., Zool. Proc., 1842, p. 44 ; Icon. sp., 8.

I have a single valve, well preserved and which differs from recent specimens in being straighter in the lunular region, and more obliquely truncated behind. It is also regularly marked with concentric furrows. The sculpture is not constant in this genus, and the differences of outline are not sufficient to permit me to separate it on a single specimen. If however, these differences should prove to be constant, the fossil form might be separated under the name of *C. Reevei.*

CARDITA. Brug.

C. scabricostata. Guppy, Quart. Jour., Vol. XXII., p. 293, pl. 18, fig. 10.

The figure does not partake of the usual excellence of Mr. Guppy's illustrations. The shell is placed in a false position, and the correct number of ribs is not given. The blame, however, can hardly rest upon the author since he was probably in Trinidad when the plate was drawn in London. I mention the inaccuracy in no spirit of hypercriticism, but that other students may not be misled by it.

CRENELLA. Brown.

C. divaricata. D'Orb., sp.
Nuculocardia divaricata. D'Orb., La Sagra, pl. 27, fig. 56-59.
Crenella, id. H. and A. Ad. Gen. Rec. Moll., Vol. II., p. 515.

MODIOLA. Lam.

M. *sp.?*

Two minute specimens, too small for satisfactory determination.

LITHOPHAGUS. Mühlf.

L. corrugatus. Phil., sp.

Modiolo corrugata. Philippi Abbild., Vol. II., p. 147, pl. 1, fig. 1.

Lithodomus, id. Rve. Icon. sp. 1.

Lithodomus Antillarum. D'Orb., La Sagra, pl. 28, fig. 12, 13.

Not *L. Antillarum.* Philippi.

Found boring coral at Cevico and elsewhere at the extreme top of the formation. I have never found it in the shales of a lower horizon.

L. n. s.

A second species, about an inch long, apparently nearly cylindrical, regularly rounded at the posterior end and without transverse corrugations, occurs in the corals west of Santiago. I have never succeeded in breaking it out in sufficiently perfect condition for description.

AVICULA. Brug., Lam.

A. inornata. Gabb, n. s.

Shell small, oblique, convex; anterior ear small, triangular, posterior moderately long, acuminate; surface smooth, without ornament. Length 1 inch.

In shape and in the character of its ears, this shell is nearest to *A. Tarentina*, except that it is not so produced below. The anterior margin is also a little less convex immediately below the ear. There is a similar shell in the Museum of the Philadelphia Academy, without a name, labelled "Coast of Brazil." It is probably this species, but I cannot find it in any of the books. From *A. cornea*, Rve., it can be distinguished by its smaller posterior ear, its less obliquity and its more convex form.

PINNA. Linn.

P. sp.?

A single little fragment, only sufficient to recognize the genus.

ARCA. Linn.

A. (Anadara) grandis. Brod. and Sby., Zool. Jour., Vol. IV.

A. Patricia. Sby., Quart. Jour., Vol. VI., p. 52.

Arca, very like grandis, Moore, Quart. Jour., Vol. IX.

In his description, Sowerby dwells so carefully on the difference between the fossil and Panama shell that I have taken the pains to make a very careful comparison between the two. The species is exceedingly common, and I have it of all sizes from that of a pea to six inches in length. The base is not more convex than the recent shell; there is no difference in the hinge more than occurs between individuals of different ages; and on carefully counting the ribs in a series of each, I can find no difference in their number, form or arrangement.

A. (Anadara) consobrina. Sby., Quart. Jour., Vol. VI., p. 52, pl. 10, fig. 12.

Anomalocordia Floridana. Con. Am. Jour. Conch., Vol. V., p. 108, pl. 13, fig. 12.

There can be no doubt of the above synonymy since I have used Mr. Conrad's original specimen in the comparison. We have therefore another supposed extinct species brought to light on our Gulf coast.

A. imbricata. Brug., Enc. Meth., 1789, p. 98.
A. Americana. D'Orb. (not Gray), La Sagra, pl. 28, fig. 1-2.
A. Noæ. Guppy (not Linn.), Quart. Jour., Vol. XXII., p. 293.

Brugiere's species is said by Reeve to come from the East Indies. There are recent specimens of this species in the Museum Philadelphia Academy, labeled St. Thomas, and on comparing them with the description in Icon. Conch. (the figure is valueless), they agree in every detail. D'Orbigny's name is preoccupied by Gray, so the species must either be called by Brugiere's name, or there is an opportunity for somebody to propose a new one. I do not feel warranted in separating it from *A. imbricata*, unless the West Indian shell should prove different from the Oriental.

A. (Anadara) Pennelli. Gabb.

Shell sub-quadrate, widening posteriorly, very oblique; beaks a little less than a third of the length from the anterior end, approximating; area very narrow, wider in front of the beaks than behind; base convex, sloping upwards continuously with anterior end; posterior end broadly rounded sub-truncate; surface marked by about 35 square ribs, slightly beaded in the young shell. Length 1.4 inch, width 1. inch, diameter 1.05 inch.

The most abundant of the Santo Domingo *Arcas*, this species can be at once distinguished by its oblique and very convex form. It is nearest to a shell which I find in the Museum Philadelphia Academy, labeled *A. lobata*, Rve., but which I cannot find in the books. It is more oblique and more convex than that species, with the beaks, more anterior. That has 28 ribs, while this has 35. In this the ribs are of uniform size, while in that species the posterior ribs are broader than the others.

Named after Mr. A. Pennell, the chief topographical assistant in the survey.

A. multilineata. Gabb, n. s.

Shell small, obliquely oval, very convex, length and breadth about equal; beaks small, anterior, approximate, hinge line a little shorter than the shell, area broad in advance of and under the beaks, very narrow behind; posterior end broadly rounded; base convex and curving upwards regularly to the anterior end; surface ornamented by about 60 small square ribs, slightly crenulated by sub-squamose lines of growth. Hinge composed of regular transverse teeth, those of the two ends radiating outwards. Internal margin not crenulated.

A little less than a half inch in diameter, recognizable by its thin globose shape and its numerous ribs. In this latter character it approaches *A. centenaria* among the recent forms, but it differs from that in its rounder form. It is also allied to some of the Cretaceous species.

BARBATIA. Gray.

B. Bonaczyi. Gabb, n. s.

Shell elongated, compressed; very inequilateral; beaks barely more than a fourth of the length from the anterior end; approximating; umbones broad; hinge line moderately long; anterior end rounded; posterior end produced, sloping above; base undulated, area long and narrow. Surface marked by numerous small radiating ribs; more or less grooved and sometimes minutely beaded. Length 1.5 inch.

Nearest to *B. barbata*, but with the beaks much nearer the anterior end; and with the posterior end more produced and sloping.

AXINÆA. Poli.

A. acuticostata. Sby. sp.

Pectunculus acuticostatus. Sby., Quart. Jour., Vol. VII., p. 53, pl. 10, fig. 13.

Id. Guppy, loc. cit., Vol. XXII., p. 293.

A. pennacea. Lam. sp.

Pectunculus pennaceus. Lam., A. S. V. (Desh. Ed.) Vol. VI., p. 490.

Id. Guppy, Quart. Jour. Geol. Soc., Vol. XXII., p. 293.

A. approximans. Gabb, n. s.

Shell small, obliquely sub-circular, posterior basal region slightly produced; beaks small, almost in contact; area very small, not more than half as long as the shell and very narrow; surface marked by about forty square ribs, crossed by prominent lines of growth. Hinge strong, arched, teeth few; basal and lateral margins crenulated, the teeth corresponding with the external ribs. Diameter .4 inch.

Recognizable by its slightly oblique form, numerous ribs, and unusually small area.

LIMOPSIS. Sassi.

L. ovalis. Gabb, n. s.

Shell obliquely oval, posterior portion of the base produced; beaks central, small, area moderate in size, smooth, ligament pit deep. Surface crossed by concentric ribs and finer radiating lines. Internal margin smooth; hinge strong, teeth few.

About the size of the preceding species. This shell is remarkable for its oblique form. Young specimens are nearly circular, but as they grow older the increase is greater on the posterior side and base, so as to render the adult outline decidedly oblique.

NUCULA. Lam.

N. tenuisculpta. Gabb, n. s.

Shell minute, obliquely rounded triangular; surface marked by very numerous minute radiating lines, barely visible on some specimens; inner margin minutely crenulated. Length 1 inch.

N. (Acila) tuberculata. Gabb, n. s.

Shell obliquely rounded-triangular, convex; anterior end nearly straight, base convex; surface marked by radiating striæ and by small tubercles arranged in regular quincunx; on both the anterior and posterior ends these tubercles are replaced by rounded ribs which curve upwards to the margins. Anterior end occupied by a large lunule bordered by an impressed line.

This peculiar little shell is distinguished by its remarkable sculpture. The tubercles seem to be produced by the decussation of two sets of oblique ribs, under all of which lie a series of finer striæ radiating from the beaks to the base.

LEDA. Schum.

L. acuta. Gabb, n. s.

Shell elongate, convex; beaks central; anterior end rounded, base broadly convex; posterior end acute, hinge slightly concave from the beaks to the posterior end. Surface marked by regular rounded concentric ribs. Length .35 inch.

YOLDIA. Moll.

Y. ovalis. Gabb, n. s.

Shell small, compressed, sub-elliptical; beaks slightly in advance of the middle; hinge line sloping gently, base and ends rounded; surface smooth or bearing a few faint impressed concentric lines on the anterior part near the base. Length .35 inch, width .15 inch.

PECTEN. Linn.

P. opercularis. Linn., sp.
Ostrea, id. Linn.
Pecten, id. Lam. Rve. Icon. sp. 54.

Some worn specimens, with the sculpture eroded from the ribs, agree in all accessible details with this common European species.

This fossil is found, not only in the usual localities in the Cibao, but also occurs near San Cristobal.

P. inequalis. Sby., Quart. Jour., Vol. VII., p. 52.
Id. Guppy, Quart. Jour., Vol. XXII., p. 294, pl. 18. fig. 6.
Slightly inequivalve, ribs rounded.

Common in the Cibao, and found by Mr. Bonaczy at Loma Cristina on the south side of the Island, near San Cristobal.

P. oxygonum. Sby., Quart. Jour. Geol. Soc., Vol. VI., p. 52.
P. exasperatus. Guppy, loc. cit., Vol. XXII., p. 294.

This species may be, as Mr. Guppy thinks, a variety of *exasperatus*, but it seems to me rounder, with smaller ears, and with two or three more ribs.

P. thetidis. Sby., Quart. Jour., Vol. VII., p. 52.

Two varieties of this shell occur, with the same form and number of ribs. The first has the ribs square, with a longitudinal groove, or the angle of the rib is extended into a roughened ridge which stands erect. The other variety has the rib also flat or grooved, but the angular ridge is well marked and stands out laterally.

P. eccentricus. Gabb, n. s.
Shell slightly inequivalve, sub-circular, oblique, ears small, surface covered with twenty-two flat ribs, sometimes slightly grooved, and with concave interspaces. Diameter 1 to 1.5 inch.

Nearest to *P. irradians*, Lam., but more oblique, and with broader, flatter ribs.

P. augusticostatus. Gabb, n. s.
Shell small, elongated sub-circular, equilateral; ears small; base and sides regularly curved; surface marked by about twenty-three prominent, very narrow and acute ribs.

Of the size and general style of *P. oxygonum*, this shell is distinguished by its peculiar ribs, which have a narrow, almost knife-like edge.

P. interlineatus. Gabb, n. s.
Shell slightly convex, nearly equilateral, base and sides evenly rounded; ears large, radiately ribbed; surface marked by about eighteen round or sub-angulated ribs, with a single small line in each interspace. Length 1 inch.

About the size of the preceding, this shell is longer and flatter, with a marked difference in the character of the ribs.

P. magnificus. Sby., Proc. Zool. Soc., 1835, p. 109.

A single specimen was found by Mr. Bonaczy. I cannot find any difference between it and the Columbian shell.

JANIRA. Schum.

J. soror. Gabb, n. s.

Shell sub-orbicular, nearly equilateral, very inequivalve; ears nearly equal; right valve very convex, left valve concave; surface marked by about twenty-two square radiating ribs, crossed by fine squamose lines of growth. Length 1.9 inch.

Allied to *J. Jacobæus*, *J. maxima*, and *J. media*, but different from them all in the greater number and minutely squamose character of its ribs.

PLEURONECTIA. Sw.

P. papyracea. Gabb, n. s.

Shell discoidal, sub-circular, very slightly longer than wide; slightly inequivalve; ears nearly equal; surface perfectly smooth, or marked only by faint lines of growth; internal surface marked with small double radiating ribs. Length from beak to base 2.2 inch, width 2 inches.

A very distinct species, without any of the radiating lines of the living West Indian smooth *Pecten*.

SPONDYLUS. Lam.

S. Americanus. Lam., A. S. V., Vol. VII., p. 185.

My specimens agree perfectly with those from the coast of Florida, and usually the lower valve is immensely developed, the spines small and frequently equaled in size by transverse squamose plates. The upper valves usually bear long spines, not much expanded.

S. bostrychites. Guppy, Proc. Sci. Assn., Trinidad, 1867, p. 176.

S. bifrons. Sby. (not Goldf.), Quart. Jour. Vol. VI., p. 53.

A beautiful convex, almost equivalve, Pecteniform species with remarkably narrow areas and a thin shell.

PLICATULA. Lam.

P. cristata. Lam., A. S. V., Vol. VI., p. 185.

A single specimen in excellent condition and the valves yet in contact.

ANOMIA. Linn.

A. ephippium. Linn., Syst. Nat., p. 1150.

A single large specimen, nearly two inches in diameter.

OSTREA. Linn.

O. Virginica. ~~Gruel.~~

This species is not rare, and usually grows to a length of about five inches.

O. Haytensis. Sby., Quart. Jour., Vol. VI., p. 53.

O. Veatchii. Gabb, Pal. Cal., Vol. II., p. 34, pl. 11, fig. 59; pl. 17, fig. 21.

O. Virginica. Guppy (not Gruel), Quart. Jour. Vol. XXII., p. 577.

Mr. Guppy is certainly wrong in considering this species even closely allied to *Virginica.* Hardly any two species in the genus are more remote from each other. He must have confounded a plicate variety of *O. Virginica*, which is not rare, with Sowerby's description. Thanks to an excellent lithographer, my figure in Pal. California, pl. 17 of Vol. II., gives a very clear idea of the species. Although living in the Tertiary seas which divided North from South America, it is now, so far as we know, extinct. At the time of writing my second volume of the California reports, I was not acquainted with Sowerby's two-line description, and thus, unfortunately made a synonym.

In addition to these two species there are valves indicating two or perhaps three other species of small oysters, among which one appears to be the common Mangrove oyster, *O. frons L.* (*limacella*, Lam.)

I have also two or three undeterminable species of Mactras and Tellinas.

List of the Post Pliocene Fossils from the Antillite or "Coast Limestone" Beds near Macoris. Collected by Mr. Bonaczy.

Murex recurvirostris. Brod., Proc. Zool. Soc., 1832.

M. pomum. Gruel., Syst. Nat., p. 3527.

M. hexagonus. Lam., A. S. V., Vol. IX., p. 585.

Tritonium commutatum. Dhr.

Lagena cingulifera. Lam., A. S. V., Vol. IX., p. 384.

Columbella mercatoria. Linn., s. p., Gmel., Ed., p. 3446.

Cypræa spurcoides. Gabb, *supra*.

Cyphoma gibbosa. Linn.

Cerithum pictum. Wood, Ind. Test. Supp., pl. 5, fig. 4–5.

Turritella exoleta. Linn. sp., Gruel., Ed., p. 3607.

Petaloconchus sculpturatus. Lea. ? Tr. Am. Phil. Soc., Vol. IX., p. 230.

Attached to the *Cerithium* is a partially spiral tube with the external sculpture of this species.

Lucapina alternata. Say. sp., Jour. Phil. Acad., 1 Ser., Vol. II., p. 224.

Scurria mitra. Esch. sp., Zool. Atl., 1833, p. 18, pl. 23, fig. 4.

Rocellaria. sp. ?

A broken specimen; indeterminable.

Corbula carinifera. Gabb, n. s.

Shell sub-quadrate, convex; beaks central, anterior end sloping above, rounded below, base slightly sloping upwards posteriorly; posterior end obliquely sub-triangular; a sharp erect rib running from the beaks to the base on the umbonal angle, with a less marked one behind it, becoming gradually obsolete as the shell grows older; surface marked by small regular concentric ribs.

Nearest in size and form to *C. Lavaleana*, d'Orb., from which it can be distinguished by its being much less produced posteriorly, and by the peculiar erect rib on the umbonal ridge.

Tellina (Arcopagia) fausta. Donovan, Vol. III., p. 98.

Semele variegata.

I find a shell in the Mus. Phil. Acad. marked by this name, from the Coast of Brazil, identical with one of my fossil species, but have failed to find it in the books.

Venus multicostata. Sby., Proc. Zool. Soc. 1835, p. 22.

V. (Lioconcha) hieroglyphica. Con., Jour. Phil. Acad., Vol. VII., p. 253, pl. 19, fig. 22.

V. cancellata. Linn., Syst., 12 Ed. p. 1130.

Cardium (Liocardium) serratum. Linn., Syst., 12 Ed., p. 1123.

C. (Trachycardium) isocardia. Linn., loc. cit. 3249.

C. (Hemicardia) medium. Linn., loc. cit. 1121.

Chama macrophylla. Chemn., Conch. Cab., Vol. VII., p. 149, pl. 52.

Lucina imbricatula. C. B. Ad., Proc. Boston, Vol. II., p. 9, fig. 514, 515.

Lithophagus corrugatus. Phil. sp., Abbild. Vol. II., p. 147, pl. 1, fig. 1.

L. appendiculatus. Phil. sp., loc. cit. p. 150, pl. 1, fig. 6.

Arca Noæ. L. Syst. Gmel. Ed., p. 3306.

Barbatia velata. Sby., Proc. Zool. Soc., 1833.

Axinæa sericata. Rve. sp., Proc. Zool. Soc., 1843.

Spondylus longitudinalis. Lam., A. S. V., Vol. VII., p. 190.

Ostrea Virginica. Gmel.

The typical long variety, showing a few radiations on the beaks occasionally, occurs not only at Macoris, but also at one or two localities in the province of Seybo along the ancient Post Pliocene shore-line. Beds of a small thin-shelled oyster, probably a local variety, occur on the Bani coast road, just west of the Nigua River, where the coast gravels merge into the old border reef of calcareous matter. The oyster-bed was evidently on the shore flank of the reef.

O. rhizophoræ. Guild., Zool. Jour., Vol. III., p. 542.

O. folium. Gmel., Syst. Nat.

This species, like the other two, is still abundant on the coast. I believe it to be identical with *O. frons*.


GEOLOGICAL MAP
OF THE
REPUBLIC
OF
SANTO DOMINGO
BY
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Geologist in Chief.
Aided by
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Topographical Assistants.
A. BONACZY & S. SPEARE, Geological Assistants, J. A. READ & J. de la C. MARTINEZ, Draughtsmen.
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MIOCENE
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SANTO DOMINGO
PORT AU PRINCE
SANTIAGO
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LAGUNA DE ENRIQUILLO
PASO CATUANO
CABO FALSO
CABO BEATA
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MOCA TO HILL SOUTH OF JARABACOA
SANTIAGO TO LA VEGA
MONTE CRISTI TO GUARAGUANO.
MACORIS TO THE MOUTH OF RIO JOBO
SANTIAGO TO THE COAST BY THE PASO QUEMADO PASS
ALTA MIRA PASS TO PUERTO PLATA
MOUTH OF SAN JUAN R. TO ST. BARBARA DE SAMANA
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B. DE OCOA
SAN JUAN
PASO CATUANO
I. CATALINA
CABO FALSO
CABO BEATA
LOS FRAILES
ISLA BEATA
CABO ROJO
MIREBALAIS
LAS CAOBAS
SABANETA

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ARTICLE V.

SUPPLEMENT

TO THE

EXTINCT BATRACHIA AND REPTILIA OF NORTH AMERICA.

I. CATALOGUE OF THE AIR BREATHING VERTEBRATA FROM THE COAL MEASURES OF LINTON, OHIO,

BY EDWARD D. COPE, A.M.

Read before the American Philosophical Society, Feb. 6, 1874.

In the last descriptive catalogue of the species of the character here considered, that contained in the author's "Synopsis of the Extinct Batrachia, etc., of North America," nine only were described; the number is now increased to twenty-six. This addition, as well as the creation of the original collection, is due to the attention of Professor J. S. Newberry, now Director of the Geological Survey of Ohio, for whom an extended and illustrated report is now in course of preparation.

The result of the newer investigation into their structure confirms the opinion to which the author was originally led, that all the air-breathing vertebrata of the coal measures were Batrachians, and that true Reptiles did not then exist. Any generalization to this effect extending to the whole earth is premature, and scarcely likely to be verified; nevertheless, it is still applicable to the localities with which we are now acquainted. The Batrachians from Linton present the most varied forms; some are broad and stout bodied, others lizard-like; some exhibit heavily mailed surfaces, and others are slender and attenuated as snakes. They are here referred to twelve genera. These may be arranged as follows, in accordance with their general appearance and structure.

Group I. Snake-like forms without limbs: *Phlegethontia, Dolichosoma, Molgophis.*

Group II. Elongate forms with limbs and lanciform heads; *Oëstocephalus, Ptyonius, Lepterpeton.*

Group III. Lizard-like forms with limbs and broad frog-like heads: *Pelion, Sauropleura, Tuditanus, ?Leptophractus.*

Group IV. *Ambulatory* limbs and unossified vertebral column: *Colosteus*, *Amphibamus.*

Group V. Vertebral column osseous, the branchial hyoid bones well developed: *Cocytinus.*

The locality from which these fossils were procured is near Linton, Columbiana County, near Yellow Creek, and is thus near the Pennsylvania State line, and the Ohio River. They occur in a small basin near the middle of the series, in the lower part of the "diamond bed," which is eight feet in thickness, on the slate which is in contract with the lower three to six inches of the seam, which is cannel coal.

It is to be observed that the specimens are, in some cases, quite obscure, and although little or nothing of a doubtful nature has been introduced into the following descriptions, yet the elements are sometimes covered by a thin layer of carbonaceous matter, which prevents their entire definition.

PHLEGETHONTIA, *Cope.*

Proceed. Amer. Philos. Soc., 1871, 177.

This is one of the most interesting genera of the present series. It rests chiefly on a single specimen of one species, which is not perfect, but which displays the following character.

Head elongate triangular; body and tail extremely elongate, the dorsal vertebræ without ribs, and the caudals without dilated spines. No ventral armature nor limbs.

As a great portion of the length is preserved and no ventral rods nor scales are visible, and as this character is confirmed by a second species, it probably belongs truly to the genus. The pectoral shield is also wanting in the specimen, but, as there is a considerable hiatus behind the skull of the specimen, it may be that these were lost with other parts. Chevron bones are not observable on the caudal vertebræ. This form is a true batrachian snake.

PHLEGETHONTIA LINEARIS, *Cope. Sp. Nov.*

In the only specimen, the dorsal vertebræ are much involved anteriorly, so that the length is not readily ascertained. The entire outline of the skull is preserved; it is elongate triangular in form, with the angles of the mandibles produced backward and the outlines of the rami a little convex. Nothing definite remains as to sculpture or dentition. The vertebræ have longitudinal diapophysial keels, and have a zigzag interlocking of neural arches, probably by an external zygosphen above the zygapophyses. The latter are distinctly turned outwards. The vertebræ are very numerous, and the tail very attenuated. The total length of the coils unwound is about m .295 or 11 in. 8 lines; but there are interruptions not measured, and some confusion not unraveled. The number of dorsal vertebræ in .005 m., two; of distal caudals, three and a-half. Length of cranium, .022; with behind .009. Its size is about that of the skull of *Ptyonius marshii*, Cope. The slenderness of the body may be estimated from the diameter of the dorsal vertebræ, m. .0023; and of the caudals .0014. The whole number of vertebræ preserved is fifty-six.

Another specimen embracing fifteen vertebræ without processes or ribs or other parts, resembles this species. There is nothing additional to be learned from it.

PHLEGETHONTIA SERPENS, *Cope. Sp. Nov*

This batrachian is much larger than the last, approaching nearly in its dimensions the *Molgophis macrurus*. It is represented by a series of twenty-two vertebræ, which like those of *P. linearis*, are devoid of ribs, abdominal armatures, dilated neural spines, etc. The series when complete must have been very long, as there is little difference in size between the first and last of the twenty-two. They are emarginate fore and aft, and much contracted medially, owing to the transverse expanse of the diapophyses. There may be indeed a diapophysial element beneath these, but if so, the two are undistinguishable. They are connected by longitudinal impressions, indicating the existence of the tendinous bands in the longitudinal muscles seen in *Amphiuma*, or the osseous spicules seen in the same situation in birds. The neural spines, as indicated by their narrow bases, occupy the length of the neural arch, and remind one of *Amphiuma*. Width of one of the vertebræ, three lines.

This species appears to be rare at Linton.

MOLGOPHIS, *Cope*

Proceed. of the Acad. of Nat. Sci., 1868, 220. Transac. Amer. Philos. Soc., XIV., 20.

The characters of this genus are: Body long serpentine, without dermal armature, so far as known. Vertebræ large and broad with very prominent zygopophyses and moderate neural spines; ribs large, convex.

No limbs nor cranium can be ascribed with certainty to the type of this genus. The ribs are long, and though the head is not bifurcate, there appears to be both tubercle and head on the dilated extremity. Where crushed, they display a large median vacuity.

This genus differs from *Ophiderpeton*, Huxl., in the character of its dorsal vertebræ, which in their projecting zygapophyses resemble those of *Amphiuma*. The lack of ventral armature distinguishes it from *Oëstocephalus*, while its well developed ribs separate it from *Phlegethontia*.

MOLGOPHIS MACRURUS, *Cope.*

Transac. Amer. Philos. Soc., 1869, XIV., p. 21 (part).

MOLGOPHIS WHEATLEYI, *Cope, Sp. Nov.*

Established on a specimen which exhibits about twenty-five vertebræ, with ribs, and the posterior portion of the cranium. No traces of abdominal scales or rods, thoracic shields or limbs are visible. By such negative characters it is referable to the genus *Molgophis*, although the definition of the latter is as yet incomplete. The present batrachian may indeed be ultimately found to be an *Ophiderpeton*, to which it also bears resemblance.

The specimen is that of an animal of very much smaller size than the *M. macrurus*. The vertebræ are of moderate length, with a low neural spine, and centrum angular at the sides and truncate at the articular extremities when in place. The ribs are rather short, slightly curved, and apparently hollow. Although the vertebral centra are ossified, the elements of the cranium have a larval appearance. These consist of two parallel flat bony plates, which resemble the frontoparietal bones of a frog; they are slightly separated from each other, but do not enclose a fontanelle. A wedge-shaped bone extends from the outside of the front of these, acuminate behind and widening anteriorly, in the position of a post frontal bone. In front of the posterior border of each (?) parietal, on its outer side, a bony enlargement arises, which contracts outwardly and forward into a narrow element which curves forwards beneath the (?) post-frontal. These look like an anteriorly directed quadrate with articular bone, such as are seen in larvæ and some adults of existing batrachians. These determinations will require confirmation from additional material. In the meanwhile it is evident that the present specimen cannot be referred to any of the species herein described.

Measurements.	M.
Total length of specimen,	0·0650
" " a rib,	.0050
" " parietal and post-frontal bones,	.0085
Width of head at (?) quadrate,	.0080
Length of a vertebra,	.0020
Depth " "	.0025

This animal is dedicated to Chas. M. Wheatley, A. M., of Phœnixville, Pennsylvania, one of the original investigators of the deposit in which it occurs.

PTYONIUS, *Cope*.

Genus novum. *Sauropleura* part. Cope, Proceed. Acad. Nat. Sci., Philadelphia, 1868, 217. *Oëstocephalus* part. Cope, Transac. Amer. Philos. Soc., XIV, p. 20.

Form elongate, with long tail and lanceolate cranium. Limbs weak, a posterior pair only discovered. Three pectoral shields present; abdomen protected by packed osseous rods which are arranged *en chevron*, the angle directed forwards. Neural and hæmal spines of caudal vertebræ expanded and fan-like. Ribs well developed.

This genus is the most abundantly represented by species and individuals, among those found at Linton. These are almost snake-like in their proportions, and vary in length from three to ten inches. The muzzles of the known species are acuminate, and the upper surfaces of the cranium in the three species, where it is preserved, are sculptured by rather distant crests and tubercles. The squamosal is evidently more expanded than in recent *Batrachia* either of the tailless or tailed orders. In *P. pectinatus* and *P. vinchellianus* it is a broad plate concealing the quadrate, and apparently readily separated from it, as it is loose in some of the specimens. This is an interesting point, as the homology of the squamosal with the preoperculum of the fishes has been proposed by Parker and the writer,* and the view is confirmed by the resemblance of the former to an operculum in these the most fish-like of the Batrachia. The teeth are numerous, small, and some of them apparently simple; others appear to be grooved. In a cranium (No. 140) perhaps of *P. pectinatus*, they extend to the tip of the slender jaws, are rather stout, acute, and evidently marked with a few strong grooves on the shank. The form of the head is a curious miniature of *Ichthyosaurus*.

Remains of limbs have only been observed in the position of the posterior pair, and that in several individuals.

*See Proceed. Amer. Asso. Adv. Sci., Vol. XIV., p. 222.

The present genus resembles *Lepterpeton*, Huxl., of the Irish coal-measures, in the form of the cranium and in proportions of body, but that exhibits divided abdominal rods, or "oat-shaped scales" and the caudal vertebræ have not the fan-like processes. In the last point they agree with *Urocordylus*, Huxl., but this genus is not represented as possessing ribs, and the abdominal rods are also divided, forming the "oat-shaped scales." I formerly referred the species of *Ptyonius* to *Oëstocephalus*, but in that genus no pectoral shields have been observed. The vertebræ in *O. remex* are of rather more elongate form than in the species of Ptyonius. Should, however, the pectoral plates be found in *O. remex*, this genus must be united with that one.

Four species have been detected by the geological survey of Ohio.

I. Vertebræ shorter; fan-like processes of caudal vertebræ broad, equilateral.

a Abdominals rods coarser, not more than ten in .005 m.

β Median pectoral plate broad, radiate ridged. P. MARSHII.

aa Abdominals rods hair-like, fifteen or more in .005 m.

β Middle pectoral shield with radii from the centre, the principal forming a cross; form wider. P. VINCHELLIANUS.

β Middle pectoral with pits at the centre and few or no radii; form narrow. P. PECTINATUS.

β Middle pectoral shield narrow, closely reticulate medially, and radiate towards the circumference; size half that of the last. P. SERRULA.

PTYONIUS MARSHII, *Cope.*

Colosteus marshii, Cope, Transac. Amer. Philos. Soc., XIV., 1869, p. 24; *Oëstocephalus marshii*, Cope, Proceed. Amer. Philos. Soc. 1871, p. 177.

PTYONIUS VINCHELLIANUS, *Cope.*

Oëstocephalus vinchellianus, Proceed. Amer. Philos. Soc. 1871, 177.

Represented by the opposite halves of a single specimen, which includes only the cranium and anterior half of the body. The fan-shaped neural spines commence but a short distance behind the line of the pectoral shields; they are low, and with a few coarse ridges; the margin entire. The abdominal rods are delicate and hair-like. The pectoral shield is an oval, with a few radiating crests which originate at the centre; in the areas between these there are a few scattered tubercles. The lateral shields are ridged near the margin.

The cranium is lanceolate in form, and the bones of the superior walls are marked with a few raised points and ridges. There is a thin bone which I have already alluded to as the squamosal or preoperculum, shaped like a right-angled triangle separated from the outer posterior angle of the head, which exhibits a few similar marks.

	M.
Length of cranium,	0.020
Width " "	.008
Length median pectoral plate,	.0042

This small species is about the size of *P. pectinatus*, and should be especially compared with it. In specimens of that species in which the cranium has the same size, the median pectoral plate is narrower and more prolonged longitudinally, and exhibits tubercles and a few ridges near the circumference, but no cross-like figure.

Dedicated to Prof. Alexander Winchell of the New York University, at Syracuse, author of the "Sketches of Creation," etc.

PTYONIUS PECTINATUS, *Cope*

Sauropleura pectinata, Cope, Proceed. Acad. Nat. Sci., Phila., 1868, 218; *Oëstocephalus pectinatus*, Transac. Amer. Philos. Soc., 1869, XIV, p. 20.

PTYONIUS SERRULA, *Cope.*

Proceed. Amer. Philos. Soc., 1871, p. 177. (*Oëstocephalus*)

Represented especially by a single almost complete specimen, and perhaps by another originally referred to the *P. pectinatus.* It is only half as large as that species, but displays a more complex sculpture of the pectoral shields, indicating that it is not immature. The tail is relatively longer.

The remains of the head indicate a trigonal outline; but the muzzle is lost. The pectoral shields are narrow and elongate, both median and lateral a little wider behind. The median has a considerable smooth anterior prolongation. Its surface is near the middle sharply reticulate-ridged, then closely radiate-ridged to the margin. The lateral shield is reticulate-ridged behind and sends out radii, those on the anterior part sub-parallel. The triangular hæmal spines begin far forward; with the neurals, they are rather elongate-deltoid in form without the distinct peduncle seen in *P. pectinatus*, but instead, a short concave or cresent shaped base from the concavity of which the sculpture rises. This consists of ridges which extend beyond the intermediate spaces, like teeth. Abdominal rods hair-like. Ribs distinct. Remains of limbs not discernible.

In the second specimen alluded to, weak limbs are seen on each side of the posterior part of the abdominal cavity. On the right a moderately stout femur is given off, which is followed by a broken tibia and fibula, and then by five closely appressed metatarsals. The last are 2–5 as long as the space between them and the femur, beyond them a few slender phalanges are moderately distinctly defined. The tibia is more distinct on the left, but there are no tarsus nor phalanges; some of the metatarsals remain. Length of limb to end of metatarsals equal to five juxtaposed vertebræ measured along the edge of the neural spines. The limb, especially the foot, is slender. In this specimen there are ten neural spines included in a length of half an inch.

In the typical specimen twelve neural spines are included in a half inch. The dorsal vertebræ are somewhat dislocated in the anterior region, nevertheless it appears that the length from the front of the pectoral shield is contained twice in the length of the tail; in the smallest example of *S. pectinata*, it enters the same .75 of a time, though perhaps a very little should be added for the missing extremity.

	M.
Length of type from anterior edge of pectoral shield,	0.085
Length of median pectoral plate,	0.006
Width of neural and hæmal spines at first caudal vertebra,	.0045
" " " " at middle of tail,	.0040

OËSTOCEPHALUS, *Cope.*

Proceed. Acad. Nat. Sci., Phila., 1868, p. 218. Transac. Amer. Philos. Soc., XIV., p. 16. *Sauropleura*, pt. Proceed. Acad. Nat. Sci., Philada., 1868, p. 217. Proceed. Amer. Philos. Soc. 1871, p. 41.

Another genus resembling in its fan-like hæmal and neural spines of the tail, the European form *Urocordylus*, and differing from it as *Ptyonius* does, *i. e.* in the rod-like abdominal scales, and the well developed ribs. Its form is long and snake-like, and it thus resembles *Ophiderpeton*, Huxl. But in the latter there are no limbs, and the cranium is very differently constructed; in *Oëstocephalus* it is much as in *Ptyonius* and *Lepterpeton*. The characters then are as follows:

Form slender and snake-like; caudal vertebræ with dilated and sculptured neural and hæmal spines. Cranium lanceolate. Teeth numerous, of nearly equal size. No pectoral shields; abdomen protected by very numerous bristle-like rods, which converge forwards; scales none. A pair of weak posterior limbs; branchihyal bones present.

In the only well-preserved species, the cephalic bones exhibit no sculpture from the parietal region forward. The angles of the mandibles are prolonged backwards as in *Apateon* and the *Anura*, and the well developed ribs commence but a short distance behind the head. The vertebræ are slender and furnished with well developed diapophyses. The neural spines of the dorsal vertebræ in *O. remex* are flattened and antero-posteriorly expanded and weakly grooved to their superior margin.

The character which separates this genera from *Ptyonius* is the absence of the three usual pectoral shields. In two specimens the pectoral region is presented, and no trace of the shield appears; on the contrary the ventral armature of bristles or rods extends to the head.

A pair of symmetrical bones, whose impressions are seen posterior to the occipital bone, I once thought might belong to rudimental limbs. They however appear to be the elements of the second or third branchial hæmal arch; the first or hæmal is followed by a second element which is probably the inferior pleural segment of the arch. A third piece follows, which is the superior pleural element of the same. The other branchial arches are lost, but some impressions are visible.

Before I was fully acquainted with the structure in this genus, I referred some of the species to *Sauropleura*, which is quite distinct. The name is from οϊστος, a javelin or dart, in allusion to the form of the head. My friend, Dr. Benjamin H. Coates, informs me that this Greek word retains the diëresis in composition, and should not be spelled with a dipthong.

I am acquainted with one species from more or less completely preserved skeletons, with portions or wholes of crania, and another species from cranial remains alone.

They may be distinguished as follows:

I. Vertebræ elongate; fan-like caudal processes narrower. Size large; mandibular teeth of unequal lengths, with the apices turned backwards. O. REMEX.

II. Species only known from cranial bones with teeth; teeth equal, erect, with acute conic apices, eleven in .005 m. O. RECTIDENS.

OËSTOCEPHALUS REMEX, *Cope.*

Transac. Amer. Philos. Soc., XIV, 1869, p. 17.

OËSTOCEPHALUS RECTIDENS, *Cope, Sp. Nov.*

Indicated by a left dentary bone with its teeth and external surface preserved. The latter is nearly smooth and without sculpture. The outer face is convex, and the general form is slender, but not curved upwards at the extremity. Teeth straight and conic, apex acute; no visible grooves of the surface; eleven in m. .005, closely placed, and of equal lengths. The extremity of the dentary does not exhibit teeth, but they may be concealed.

	M.
Length of dentary,	0.022
" tooth line,	.0152
Depth dentary at last tooth,	.0027

This represents a smaller animal than does the skull of *O. curvidens*, and differs much from the latter in the more closely placed and perfectly straight teeth.

I describe here a specimen which is closely related as to size to the *O. rectidens*, and is probably a member of this genus; but the specific reference will remain uncertain till other portions of the skeleton are discovered. Those preserved consist of twenty-five caudal vertebræ, probably from the anterior part of the column. There are therefore no ribs nor ventral armature. The centra are rather elongate and expanded at the extremities. The neural arches have a close union. There are no diapophyses, but the fan shaped and striate neural and hæmal spines are present. They are, however, shorter than in *O. remex*, and not so expanded as in the species of *Ptyonius*. The bases are quite narrow. Their reduced size may be derived from the following measurements. Length of three centra, m. .0086; extent of neural and hæmal spines, .0087. The same dimensions in *O. remex* are .012; extent of spines, .02. While this species is smaller than the latter, it is larger than any known *Ptyonius*, its elongate vertebræ are most like those of *Oëstocephalus*.

BRACHYDECTES, *Cope*

Proceed. Acad. Nat. Sci., Philadelphia, 1868, 214. Transac. Amer. Philos. Soc., 1868, XIV., p. 14.

This genus is indicated by two rami of a mandible and a portion of a premaxillary only. These, when compared with those of *Oëstocephalus* and *Dendrerpeton*, from the same locality, and with others described by authors, are so much stouter, *i. e.*, shorter and more elevated, that they evidently belong to a peculiar genus. The genus further differs from *Oëstocephalus* in having the teeth of equal size to the posterior parts of the series, that is, to the base of the elevated coronoid process. The teeth are elongate cylindric cones, with their acute tips turned a little posteriorly. The fractured ones display a large pulp cavity. The three premaxillaries preserved are similar, but without curvature of the tips. They do not exhibit striæ or any other sculpture.

So far as the remains known go, the genus is nearer *Hylerpeton* than any other. According to Dawson that genus is provided with a large canine-like tooth, at the anterior extremity of the maxillary, on the inner row, which is inserted into a distinct socket. No such tooth appears among those of this genus. The latter does not give any indication of the very elevated coronoid process of *Brachydectes*, though the external portion of the dentary bone in that region being lost, little can be said about it. Professor Owen's plate indicates a ramus whose depth at the last tooth enters $8\frac{1}{2}$ times the total length. In our species this depth enters about 5 times.

BRACHYDECTES NEWBERRYI, *Cope.*

Proceed. Acad. Nat. Sci., Philadelphia, 1868, p. 214. Transac. Amer. Philos. Soc., XIV., 1869, p. 14.

PELION, *Wyman.*

Proceed. Acad. Nat. Sci., Philadelphia, 1868, p. 211. Transac. Amer. Philos. Soc., 1869, p. 9. *Raniceps,* Wyman, Amer. Jour. Sci. Arts, 1858, p. 158, not of Cuvier (Pediculati).

Three genera are here indicated as pertaining to a lacertiform type of *Stegocephali.* In one of these there are abdominal chevrons and no thoracic shields (*Sauropleura*); in another (*Tuditanus*) no abdominal chevrons, and thoracic shields present. These genera are doubtless well defined, but one or the other of them may possibly, not probably, be identical with *Pelion.* The only specimen of the only species of the latter exhibits an inferior view of a portion of the skeleton, and the obverse, on which the thoracic and abdominal armor could have been preserved, has not come under my observation. The specimen however, does not exhibit any ribs, although the vertebræ are well preserved; in the two genera above mentioned, well developed ribs are preserved.

As observed by Prof. Wyman, the genus presents some points of similarity to the *Anura.* The prolongation of the angles of the mandible is of this character, as well as the general form of the head. The bones of the forearm may be united as in frogs, and the length and curvature of the femur, are seen among these animals rather than the Salamanders. The form of the femur is different from that of *Amphibamus grandiceps,* which also differs in the unossified condition of the vertebræ and presence of dermal scales.

PELION LYELLII, *Wyman.*

Loci citati.

SAUROPLEURA, *Cope.*

Proceed. Acad. Nat. Sci., Phila., 1868, p. 215. Transac. Amer. Philos. Soc., 1869, 15.

Vertebræ and ribs well developed, no fan-shaped processes of the former. Limbs four, well developed and elongate. Ventral armature of slender rods arranged *en chevron,* the angle anterior. Probably no thoracic armature.

This is the most lacertilian of the Carboniferous genera, and might almost be suspected to be a reptile were it not for the ventral armature, which is precisely that of *Oëstocephalus* and other genera. It appears to lack the thoracic shields* of those

*When I state, Transac. Amer. Philos. Soc., 1869, 16, that *Sauropleura* lacks the ventral armature of *Oëstocephalus,* thoracic armature, is intended.

genera, for no trace of them can be seen in two specimens and their reverses of *S. digitata* and *S. longipes*, though the thoracic region is well preserved in both.

Unfortunately the structure of the cranium in this genus is quite unknown, the part preserved in *S. longipes* being too much injured to furnish characters. The only genus with which it can be compared in the structure of the skeleton remaining, is *Tuditanus*, and it is possible that some of the species of the latter in which the cranium only is known, should be placed in *Sauropleura*. The type however, *T. brevirostris*, has thoracic shields and very weak limbs, so that the genera are well distinguished. As to species, the only one of *Tuditanus* which could, by reason of size, belong to either of those of *Sauropleura*, is *T. mordax;* the *T. radiatus* and *T. obtusus* being larger than either *S. digitata* or *S. longipes*.

The vertebræ are not elongate and the ribs are quite well developed. In *S. longipes* the neural spines of the dorsal vertebræ are vertical laminæ, subquadrate in outline. The tail is elongate, being proportioned in *S. longipes* much as in lizards of typical forms. Of scapular arch I can find nothing, but in *S. longipes* the iliac bones are preserved. They are short flat rods slightly narrowing towards the base, which is a transverse expansion, with the distal margin presenting two faces separated by an angle. The limbs are well developed, the ulna and radius separate. In *S digitata* there is no osseous carpus.

The sizes of the species known are about that of our medium and larger lizards. The *S. digitata* is the larger, and of shorter body and more robust limbs than the *S. longipes.* While the former has thirteen pairs of ribs, the latter has nineteen, perhaps twenty-one.

The dermal abdominal rods are arranged *en chevron* with the angle anterior, and are separated by interspaces.

SAUROPLEURA LONGIPES, *Cope, Sp. Nov.*

Body long, slender, with long neck and long tail, ribs 19 or 21 pairs, moderately curved, the anterior stouter, and with widened extremities, the posterior slender, and drawn out to a fine point. Dorsal vertebræ 1.5 times long as wide, with well developed neural spines. These are rather narrower than high, the height about equalling the length of the centrum. They are rugose with small tubercles which are sometimes confluent into ridges.

The humerus is longer than the ulna and radius, which are of equal lengths, that is about as long as four dorsal vertebræ. The ulna and radius are not widely separated, and expand at the carpal region. The humerus is rather more slender, and is distally expanded. The digits are not all preserved. One metacarpal is seen at an interval beyond the forearm, and series of phalanges extend beyond the metacarpal. The latter is about half as long as the forearm, and a little larger than the first phalange, which is, like the former, very slender. Parts of two or three phalanges of perhaps other digits appear along side, as though turned backwards. The femur is about as long as the humerus, equalling six and three quarter posterior dorsal vertebræ. Proximally it is enlarged gradually and terminates regularly so far as can be seen, as it is partially concealed beneath the distal extremity of the ilium.

Measurements.	M.
Length of vertebral column between pelvis and humerus,	0.070
" " " " in front of humerus,	.0235
" " caudal series preserved,	.070
" " humerus, about	.0185
" " ulna and radius,	.012
" " part of fore limb in line,	.0455
" " ilium,	.007
" " femur,	.020

Number of chevron rods in .004 ; seven.

A single specimen of this Batrachian was obtained by Prof. Newberry, at Linton; it is in a good state of preservation.

SAUROPLEURA DIGITATA, *Cope.*

Transac. Amer. Philos. Soc., 1869, XIV., p. 15.

TUDITANUS, *Cope.*

Proceed. Amer. Philos. Soc., 1871, 177.

Cranium broad flat, orbits anterior, bones more or less sculptured. Teeth on premaxillary and maxillary bones of nearly equal sizes. Three pectoral shields sculptured externally. Form lizard like ; two pairs of limbs of medium proportions.

This genus is established on two species of which the collection contains nearly entire specimens. In these no chevron abdominal rods or scales can be discovered, and it is not probable that they exist. The presence of the pectoral shields distinguishes this genus from *Dendrerpeton*, Owen, while the thoracic plates and lack of ventral rods separate it from *Sauropleura.* The plates may, however, be found in the latter; should the rods be found in *Tuditanus*, which is not probable, these genera must be united. I associate with the *T. punctulatus*, and *T. brevirostris* three other species known only from crania, a reference to be finally criticized when more is known of them. They are all evidently allied. The largest is *T. huxleyi ;* the next, *T. radiatus*, is named from elevated radiating ridges of the cranial sculpture, *T. mordax* has a strongly sculptured cranium, and large premaxillary teeth, while in *T. obtusus* the orbits are less anterior, and the teeth small. I formerly described it as a *Dendrerpeton.*

TUDITANUS PUNCTULATUS, *Cope, Sp. Nov.*

This amphibian is known from a single individual well preserved on the opposite halves of a block of slate. The head, fore-limbs, and twenty-three consecutive vertebræ with ribs are well defined, but of pelvis and hind limbs, nothing is visible.

The cranium is less exposed posteriorly than in the other species referred to the genus, and has a triangular outline with narrowed but obtuse muzzle. If I do not mistake the outline of the left orbit, it is near the transverse line which divides the head equally. The surface of a considerable portion is preserved, and is sculptured by small pits placed closely, the intervals in a very few parts assuming the form of ridges. The sculpture is thus more minute than in any other species. The under jaw of the right side is partially preserved, and displays longitudinal grooves. The ramus is stout and straight, and approaches the form seen in *Brachydectes newberryi*. Its teeth are not preserved, but the extremities of the opposing maxillaries remain. They are small and acutely conic; both they and the ramus are much less robust than in the above mentioned species, and the enamel preserved is smooth.

The three *pectoral shields* are preserved, and as the exposed surface is the interior it is smooth. The laterals resemble imperfectly, spherical triangles. The outer margin is thin and convex, and the anterior angle curves round the apex of the median shield and joins that of the opposite side forming a coarse interlocking suture. The median scute is formed like some of the patterns of ancient mirrors. It is a wide oval excavated on each side behind, and produced from between these concavities into a long flat sternum-like process. The latter thus resembles the xiphisternal production of frogs and of some lizards; as in the former, the ribs having no hæmal elements, have no connection with it. Its extremity is simple and obtuse.

The *humerus* originates at the outer posterior angle of the lateral thoracic scutum. It is relatively as large as that of a frog, is contracted medially, and much expanded distally. It is followed at a short interval by a shorter ulna, which is also expanded at the ends and contracted at the middle. Then succeed numerous well developed phalanges, which are so scattered as to render it impossible to ascertain the number that compose the digits and how many of the latter existed.

The *vertebræ* are osseous and with slightly concave extremities on a lateral view; they are subquadrate in outline; their spines are not distinguishable. There are 22–3 pairs of osseous ribs, which are slender, rather short, and strongly curved backwards.

Measurements.	M.
Length of specimen as preserved,	0.097
" " head,	.024
Width of head posteriorly,	.020
Depth of ramus mandibuli,	.004
Eight apices of teeth cover,	.005
Length of 23 vertebræ.	.063
" median pectoral scute,	.010
Width " " "	.005
" of the three scuta,	.010
Length process of median scute,	.005
" humerus,	.009
Width "	.004
Length ulna,	.006
Width "	.002
Length phalange,	.003
Expanse of longest ribs,	.015
Length of a long rib,	.009

Besides the generic characters already pointed out, this species differs from the *Sauropleura longipes*, to which it has some resemblance, in the much shorter fore limbs, and shorter vertebral column in the anterior region of the body.

TUDITANUS BREVIROSTRIS, *Cope, Sp. Nov.*

Represented by two individuals and probably by part of a third. Those with the cranium show that this part is large in comparison with the size of the body, and is as wide as long, with broadly rounded muzzle. The orbits are large, and situated for the greater part in front of a line marking the anterior third of the length of the head. The bones of the head are coarsely sculptured with radiating ridges, and with some tubercles posteriorily; the supratemporal exhibits radii which extend outwards. The teeth are in two rows on that part of the maxillary arch anterior to the orbits; they are of equal sizes; the outer row appears to be directed more obliquely outwards than the inner. The former number five in .002 M. The thoracic shields are rather large, and have coarse radiating ridges.

Vertebral centra and arches are not well distinguished in two individuals, but instead, an axial mass which may represent *chorda dorsalis*. In one, three diapophyses are distinctly developed at the sacral region. In a third individual without head or thoracic region, but in which the ribs and hind limbs are similar, as well as the general proportions, the vertebræ are distinctly ossified; but its reference to this species is uncertain.

Remains of both fore and hind limbs are preserved. They are rather stout, not large, and with short phalanges. The number of these is not distinguishable.

Measurements of Limbs.	M.
Length femur, No. 1	0.060
" tibia and fibula, No. 1,	.050
" anterior phalange, No. 1, obverse,	.0285
" femur, No. 2,	.060
" tibia and fibula, No. 2,	.070
" femur, No. 3,	.052
" posterior phalange,	.026

The deficiency of length of the tibia in No. 1, is probably due to imperfection of the specimen. There are bones of the fore limbs in No. 2 which are not determinable. The ribs are rather long and rather curved. The caudal extremity is not complete, but was evidently well developed.

	M.
Length from head to femur,	0.0356
" head,	.0154
Width " behind,	.0175
" " interorbital,	.0042
Length of orbit,	.0040

TUDITANUS RADIATUS, *Cope, Sp. Nov.*

Represented by crania of several individuals, one of which is nearly perfect, and is selected for description; others are more or less complete; and present the prominent peculiarities of the species.

The marked character of this form is seen in the very anterior position of the orbits and contraction of the muzzle. The orbits are large and separated by a little more than their own diameter; the posterior border is in front of a line measuring the anterior third of the length to the supra-occipital crest, and nearly at the line marking the fourth of the length to the quadrate region. The posterior outline of the skull is deeply concave, the quadrate angle projecting beyond the occipital condyles, which are themselves quite prominent. The osseous segments composing the cranium are from the orbital region posteriorly, three median, and four lateral on each side. The supra-occipital is rather small, and is broader than long. Its posterior border is straight, as are the short lateral margins. The anterior suture presents an obtuse angle forwards. A large rhombic plate occupies the parietal region, which is probably divided longitudinally by a suture, and represents the parietal bones. It extends narrowing, nearly to the orbits, when the middle line is occupied by the much smaller frontal. The suture between the two is obscure, but seems to form an emargination of the parietals. There is a subtriangular post-frontal which expands posteriorly and is succeeded by a supra-temporal which narrows and becomes acute posteriorly, being wedged between the parietal and what may be an anterior production of the plate representing the epiotic. A very large jugal plate extends from the orbits two-thirds the distance to the extremity of the quadrate, the remaining third being covered by a quadrato-jugal. After the jugal the epiotic is the largest of the cranial shields or bones, and sends a prolongation forwards between the parietal and supra-temporal, as well as on the outer side of the latter.

There is no trace of mucous canals. The sculpture consists of strong ridges radiating and inosculating. Radiation is more uninterrupted on both jugal, supra-temporal and anterior part of epiotic; in the first, they originate in front of the middle exteriorly; on the supra-temporal, near the anterior part. The inosculation is honeycomb like on the parietal, supra-occipital and posterior parts of the epiotic.

Measurements.	M.
Length to middle of supra-occipital,	.055
" " angle of quadrate,	.0711
Width at " "	.069
" " orbits (approximate),	.031
Interorbital width,	.0085

No teeth are preserved with this cranium. A second specimen exhibits nothing more distinctly than the one described.

TUDITANUS OBTUSUS, *Cope.*

Proceed. Amer. Philos. Soc., 1871, p. 177. *Dendrerpeton obtusum,* Cope, Transac. Amer. Philos. Soc., 1869, XIV., p. 12.

TUDITANUS MORDAX, *Cope, Sp. Nov.*

Represented by a partially complete cranium and some other fragments.

The muzzle is broadly rounded as in *T. obtusus*, and the premaxillary teeth are relatively much larger. The bones are sculptured with delicate acute radiating and inosculating ridges. The maxillary bone is preserved for the length of an inch; its teeth are smaller than those of the premaxillary bone; I count four in a line, which have a simple conic crown. The external surface of the maxillary is not very strongly sculptured. The orbits and nares are not well defined in the specimen.

TUDITANUS HUXLEYI, *Cope, Sp. Nov.*

Represented by a considerable portion of the face and muzzle of a single individual. A portion of the left mandible, supporting three teeth remains in place, and almost the entire boundary of the right orbit is preserved.

The fragment indicates a much larger species than any other referred to the genus, and next to the *Leptophractus obsoletus*, the largest of the Batrachians of the Ohio Coal Measures. Without more complete remains it is not easy to determine its generic relations finally. It differs from the *Leptophractus* in the absence of the symmetrical scutellation of the cranium.

The form of the head is probably elongate and the muzzle neither very obtuse nor elongate. The orbit is rather small and near the middle of the length of the specimen, which is, however, incomplete at both ends. The sculpture of the surface of the head posterior to the orbits, as well as round their borders and for some distance in front of them, consists of a rather coarse pitting. On the middle line between the orbits and on the muzzle, the intervals become narrower, and are confluent into transverse ridges or a delicate reticulation. The surface of the mandible displays a coarse reticulation.

The teeth are stoutly conic, and with delicately striate grooved cementum. They are slightly recurved.

This species differs from the *T. radiatus* and *T. obtusus*, in the absence of the segmental areae into which the sculpture is thrown in them.

Measurements.	M.
Longitudinal diameter of orbit,	0.019
Length of alveolar border supporting three teeth,	.013
Diameter of basis of tooth,	.003
Eight pits in,	.010

Dedicated to Professor Thomas H. Huxley, *facile princeps* among English systematists, and an important contributor to the knowledge of the extinct Batrachia.

LEPTOPHRACTUS, *Cope.*

Proceed. Acad. Nat. Sci., 1873, 340.

LEPTOPHRACTUS OBSOLETUS, *Cope.*

Loc. cit., 1873, p. 341.

EURYTHORAX, *Cope.*

Established on a large thoracic shield of peculiar form. It is a median, and exhibits broad smooth surfaces for the contact of the overlapping margins of the lateral plates. The form is subround with a large excavation from the posterior margin on each side. The narrowed portion left has a convex outline. Sculpture none. The form resembles remotely the corresponding scute of *Tuditanus punctulatus*, the posterior narrow face representing the xiphisternal process of that species.

EURYTHORAX SUBLÆVIS, *Cope.*

Proceed. Amer. Philos. Soc., 1871, 177.

The specific characters expressed by this shield are best perceived in the measurements:

	M.
Length,	.0715
Greatest width (imperfect),	.078
Width of lateral concavity,	.039

Some delicate radiating grooves are seen on the exposed surface, but they are very shallow. They are not visible on the faces of contact.

This represents one of the largest species of this fauna, having pertained to an animal of probably four feet in length, perhaps longer. It will be desirable in future to compare it with the corresponding part of the *Tuditanus huxleyi*, though the latter, so far as known, is the smaller species.

COLOSTEUS, *Cope.*

Transac. Amer. Philos. Soc., 1869, XIV., p. 22.

COLOSTEUS SCUTELLATUS, *Newberry.*

Cope, Proceed. Amer. Philos. Soc., 1871, p. 41. *Pygopterus scutellatus*, Newberry, Proceed. Acad. Nat. Sci., Philadelphia, 1856, p. 98. *Colosteus crassiscutatus*, Cope, Transac. Amer. Philos. Soc., XIV., 1869, 23.

COLOSTEUS FOVEATUS, *Cope.*

Transac. Amer. Philos. Soc., 1859, XIV., p. 24.

COLOSTEUS PAUCIRADIATUS, *Cope, Sp. Nov*

Established on median and lateral pectoral plates of two individuals, the latter of which I formerly referred to the *C. scutellatus*. It belonged to a larger specimen than either of the preceding, and is distinguished by the paucity and weakness of its ridges. These are entirely transverse on the posterior third of the length, but are interrupted and irregular on the median portion; the anterior third is almost smooth.

The lateral shield is little larger than the largest of *C. scutellatus*, but resembles the median plate in its low and distant carinæ. An arc drawn at about the middle of a radial line from the outer angle crosses about eleven of these ridges; in *C. scutellatus*, twenty in the same space.

The median plate is pyriform with the posterior angle little produced, and the anterior not narrowed and rather short. The lateral shield is a right angled triangle, the inner or thin edge concave posteriorly, the posterior convex.

	M.
Length of median,	0.063
Width " "	.040
" " lateral behind,	.0242
Length of lateral,	.045

COCYTINUS, *Cope.*

Proceed. Amer. Philos. Soc., 1871, p. 177.

Vertebræ and ribs osseous; anterior limbs, thoracic shields and abdominal armature apparently wanting. Teeth on the premaxillary bone, none on the maxillary. Hyoid elements largely developed. An axial hyal with basihyal on each side, closely united with the corresponding ceratohyal, at the end of which is an element in the position of a stylohyal. Hæmal or basal branchihyals three, the anterior two each supporting one pleural branchihyal, and the third supporting one also. The first or anterior hæmal branchihyal on the inner side of the ceratohyal, approaching the median line, and with elongate pleural element. Urohyal not seen.

Such are the characters of a genus, whose affinities are interesting but somewhat obscure. The hyoid apparatus is better developed than in any other here described, but it is by no means certain that it was branchiferous at maturity, nor does this character on the other hand render it certain that the animal is the larva of one of the other forms here described. The well ossified ribs and vertebræ are favorable, though not conclusive evidence for adult age, while the structure of the hyoid apparatus is more like that of the gilless genera *Amphiuma* and *Pro'onopsis,* than it is like the branchiferous genera *Siren* and *Necturus*, or the branchiate young of Salamanders. Thus it differs from *Proteus* in the presence of the first axial hyal and the two first basihyals, from this genus and *Necturus* in the possession of four distinct pleural branchihyals. In this it agrees with *Amphiuma*, as it does also with *Pro onopsis*, in the three hæmal branchihyals.* *Siren* has only two of these elements, the first and second without the third. As a consequence in *Siren* the third and fourth pleural elements have no corresponding hæmal support, an arrangement totally different from that of *Cocytinus.* The arrangement in larval *Amblystoma* and *Triton* is quite similar to that in *Siren,* excepting that in *Triton*, the small basihyals are present.

The question as to whether this genus was in life branchiferous or not, is not easily decided, since the hyoid apparatus is about equally developed in the branchiferous genera *Siren* and *Necturus*, and the air breathers *Amphiuma* and *Protonopsis.* Some considerations however point to an air breathing type, like the last two, though the individual may possibly have been immature. In the gill-bearing genera, as well as in the larvæ of *Amblystomæ*, *Tritons*, etc., the branchial arches approach nearest to archetypical perfection. Thus in the *Siren lacertina*, two of the four superior branchihals are supported by corresponding inferior or hæmal branchihyals, and these in turn are articulated each to its proper axial hyal. The absent elements are the two

* For the nomenclature of these bones, I follow Fischer's Ueber die Perennibranchiaten und Derotremen: Hamburg, 1864.

axial and two hæmal elements which exist as supports of the posterior two inferior brachihyals in the fishes. In the branchiferous *Necturus maculatus* a considerable modification ensues. The four superior branchihyals are present, but according to Fischer, the first and second hæmal elements are confluent. A third inferior branchihyal is added. If we now turn to the air-breather *Protonopsis horrida*, we observe a marked peculiarity. The third hæmal branchihyal remains, while the second is confluent with the corresponding superior element, and the first is similarly confluent or, as Fischer interprets it, the first branchiyal of the superior series extends to the axialhyal. In *Murænopsis* (*Amphiuma*), a greater divergence from the archetype exists. With all the peculiarities of *Protonopsis* it further almost loses the second hæmal element, which appears at maturity as a process on the first pleural element.

These characters may be tubulated as follows:

A Third hæmal branchihyal present.

a First and second hæmal branchihyals free and distinct.

COCYTINUS.

aa First and second hæmals separate from each other but confluent with their pleural elements.

PROTONOPSIS.

AMPHIUMA.

aaa First and second distinct from pleurals, but united with each other.

NECTURUS.

AA Third hæmal element wanting.

z Second hæmal element reaching the axis.

SIREN.

Larvæ, { AMBLYSTOMA. TRITON. SALAMANDRA.

zz Second hæmal element reduced, not reaching axis.

PROTEUS.

Now it has been pointed out that *Cocytinus* agrees with the air-breathing genera in the larger development of the first pleural and hæmal branchihyals, and that it agrees with them both in the presence of the second and third hæmal elements. But these are more distinct than in either of these genera, and the third is larger, and supports the fourth as well as its own pleural element.

The presence of the maxillary bone furthermore excludes this genus from near affinity to either the *Trachystomata* and *Proteida*, and allies it to the *Amphiuma* and

Protonopsis. It differs from both these genera in the absence of teeth from this bone as well as its apparently small development. This may indicate that the animal was not fully grown. In the hyoid region it differs from these in the apparent absence of the second axial hyal, and in points of the hæmal segments. Thus the second is confluent either with the 1st or 2d pleural element in those genera, and the third hæmal element is much reduced and does not support the fourth pleural in either.

The present genus is then to be referred to the neighborhood of *Amphiuma* and *Protonopsis*, but as forming the type of another family. The branchial apparatus is more fish-like than in either of these, in (1) the three distinct and well developed hæmal branchihyals, (2) the four distinct pleural elements of the same; (3) the distinct ? stylohyal.

Its weak maxillaries have a larval aspect, but the ossification of all the bones and the small size of the pleural branchihyals as compared with the rest of the cranium, render it probable that the form is no more larval than the genera to whose neighborhood it is referred. That it passed a portion of its existence as an aquatic branchiferous animal is no less certain.

COCYTINUS GYRINOIDES, *Cope, Sp. Nov.*

The only specimen of this batrachian, embraces the inferior bones of the cranium in a complete state of preservation, with the muzzle with its teeth; also the anterior eight vertebræ with their ribs. The condition of the hyal elements is as follows: The hæmal element of the first branchial arch is partially concealed on both sides by the ceratohyal. An expanded truncate face of attachment to the axial element is visible on both sides, but the body of the bone is flat, and presents the edge in the specimen. The first pleural element proceeded from just behind and within its extremity; it is longer than the other pleural elements. A slender bone is visible extending from the space between the ceratohyal and mandibular angle; it may therefore pertain to the suspensiorium of the jaw as well as to that of the hyoid arch, or be squamosal as well as stylohyal. The second hæmal bone is slender, but with enlarged axial extremity; that of the right side is not so well preserved as to be safely determined. The third hæmal elements are the smallest, and originate immediately in front of the occipital condyles and diverge outwards and backwards. They are little curved, subcylindric and slightly expanded at the extremities.

Of the pleural elements the first and second are little curved, the first is marked by a pit or foramen on the under side near the distal end, which is clearly visible on both sides of the specimen. The third and fourth pleurals are more curved, and the outer ends slightly expanded and directed backwards.

The obverse of the specimen shows that the anterior axial hyal is wedge-shaped. The lateral basihyals are massive. The second hæmal branchihyal is dilated fan-shaped distally, and supports two pleural elements.

The muzzle projects over the lower jaw, and was rather broadly truncate. The premaxillary teeth are cylindric and six in number on each side. The maxillary bones represented by a lamina at each lateral extremity of the premaxillary. The mandibular rami are very stout, as are also the ceratohyals. The vertebræ have possessed some apophyses, apparently keel-like diapophyses. The ribs are slightly curved.

Length of head and eight vertebræ, M. .0335; of head .0152; expanse of mandibular rami .013; length of left ceratohyal .0085.

ARTICLE VI.

AN ANALYSIS OF THE LIFE-FORM IN ART.

By Harrison Allen, M. D.,

Professor of Comparative Anatomy in the University of Pennsylvania.

Read March 6th, 1874.

GENERAL CONSIDERATIONS.

Section 1. *The Imitative.* We are informed on the highest authority* that the language-character of primitive people is largely if not entirely composed of signs, which are either direct copies of familiar objects, or can be shown to be derivatives of them.

A language or letter-type and an art-form have thus much in common, although the processes are different by which they are evolved. To produce the letter-type, a series of abridgments must be practiced for a long time, with the result of simplifying the form by the elimination of non-essential attributes. Of course the resemblance to the original design is, by such treatment, sooner or later lost. To produce the art-form the rude outline becomes in time a reasonably faithful copy of the natural model, and from this realistic stage may pass under favoring conditions to an art-type capable of expressing the highest culture.

From among the innumerable objects surrounding man, those selected by him for delineation have been relatively few in number. He appears to have been influenced in his choice by his necessities, both real and imaginary. Among the first may be placed the objects he sought for food, and those he dreaded as enemies. Thus we meet with figures of birds, fishes and the grazing animals, as well as those of rapacious and venomous creatures. Next in order may be placed representations of the heavenly bodies and the signs of the elements, indicating his dread of the violent phenomena of the earthquake and thunder-storm, or his appreciation of the benefits of rain and favoring winds. Outlines of his own form are often of great antiquity.

* Egypt's Place in Universal History, London, Chev. Bunsen, I, 333. Five Ancient Monarchies, etc., London, Geo. Rawlinson, I, 81. Dissertation on the Nature of, and Character of the Chinese System of Writing, Phila., 1838, XV, Duponceau.

They are for the most part, expressive of an anthropotized deity, or of himself in heroic action.

With such simple factors many secondary figures may arise by specialization of the details of the more complex. The human figure yields the head, and its separate parts, the eye, mouth, ear and limbs, particularly the hands and feet. The house with the gable and door is appropriated, each with its special significance; and as the use of weapons and household utensils become gradually adopted, a system of picture-signs is elaborated sufficient for the purposes of the people inventing it.

The difficulty of identifying the objects of such a system is apparent. Apart from the rudeness of the execution, we find objects closely resembling one another having diversive significances. Many figures, for example, are circular in form, which we cannot, from that fact alone, place together. Upon the monuments of Central America the circle is often used to designate both the human eye and the ear drum of reptiles. It also represents the moon,* mammæ, and a variety of other things.

SECTION II. *The Inventive.* But many designs can by no force of ingenuity be included in the list, either of organic objects, of implements, or their derivatives. Some of these are inventions. This is a natural result of human effort. As earthen pottery could easily have been suggested by the gourd, or hollow stone, so the designs upon fictile implements may have arisen from the minor accidents occuring during manufacture. The unintentional imprint of the finger tip may have passed into the ornament adopted in the pottery of the stone age of Europe.† In the same manner the stamp made by the end of a hollow reed‡ may have originated the circular ornament, as the impress of a fibrous cord created the almost universal spiral border.

Excluding this group of objects, there yet remain many markings such as those seen upon early pottery, which cannot be so explained, and are probably examples of inventive design. Such are the herring-bone patterns and chevrons, and the numerous crossed lines, which do not form determinate figures. What the ultimate shapes would have been, originating from a basis so meagre, it is difficult to surmise. There are many elaborate examples of carvings among the South Sea Islanders in which the simple repetition of the lines above mentioned is never departed from. The result is pleasing, but without other interest.

* According to Lt. Simpson (Reconnoissances in New Mexico, Texas, etc., 1850), the circle, among the Pueblo Indians, means the sun and moon,—the half-circle, clouds,—the zigzag, lightning, etc.

† Prehistoric Times, Sir John Lubbock, p. 469. It is asserted by Wm. Chaffers (Keramic Gallery, II, 1872, 185), that the gourd, pumpkin, or the fruits with a hard rind or shell, were in England the most primitive vessels.

‡ Antiquity of the Southern Indians, particularly of the Georgian Tribes, Charles C. Jones, Jr., New York, 1873, 459.

When an attempt to produce symmetrical designs upon the same supposed inventive basis is recognized, it is doubtful whether at some earlier stage of its development a class of natural objects had not been the original source of inspiration. In the later examples only of the ornamentation of the so-called Iron Age and the Saracenic styles, namely at the time of approaching decadence, do we find engrafted upon them imitations of the life form. In the former, it is of an animal type, and in the latter, it is a vine-like tracery.*

But even here it is not by any means certain that imitation did not form the basis of design. Worsaæ claims that the embellishment of the ornaments of the Iron Age was derived from the Roman taste,† while for the Saracenic, it would be very difficult to prove that at the time of the rapid development of this style, much was not unwittingly copied from the ancient monumental ornamentation constantly before the Moslem people.

The ease with which designs, either apparently or really the outgrowth of man's ingenuity, rather than direct copies from nature, run into set figures, endlessly repeating themselves, is very noticeable. The time at which a given people will adopt a pattern holds a direct relation to the tendency of their art. If the art inclines to invention, the patterns will appear early; if it inclines to imitation, they will appear late. We have seen that primitive man copies the animal forms about him; now of these the serpent is the only one which is facile to the purposes of the pattern-maker, if we exclude that exceptional accessory, the feather. As a result, the animal form is excluded from the arabesque, which is noted for its involved and apparently artificial ornamentation; and towards its decline when its typical expression has been modified, the vegetable form is introduced instead of the animal. It is, indeed, almost a necessity that the animal, or at least the footed form of it should be so excluded, both from the style of the Iron Age and Islam. It is interesting to compare these examples of traceries with the elaborate entwinings of Celtic ornament. The labors of the Celtic artist to construct monograms and mouldings from the animal form, ended in a tangle of eccentric lines; and in order to make the four-footed shape in any degree obedient, it has been stript of all characteristic proportion and made as snake-like as possible.‡

* The Arabian Antiquities of Spain. J. C. Murphy, 1813.

† "The characteristic ornamentation of the iron period are symmetrical windings and arabesques. As they not infrequently terminate in a rude representation of the head of some fantastic animal, these symmetrical winding ornaments have been regarded as the figures of snakes, whence they have been called snake ornaments. * * * These occupy the place of what were originally leaves." J. A. Worsaæ. The Primeval Antiquities of Denmark, Lond., 1849, 72.

‡ For a good example see Grammar of Ornament. Owen Jones, London, 1856, pl. lxiii.

SECTION III. *The ethnic value of Design.* Having defined two distinct bases for design, the natural and artificial, and concluding that the former is by far the more frequent, it would yet be unsafe to deduce the tempting theory that peoples may be graded by the choice of one or the other of them. Prescott* truly says "coincidences naturally spring up among different nations under the same phase of civilization." May we not go farther and say that coincidences spring up as well under different phases of civilization? Tribes upon the same level may differ widely in their art methods, as well as in the love for the art performance. Wallace† found the Papuans excellent carvers in wood, yet living in a state little better than Andamanders—probably the lowest of men. The Tahitians when discovered by Cook were found using none but stone implements. Lubbock‡ considers that we have in this people a fair example of one living in an age of stone. Now among the remains of the people of the stone age in Europe have been found fragments of bone covered with etchings. In instituting a comparison of the art-products of these two races so far removed in time and location, yet restricted to the use of the same tools, we find striking contrasts. The Tahitian was content to repeat indefinitely a simple pattern composed of oblique lines, zigzags and lozenges, a thing over-wrought and tasteless, without a trace of the gracefulness of the life-forms which were so abundant about him; while the pre-historic designer drew what he saw so accurately that his limnings have scientific value. Prof. Owen§ informs us that some of the characters of the horse, employed by zoologists to distinguish this animal from its congeners, to wit: the small pointed ears, the bushy tail, the beard–like hairs in the stallion, are all faithfully represented in etchings on bones found in the cavern of Bruniquel. The same authority says that the reindeer is recognizable among similar pre-historic drawings. See also the deer (Fig. 1).

Surely, while we should make every allowance for the differences in motive, these two people were far removed in their inclinations as well as their ability to execute. But how could it be shown which was the more advanced? In no way we think with certainty, though conceding the accuracy of the statement, that picture-painting leads to alphabet making, a tribe early evincing a tendency to copy accurately from nature possesses a higher capacity for development than another in which such tendency is imperfectly manifested.

Many illustrations have been given by travelers of the dullness of perception of the savage to artistic forms, a defect brought out in strong contrast to the well-known

* History of Conquest of Peru., I, 175.

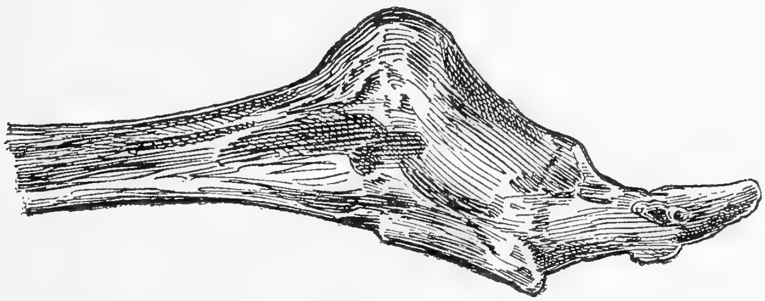
† The Malay Archipelago, A. R. Wallace, New York, 1869, p. 21.

‡ Lubbock, Ibid, 1865, 372.

§ Description of the Cavern of Bruniquel and its Organic Remains. Phil. Trans., Lond., 1869, Part II, 553. Ibid, Part I, 1864.

acuteness of observation he shows in the trail, and the remembrance of the human face. "Of the Alfouras (New Hollanders), Oldfield narrates that on being shown a picture of one of themselves, one said it was a ship, another a kangaroo, not one in a dozen identifying the portrait as having any connection with himself."* Other examples to the same effect could be quoted. This peculiarity evidently could not apply to the Indians of the northwest coast of North America, who long before any European influence was possible among them, produced elaborate carvings of animal forms on pipes, tent posts and other objects.

Fig. 1.



Realistic pre-historic design. †

It is highly probable, that a tribe might be proficient in shaping a mass in the round, and yet be defective in appreciating it in the flat. Wincklemann‡ has given it as his belief, that "art began with the simplest shape and by working in clay, consequently, with a sort of statuary; for even a child can give a certain form to a soft mass, though unable to paint anything on a surface, because"—he continues, "merely an idea of an object is sufficient for the former, whereas for the latter much more knowledge is requisite." Herbert Spencer§ would lead us to the opposite conclusion. He traces the gradual evolution of sculpture from painting, and infers that in advancing from the rude outline on the wall, rock, or slab of wood or stone to a perfect statue, the painter has in time became a sculptor. We recall the fable of the Siscyonian potter's daughter, who drew her lover's profile on the wall, and therewith began the art of sculpture, and wonder whether after all it may not be true. We are in no position to decide which of the positions cited be the correct one, although we would not be surprised if both hypotheses prove correct within definite ranges of art-growth.

* Lubbock (*l. c.*), 348.

† Mortillet Matereaux pour l'Histoire de l'Homme I, 73. Also, Man's Origin and Destiny. J. P. Lesley, Phila. 1858, 259.

‡ Ancient Art, I, 193, Wincklemann. Trans. by G. Henry Lodge, M. D.

§ First Principles, 165. Dr. J. T. Rothrock has informed us that he has actually traced such a transition among the art-products of the people of the northwest coast of North America, from the interior country westward to the sea.

In some parts of the world art may have arisen from the making of clay images, in others from outline drawings.

Section IV. *The Realistic.* Without entering into disputations of the origin of the art-form, it is more to our purpose to analyze those designs which have originated from models found in nature. The art-record of an autocthonous race—particularly that including the manner of representing animals and plants—is a fair subject for study, entirely apart from the origin or meaning of the outlines, or the bearings they may have on ethnological questions.

It will at once occur to the student that the natural productions of a country being given, we are in the best position possible to study its art. But such a proposition can have a very limited application. It is true that with an isolated people the images must of necessity be confined to the fauna and flora of the surrounding region; but if we are correct in the statement that a race with whom the artistic faculties are as yet dormant, who are driven (if we may so express it) to etchings or paintings by the combined forces of superstition and hunger, will secure but very general likenesses in their results. We may be satisfied, indeed, if we can assign even as much as the class to which the animal represented may belong. A fish, a serpent, a bird, a quadruped—these are seen, and was probably all that was intended. No distinction could be expected between serpents and serpent-like fishes, or between cetaceans and fishes. But when the shape is especially striking we are enabled to identify it more exactly. The kangaroo,* the manatee,† turtle,* shark,* trepang,* and star fish,* have been repeatedly delineated by savages. Acquaintance with the remains of more enlightened races, such as the Aztecs, Incarians, Egyptians and Eastern Asians, yield numbers of highly specialized shapes which can with ease be assigned to the genus and even to the species intended. In illustration of this remark we may refer the student to the box-lid of Incarian designing figured by Dupaix.‡ Here can be recognized, through the veil of conventionalism shrouding many of the representations, figures of the lizard, alligator, capuchin monkey, opossum (Fig. 20) and bustard (Fig. 2). The Aztecs‖ although less noted for their exactness of rendition, make the distinction between the tortoise and the turtle; and are particular in preserving the carination upon the scales of the rattlesnake. It must be remembered, however, that this people used the same character to form the shaft of the feather in their

* Lubbock, loc. cit., 347.

† Prehistoric Man, Danl. Wilson, London, 1862.

‡ Kingsborough Coll., IV. See also Dupaix, 2, 1, 4; Voy. Pittoresque et Archæologique dans la Province d'Yucatan pendant 1834 et 1836, F. de Waldeck, Paris, 1838, pl. xi.

‖ Kingsborough, Ibid. IV, Fig. 23.

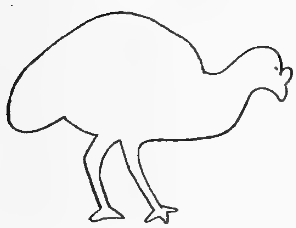


Fig. 2.

Bustard of Incarian design.

Fig. 3.

Didelphian Mammal of Incarian design.

delineations of plumage. Fishes are so well delineated on Chaldean remains, that two closely allied forms, the carp and the barbel, can be distinguished.* In Egyptian art, noted for its realistic tendencies, we have animals so truthfully portrayed that naturalists have been enabled to identify many of them.† We also find well-defined realisms in the early stage of Assyrian art.‡ It is not our purpose to enumerate the examples of realistic art to be met with in the more familiar monuments of Greece and Rome; but may mention in passing the really fine representations of crustacea,§ (such as crabs and lobsters) and mollusca,‖ in the Pompeian style.

The figures of animals and plants upon coins are often rendered with great fidelity. We may direct special attention to the tunny upon Spanish-Roman coins.¶

Palissy, in his Rustic Figulines, gives realistic examples of frogs, fishes, serpents, etc., while his representations of fossil shells from the Paris beds are so faithful, that in many instances the species can be given.** In marked contrast to the average Polynesian designs may be mentioned the admirable figures of terns, cetaceans, and sharks, carved on a beam of a hut at Uji, one of the Solomon Group of Islands.††

Section V. *The Conventional.* (*a.*) General Remarks. By far the greater number of designs adopted by man are not of the realistic type. It is a tendency of the mind to cling to a model when it has been once removed from nature. The entire fabric of society is made up usages, the origin of which is either forgotten or ignored. "*Ubi homines sunt modi sunt.* It is the deepest law of man's nature; whereby man is a craftsman and a 'tool-using' animal; not the slave of impulse."‡‡ Since art is in no wise exempt from the operation of such influences, we find

* Rawlinson, Five Ancient Monarchies, I, 107.

† Selections from Egyptian Ant. in British Mus., Birch.

‡ Botta. Mon. de Ninive, pl. 95, A, fig. 17.

§ Museo Borbonico, Vol. IV, 29; Vol. VI, 38; Vol. XV.

‖ Agancourt, History of Painting, Tab. 4, fig. 4.

¶ Archæologia.

** Morley's Life of Palissy, Boston, 1853, I, 202. (Also, Keramic Gallery, Wm. Chaffers, I, pl. 60.)

†† Jottings during a Cruise of the *Curacoa*, Lieut. J. S. Brenchley, London, 1873, Frontispiece.

‡‡ Carlyle, French Rev., II, 178.

mannerisms early appearing; and persisting to a degree varying with the general character of the people maintaining them. We have found that primitive people are realistic in their tendencies; early art being the purest so far as faithfulness to the model is concerned. We are informed by Dr. Brinton* (who is speaking of the construction of language), that "fidelity to form is everywhere the test of excellence." This must be true of all systems dependent on the purity of types—whether it be of word-roots or of life forms. It is especially noticeable that nations just emerging from darkness into the light of civilization, when they have attained sufficient mastery over their material to satisfactorily produce what they intend, that their art is more vigorous and truthful than at any subsequent period.†

But in time, the figures are distorted by conventionalities, or encumbered with the attributes of an obscure symbolism. They no longer reflect the grace of untrammeled motion, but the formalities of national prejudice. In some phases of art, as for example that seen in Egypt, it is said development was stunted by the enactment of rigid laws. But no legal restrictions are needed to fix the customs of workmen. They are a law unto themselves. It would have been a more difficult task, we believe, to induce an Egyptian artist of the later dynasties to change his method by force of law than to restrain him within the familiar limits which had been handed down to him through many generations.

(*b.*) *Conditions Favoring the Conventional.* Glancing at the conditions which appear to favor the conventional, we find, first, a rapid growth in the arts of design without a corresponding development of the perceptive powers. Numerous examples of this fertile course of formalism are met with in Central America and in Buddhistic India; secondly, the acceptance of a given form as a symbol; thirdly, decadence in art: of the last mentioned we have two varieties, either an abrupt descent from excellence incident to the influence of the schools, in which the style of the master is lost in the mannerism of the disciple, or where art becomes tainted by the whims of uncultured patrons; fourthly, the gratification of the æsthetic sense at the expense of the form. This is easily derived from the preceding, and is either characteristic of it or is indicative of its approach.

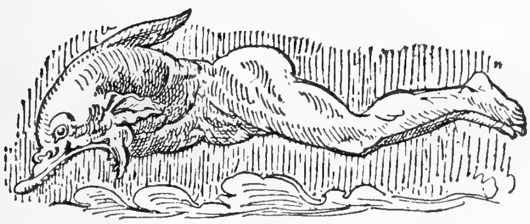
(*c.*) *The Fantastic.* Thus when we see a sphinx delineated in the cinquecento style (it is furnished, let us say, with an enormous tail volute, the basis of which is the acanthus leaf and stem), we are convinced that the artist has deliberately deserted his model for one of those "hazardous caprices sure to please." Equally

* Myths of the New World. D. G. Brinton, M. D., New York, 1868, 8.

† Layard. Nineveh and its Remains, II, 222. The author makes the same application to Egyptian Art, p. 223.

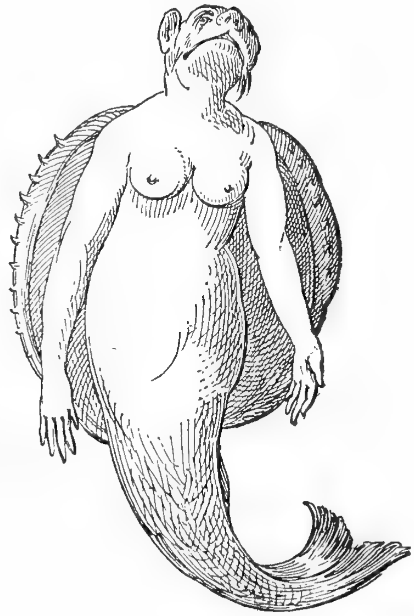
beautiful is the combination of the man and dolphin, from the ruins at Athens"* (Fig. 4), and that of the woman and fish of the popular myth of the mermaid. We copy a curious figure (Fig. 5) of a mermaid-like outline (possibly its prototype), which is suggestive of a strictly natural origin of this form.†

Fig. 4.



Man-Dolphin, from Athens.

Fig. 5.



Mermaid-like form, after Richter.

It is easily seen that with the changes incident to the development of an æsthetic taste, conventionalities will present many varieties. With luxurious people they merge into travesty and caricature, where may be grouped those fantastic figures derived from Greek symbols, seen in Roman and Etruscan Art‡ [Fig. 6].

Fig. 6.

Fantastic form of Pompeian design.

* Antiquities of Athens, I, Chap. ix, pl. 22. Jas. Stuart, Lond., 1762.

† Icthyology, Joh. G. O. Richter. Leipzig, 1754, pl. 1.

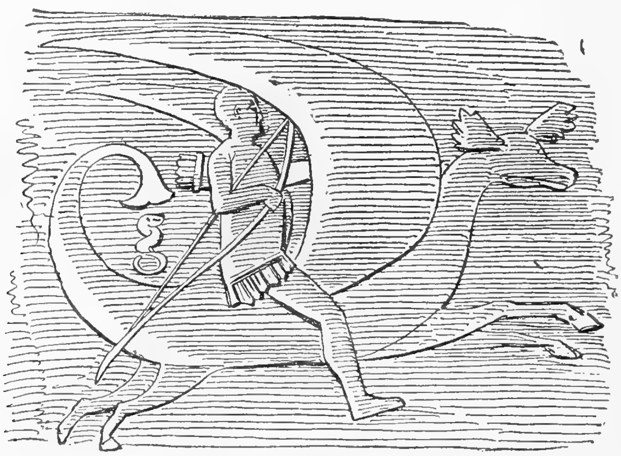
‡ Mus. Borbonio, X, tab. 8.

(*d.*) *Ethnic significance of the "Fantastic.*" Selections of objects for their beauty, or for their power of effecting fanciful combinations indicate an elevated position of the people so employing them. Their appearance in the record is evidence of improved facility in execution (hereby implying an advance in the use of implements), since a primitive people are too much occupied with the vulgar necessities of living to perpetuate a design for its shape alone.

What is vaguely called "grotesque" and "fanciful" are often the "reading of our own ideas into the labors of others." We may, without violence, assume that a people who, while portraying animal and vegetable forms with a conscientious regard to detail, occasionally produce a beautiful shape of a more or less whimsical character, are rapidly attaining perfection in design. Were all other evidence wanting to prove the culture of the Peruvians under the Incas, the single figure of a deer, whose body furnished with wings terminates in the tail of the dolphin* (Fig. 7), would in our judgment do much toward re-establishing the claim. The representation of Quetzacoatl of Aztec‡ (Fig. 9), in its boldness and grace illustrates the same idea. We have found the Incarians prone to realisms; and it is worth while in passing to institute a comparison between this "half-civilized" race, and the Chinese and Japanese. Both the realistic and the fantastic tendencies of the Incarian is found in the Chinese art. We find here, copied with slavish fidelity, figures of fishes, birds and mammals, side by side with monstrous "grotesques."

We may say, in conclusion, that, should the above proposition be received, its application to the study of pre-historic remains may ultimately prove useful.

Fig. 7.



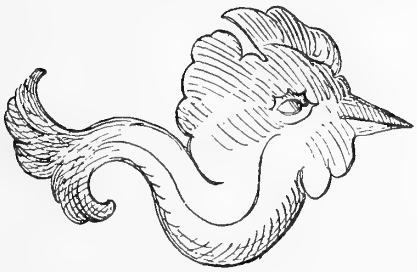
Composite of Incarian Design.

* Kingsborough, Coll. II, Codex Vaticensis, pl. 44.

† Kingsborough. Dupaix.

‡ Kingsborough, IV. Dupaix.

Fig. 8.



Composite of ancient Mediterranean design. (*)

Fig. 9.

Composite of Aztec Design.

(*e.*) *The Grotesque.* The grotesque forms, so-called, are always inventions or rather composites suggested by natural models. They conform to our standard of what is ugly or bizarre more by accident than intention. Had the conceptions of the designers of the startling and hideous been in consonance with our own, such forms as the toad and the bat—those traditional sources of metaphors of the ugly—would be more frequently seen. But these animals are rare in art. The toad occasionally makes its appearance in Aztec and Peruvian records, while the bat is met with, so far as we can recall, but in four instances,† and each of these is simplicity itself compared to the creations from their own art resources. Had the native Mexican sought in nature for examples of ugliness, he must have been a poor observer to overlook the *Centurio*‡ (Fig. 10), whose claims to a position among the ugly things of this world must be conceded

Fig. 10.

Centurio.

(*f.*) *Tendencies of the Conventional.* Let us glance at some of the common

*Inghrami, II, pl. 138.

† Galindos, account of Mon. about Lake Yashau, Archæologia, xxv, pl. 60; Kingsborough, IV, Dupaix; Bollaert, S. Ant. of A., 1860. Frontispiece; Waldeck, F. de. *l. c.* See also Whipple, q. v., p. 45.

‡ Voyage of the *Sulphur*, Mammalia, pl. 7. Brasseur de Bourbourg identifies a profile serpent-head as a bat's. See "Manuscrit Troano," 1859, 209.

tendencies of conventionalisms before passing to the considerations of the mythic and symbolic forms.

One of the most common features of conventionalisms is to repeat *the normal lines of the model*—the proportions being accurately preserved. We notice this in Assyrian art, where the tendency to multiply and make prominent the lines of the muzzle and brow of the lion—their favorite animal—is very noticeable (Fig. 11). Extravagant at best, it becomes eccentric to a degree when applied to other animals (Fig. 12). In the front-faced view of the Egyptian figure* (Fig. 13), we find the entire space between the eye—and the brow occupied by a number of lines drawn parallel with the edge of the upper eye-lid, whose multiple they represent. Examples of the same tendency exist in some rock markings of North America. As another example we may refer to a pre-columbian mask† (Fig. 14), where such lines pass entirely round the eyes and mouth. See also Fig. 1 of the Aztec skull variants, (q. v.) for multiplication of the malar line.

Fig. 11.

Assyrian lion-head. (‡)

Fig. 12.

Assyrian ass-head. (§)

Fig. 13.

Full-faced Egyptian head.

Fig. 14.

Pre-Columbian mask, from the Mosquito shore.

* Birch, *l. c.*

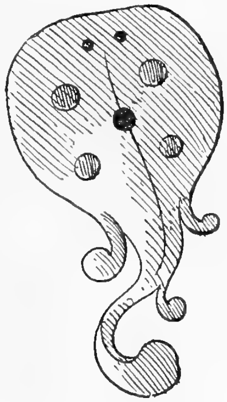
† Archæologia. Chas. Rogers, VI, pl. 11, 107.

‡ The Mouments of Nineveh. A. H. Layard, Lond., 1829, pl. 10.

§ Ibid, pl. 152.

Another, and a very beautiful class of conventionalisms result from an opposite process, viz., *by diminishing the number of the lines of the model*,—thus preserving all that is essential to the artistic form without violence to nature. The figures of the torpedo* (Fig. 15) on some of the Greek vases may be mentioned in this connection. Nothing can be more simple than the lines composing this pleasing form—yet all the essential parts of the animal have been retained.

Fig. 15.



Torpedo from Greek amphora.

(*g.*) *The Symbol.* The most interesting conventionalisms, however, are those arising from a symbolic basis. The forms of ancient symbolism with which we are most familiar, are those belonging to the history of the Indo-Germanic branch of the human race, including some engrafting received from the Chaldean stock.† Since much of the interest in studying symbols is inextricably connected with the meanings originally attached to them, we will begin our remarks with the consideration of one concerning which much is known—the griffin. We made the acquaintance of this form comparatively late in its development, when it is reasonable to suppose that it may have undergone many modifications in form, if not in significance. The griffin has been traced to an Assyrian source,‡ whence it appears to have passed westward to Greece, and southward to Persepolis and Babylon, if indeed it may not have passed from the latter place primarily. M. Roulin§ endeavors to trace the griffin to an Indian origin, and asserts that its natural prototype is the tapir (!) (Fig. 16). We are informed by Dennis,‖ that the Etruscans symbolized

* Die Gattung Torpedo in ihren naturhistorischen und antiquarischen Beziehungen. J. F. M. v. Olfers, Trans. Berlin Academy, 1831, pl. 3, fig. 3.

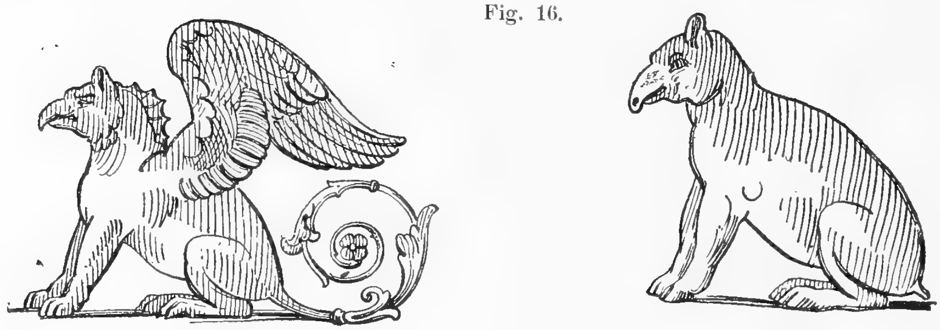
† Rawlinson, Five An. Monarchies, etc., *l. c.*

‡ Layard, the Monuments of Nineveh, *l. c.*

§ Roulin, M.—Ann. Sci. Naturelles, 1829, vol. XVIII, pl. 5.

‖ Etruria, I, 220.

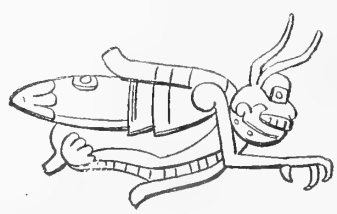
Fig. 16.



Roulin's Tapir-Griffin.

destructiveness in the griffin, and that its several parts were representative of aërial with terrestrial rapacity. After the same manner the hippichthys, was held to be a union in the flesh of the earth and the sea—an amphibious art-form denoting a soul in a state of transition. However much the spirit of speculation may enter into our attempts to interpret such symbols, of this, there can be no doubt, that many of them in their purer forms clearly expressed complex ideas.* Ferguson in speaking of the Turanians (*i. e.*, the central western Asian races), remarks: "With them it is not sufficient that a God should be colossal, he must be symbolical; he must have more arms and legs, more heads, than common man; he must have wings and attributes of power, or must combine the strength of a lion or a bull with the intellect of humanity." "We cannot," says Montaigne, "couple common faculties, such as our own, with the other faculties that astonish us, and are so far out of our sight. Therefore it is, that we give such savage form to demons; and who does not give Tamerlane great eyebrows, wide nostrils, a dreadful face, and a prodigious stature, according to the imagination he has conceived in us, by the report of his name?" Here is the motive which accounts for much apparent extravagance. As closely allied to the foregoing, may we not find in the wild and otherwise almost expressionless combinations of the Aztec paintings a faint meaning suggested by clearer methods? The curious composition of a death's-head and insect *might* resolve itself into a symbol of the leaf-devouring locust.† (Fig. 17).

Fig. 17.



Composite of Aztec design.

* Hist. of Architecture, Ferguson, I, 51.

† Codex Viennensis, Kingsborough Coll., pl. 1.

The hypothesis of Ehrenberg* that the Sphinx-head was derived from that of the baboon is ingenious if not in full harmony with the theory of Birch† that this mystic form is of Indian origin—and is part of the primeval stock of "dæmons of terrific form, who roam as bears and lions through the vast forest, or rest in the mountain's caverned sides." The figure of a leonine monster, common among Chinese wood-carving, is undoubtedly a lion, as can be seen by comparing it with the *Sinhas* of the Hindoo-Buddhistic ornament. It is a noteworthy fact that the flank of this image is marked by a stellated figure, almost identical with an ornament similarly placed in the Hindoo Sinhas, in the Assyrian lion (Layard, pl. 131), in the Moslem animal figures (Murray, xlviii), and in the Egyptian lion (Lepsius, A, vol. II, pl. 89).

(*h.*) *The Zoo-Myth.* It would be an error to suppose, however, that "monsters," either by addition of parts like unto themselves, or of combinations of diverse natures, are of necessity symbolical. Many of these have doubtless originated through misconception of the shapes of little known animals.

What we may term fabulous animals in the proper sense of that term, that is those drawn up from fabulous accounts,—may be placed in this division of conventionalisms. We can readily explain their appearance in art by one word—ignorance.

A migrating people no longer content with the products of their own land, and endeavoring to secure advantages by incursions into another, would naturally encounter many novel forms of life. The more striking of these would be accredited to the miraculous or the monstrous. Shapes when thus once established, might persist for an indefinite time and serve in their turn to furnish models for yet another series. When we recall the narrow limits which sometimes separate faunæ, as for example the deep channel of but fifteen miles in width, which flows between the islands of Bali and Lombok, and serving as the boundary between the Indo-Malayan and the Austro-Malayan faunæ,‡ or what is better known, though less distinctive, the narrow Dardanelles, which divide the Asian from the Mediterranean life,—it is a matter of surprise that figures of exotic forms are not more frequently seen in the primitive art record.

What will apply to the invader is true of the invaded, conceding of course that a people thus encountered, is sufficiently advanced to embrace the opportunity of enriching its own designs. In an Esquimaux drawing in the National Museum of Washington, we find recognizable figures of the reindeer, along side of a monstrous outline significant of nothing that is on the face of the earth, or in the waters under

* Ueber den Cynocephalus und den Sphinx der Egyptien, etc., Trans. Berlin Acad., 1834.

† Birch, Egyptian Antiq., I, 226.

‡ The Malayan Archipelago, Wallace, 45.

the earth. Lubbock,* in speaking of similar outlines, ascribes their origin, very happily we think, to the figure-head of some vessel which had been seen by the native artist.

The ship itself may become a part of the mythic system, if we are to credit the following,—which is thought to refer to the first remembered appearance in the Euphrates, of ships from a civilized country, and of the introduction into Chaldea of the arts of civilizied life:† "In the first year there appeared an animal destitute of reason, by name Oannes, whose whole body was that of a fish with feet also similar to those of a man. * * * This being was accustomed to pass the day among men, * * * and when the sun was set * * * retired again to the sea, and passed the night in the deep." We have abundant evidence that ships have at all times impressed coast-haunting tribes with wonder. The Aztecs‡ called the vessels of Cortez "water-houses," and faithfully recorded after their fashion, every particular concerning them.§

As an illustration of the difficulty encountered by an artist in representing an object with which he is not familiar, we may cite the following:

It is well known‖ that when the Spaniards under Cortes landed on the coast of Mexico, they were subjected to delays prior to their march to the capital. During this time some of the natives hovering about the invaders, were observed sketching. Fac-similes of these drawings are to be found in the Kingsborough Collection.¶ We find among them figures of the soldiers, priests, ships, horses, etc. The artists had apparently no difficulty in representing the warrior and the priest, for they differed from their own people only in color and costume. But the horse had evidently puzzled them. It was a novel shape, and their conventional lines were not mobile enough to receive it. It was natural, under the circumstances for them to represent it as a puma (Fig. 19), for this figure they had repeatedly drawn. This puma-headed horse might well have stood for some such expression as the following, had written language been employed: "The soldiers are in part mounted upon strange animals, whose necks and tails are furnished with long hair, and whose single toe-nail of each foot is encased in a stone-like shoe." Afterward the horse was more

* Prehistoric Times, p. 570, new edition.

† Prehistoric Nations, Baldwin, p. 186.

‡ Conquest of Mexico, Prescott, I, 304.

§ Sir Walter Raleigh, following the prevalent belief of his times, thought that dog-headed men inhabited El Dorado, *i. e.*, the Valley of the Amazon. Humboldt says of this statement, "that it was a gigantic lie." Kingsley (Miscellanies, Ticknor & Fields, 1859, p. 31) remarks that they were probably Indians, wearing animal masks, probably from the Aguara-head.

‖ Conquest of Peru, Prescott, I, 304.

¶ Codex Reminensis, pl. 32.

Fig. 19.

Fig. 20.

Mounted Spaniards of Aztec Design.

accurately drawn (Fig. 20).* Now let it be supposed that the Spaniard immediately after this incursion had withdrawn from the coast—is it not possible that the puma-headed figure would have passed into the traditions of the Aztecs as a fabulous visitor? Nor is it asserting too much to say that under similar circumstances a Centaur-like myth might have thus sprung into existence; for we are told that the horse excited great alarm in the minds of the Peruvians upon witnessing the Spanish cavalry dismount; "these simple people thinking that the rider and the horse were one."†

(*i.*) *The Errors of Naturalists in depicting Animals.* In proof of the manner in which figures of exotic animals may undergo modifications, even when drawn for zoological purposes, we may allude to the history of the Walrus as given by Gray‡ (Fig. 21). Surely this figure is no more than the merest dream-portrait of *Trichetus*,

Fig. 21.

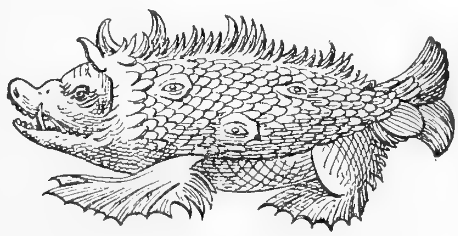


Figure of Walrus, after Olaus Magnus.

yet it was at one time, no doubt, a fair diagrammatic expression of what was known of its proportions.

Parè§ has given us an illustration of a combat between an elephant and

* Codex Bodleianæ, Kingsborough Coll., pl. 41.

† Conquest of Peru, Prescott, I, 254.

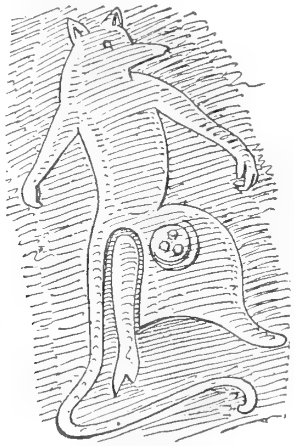
‡ Attitudes and Figures of the Morse, J. E. Gray, Proc. Zool. Soc. of Lond. 1853, p. 112.

§ The works of that famous chirurgeon, Ambroise Parè, (Trans.) London, 1649, p. 45.

a rhinoceros. The animals are placed in most amusing attitudes. The elephant with tusks pointing upward as in the above figure of the walrus, advances with lowering head, using his proboscis as a weapon of offense.

The description and figure of the opossum* (as we interpret it) given by the

Fig. 22.



Didelphian Mammal from Incarian design.

same writer, is worth mentioning in this connection. The absurdity of the elaborate figure of Gesner, from whom Parè quotes, is only equaled by the fidelity to the idea preserved in the rude and unembellished outline (Fig. 22), of the opposum-like animal drawn by a native artist. One of the most curious of all mal-constructions is found in Aldrovandus.† It is the figure of a saw-fish, given as a cetacean, with the saw in the position of a horn projecting forward from the middle of the head (Fig. 23). It is an easy task to explain these absurdities. They are all dependent

Fig. 23.

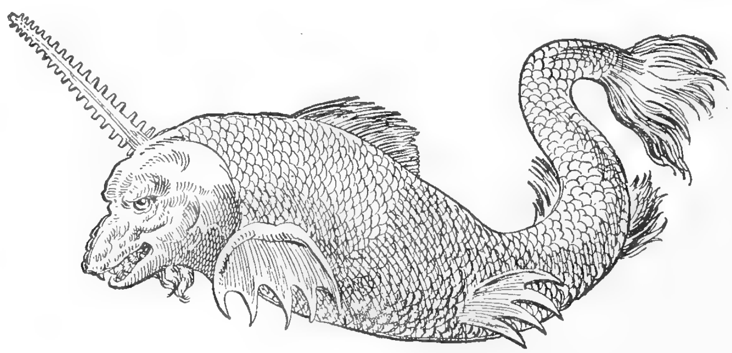


Figure of Saw-Fish, after Aldrovandus.

upon attempts either to reconstruct an entire figure from a fragment,—or in endow-

* Kingsborough Coll., IV, (Dupaix), (Incarian box-lid.)

† Aldrovandus, Pisces, p. 695.

ing an animal which is of unknown habits with functions in harmony with those familiar to the writer. The walrus and elephant tusks, and the saw-fish's maxillæ doubtless found their way to European museums long before the illiterate traders who brought them, could give any other accounts than those into which their imagination largely entered. The naturalist would draw the tusks of the walrus and elephant in the position of the wild boar, the only animal he had ever seen which possessed such appendages.

Akin to the above are the numerous examples which crowd the zoological record of errors of identification of actual forms. For the explanation of the fact that Aldrovandus* described the shriveled skin of a plagiostomatous fish as the remains of a dragon (Fig. 24), we have only to look over the distorted specimens

Fig. 24.

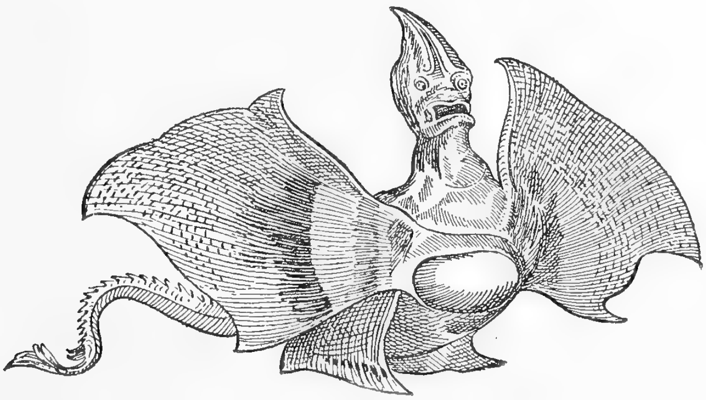


Figure of Ray, after Aldrovandus.

of every ichthyological cabinet. We could fill many pages with this kind of illustration, but will content ourselves with referring to one of the most curious of them. Leibnitz, who was gifted with a marvelous intellect in which it has been said, "mathematics and moral philosophy, history and philology for the first time found a common seat," was so far led astray as to describe the bones of a rhinoceros as those of a unicorn, and to attempt to restore them in normal position (Fig. 25). The tusk in this figure evidently did not belong to the rest of the skeleton. "This skeleton of the unicorn was found," says he, "with the hind part of the body reclining as is usual with animals, but the head elevated, bearing on the front a long extended horn of nearly five cubits, of the thickness of the leg of a man."† That a fossil unicorn had existed in past times, when, in common with all cotemporaries, the author believed that a unicorn was to be found in Abyssinia, was after all a natural

* Aldrovandus, Pisces, 316.

† Physicam Generalem, Chymiam, Medicam, Botan. Histor. Natur. etc., 1778.

Fig. 25.

A restoration of the Unicorn, after Leibnitz.

inference. It is the first step that costs ; once having accepted the existence of the unicorn, the rest was easy.

Even when an actual animal is described,—often figuratively, never faultlessly, —is there not a wide margin left for error to roam over? In a scientific sense, the hippopotamus described by Herodotus,* as having the hoof of an ox, and the mane and tail of a horse, is of course absurd; in an artistic sense, a quadruped thus hoofed and maned would be simply monstrous. The intention of Herodotus to convey the notion that the hippopotamus was an animal combining ox and horse-like characters was certainly successfully carried out by the use of figurative expressions, which, so far from suggesting a portrait of the creature itself, would directly mislead.†

* Swayne's Herodotus, 50.

† There is a curious example of this kind of misinterpretation in Retsch's outline drawings of Gœthe's Faust. In the first scene with Mephistopholes a poodle (which contains, as a "nucleus," the essence of the demon) undergoes transformation.

"Faust. Er hebt sich mit Gewalt !
Das ist *nicht eines Hundes Gestalt !*
Welch ein Gespenst bracht' ich ins Haus !
Schon sieht er wie ein *Nilpferd* aus,
Mit feurigen Augen, schrecklichem Gebiss."

Retsch draws as appearing before the eyes of the astonished Faust, not a hippopotamus, (Nilpferd) but an enormous poodle.

Section VI. *The Dragon.* The myths which have been grouped under the name of "dragon," are of such diverse character, and have been through so many ages associated with popular fancies, that we have thought it of interest to give some account of its possible origin and meaning.

The Asiatic dragon is evidently a very different form from the European. At least the "fabulous animal" of Chinese and Japanese ornament, is based apparently on the salamander type of body, with bird-like feet. This is well shown in recent examples of this design upon Japanese bronzes. The heads are more nondescript, and are furnished with some piscine characters, such as barbels, and an outline suggesting the catfish-like fishes found in the waters about Japan. The early form of the European dragon, according to Aldrovandus (*l. c.*), is probably based upon the lizard type. It is scaled, and has a well-marked lacertilian body, and, it may be a mammalian head. The tail and neck are often those of a serpent. The artistic interpretation of the dragon varies from the realistic forms of Durer, who, in his St. George, favors us with a very fair zoological figure of a lizard, through the humanized bat-winged outlines of Giotto, to the curious compound of owl and serpent of Lucas v. Leyden, and the equally odd combination of man and insect of Martin Schœn. There is no doubt that much of this kind of work is purely whimsical. It is quite impossible to surmise with any nearness to truth what the models were like from which they sprung. The combination of parts sometimes suggests that rapacity was always intended; and at least in the latter forms of the myth it has been the symbol of oppression and cruelty.

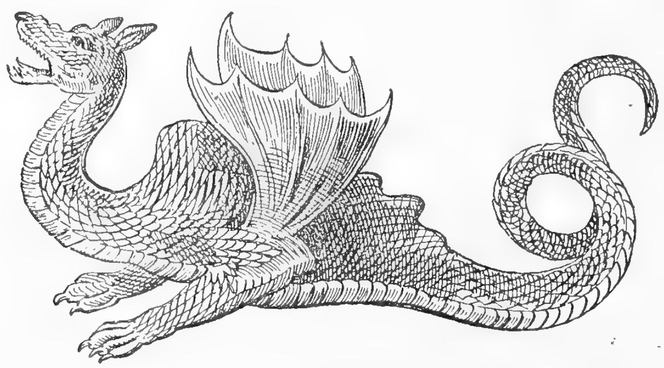
In a very curious pamphlet* preserved in the library of the Academy of Natural Sciences of Philadelphia, an elaborate effort is made to prove that the dragon was extant at the latter part of the last century. From a vast amount of evidence the author favors us with the following description of this animal: "The dragon is from eight to nine feet long, rarely more. Its color varies; commonly red, it is at times of a black or ash color. The heads of some individuals are crested, and the jaws are furnished with sharp teeth. The mouth can be opened to an extraordinary extent. The wings, which are without feathers and resemble those of a bat, maintain flight with some difficulty. The body is covered with scales of such strength that they have resisted balls. The strength of the dragon is such it can engage the eagle and the elephant to advantage. The tail is no less feared than its mortal bite. It is used with success in squeezing the prey, or striking it when thrown to the ground."

The congruity of parts expressed in such a creature, which is "neither fish, flesh, fowl, nor good red herring," was probably prominent with those who have a lingering

* On the History of the Dragon. C. L. M. Dorfeuille.

belief that the origin of the dragon is to be found in the remnants of the paleozoic world "where," in the language of Thackaray, "mighty monsters floundered through the ooze—and dragons darted out of the caves and waters before man was made to slay them."* Mr. Waterhouse Hawkins, the well-known scientific artist, entertains the belief that the dragon is a reminiscence of an extinct reptilian shape, noticeably the Pterodactylian type. We cannot agree with him in such a conclusion. The form of the dragon is not a fixed one, and its varieties can better be accounted for by reference to familiar models than in seeking figures among such absolute novelties. Amid all the combinations making the dragon, the idea is cramped and limited. He is a mere piece of of patch-work—a monster by addition—each portion, when dissected, turns out to be an old acquaintance—here a bird-foot, there an owl's head, or a serpent's tail. Indeed who could expect man to have reconstructed to such suggestive forms the impression of a Pterodactyl, possibly received from a fossil! Surely after the blunder of a Leibnitz, we may well declare the average man of the Middle Ages, if not of an earlier time, disqualified to testify on such a topic. To say that by coincidence man may have invented a "fabulous creature" like unto those that have lived in the past, is to make an assertion which cannot be supported. Man has never invented a single artistic figure. He has analyzed and infinitely re-arranged the integers of organic form, but he has never in all his vagaries or in his groupings after truth struck out a new form.

Fig. 25.



Dragon, after Aldrovandus.

*Prof. E. D. Cope (Synop. of the Batrach. and Reptilia of N. A. Trans. Philo. Soc., Phila., 1870, 182) remarks that the "restored figure of Mosasaurus is not badly represented by old Pontoppidan's figure of his sea-serpent, and that in this group of reptiles we almost realize the fictions of snake-like dragons and sea-serpents in which men have been ever prone to indulge."

PART II.

The Study of Variants.

Section I. *General Remarks.* Mr. Tylor in his work on Primitive Culture has treated of the several articles composing the armamentarium of early man as species. Thus the hatchet is a species, so are bows, arrows, etc. We have taken a hint from this and believe it to be instructive to call the forms of life of the art-record "species." The range within which they are encountered may be termed the limits of distribution, and the forms in this way included, as the faunæ or floræ respectively. The Asio-European lion, for example, has a distribution from Chaldea to Western Europe. Its varieties have established themselves along the route of man's migration and are seen to vary in style from the Chaldean to that of the modern stone-cutter. It is convenient to push the comparison between an archæological and a zoological process yet farther and name the ways by which a given species may be represented as *variants* of that species, adopting a term already employed by Bunsen in his researches among the Egyptian ideographs, and by Abbe Brasseur de Bourbourg among the Aztec.

This history of an art-species is in some cases almost as definite as that of the people of whose remains it constitutes a part. It is evident, therefore, that the study of variants should go hand in hand with chronology. With it, we can trace with ease their mutations and prove the order of their succession; without it—the premises falsely assumed—imagination may select the forms and specious reasoning determine their positions.

But are we on that account to restrict our studies to cultured races? No, if we can find standards of comparison among the forms themselves; and as the zoologist seeks for standards by which to classify living objects, so the student of art, we hope to show, can secure in the art remains of a given people certain *types* of construction. These may be in harmony with chronology; and if so, their value is doubtless increased. But even without this aid we believe they can be made interesting. In proportion as the material for the elimination of such types is more or less complete, so will the types themselves be more or less accurate, a conclusion again in exact harmony with the results of the naturalists' method. In a word we propose to study the animal form in art as though it were a natural form, employing chronology, when we can, as an accessory of acknowledged value.

In studying variants we propose the use of the following terms:

The primitive designs found in painting, etc., we term *primals.*

The final forms resulting from a series of variants starting with the primals we term *ultimates*. By divergence of variants from the primal stock (one to the letter type, and the other to the realistic) we must have to every primal two ultimate forms.

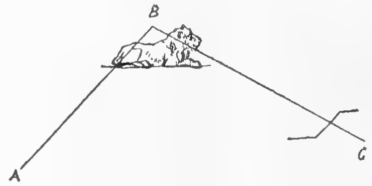
By a *radical* is meant that figure which preserves the essential lines of a natural series of variants. It is best seen in forms leading to an ideographic system. The difficulty of distinguishing a primal from the equally naked and unsuggestive letter-ultimate is apparent, and without aid from another source is often impossible.

Radicals will necessarily vary according to the method of execution. The parts which are produced with the greatest ease are naturally those which persist in the process of reducing a complex form to its simplest expression. In drawing, stress will be laid on the *lines*; in moulding, the lines will be subordinated to the general figure, as shaped by the figures. The picture radicals will thus differ from fictile radicals, as also will architectural and numismatic radicals. Neither should it be forgotten that to the females of many tribes has the work been allotted of ornamenting the pottery and other articles, while the recording of exploits, etc., has been reserved to the males.

In presenting a number of variants from a few types of life we propose the following method:

A radical will be taken, which has been developed through many variations from, a primal form. The time required to have accomplished this is, in every instance, unknown. We must assume from what we see in the art of savages that in figure-making, as in everything else of man's creation, there has been an ever-active though gradual process of evolution at work; and that in the primals of an art series this has but begun. Neither can we form any idea from contemplating the ultimate expressions of forms belonging to old and cultured races what their crude primals may have been. Such imperfections of the art-record compel us to take the radical as it is presented and trace from this the most probable ultimate rather than to take the ultimate and trace it back to its radical.

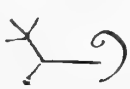
Let us accept A to be a primal, and B an ultimate, and C a radical. We cannot



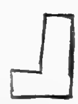
conceive the Egyptian lion at B, to have sprung at once into a realistic ultimate, but rather that it has been evolved from the unknown primal at A. And we infer that C is a letter-type abridgment of B, a descent from the completeness of the artistic figure, but nevertheless a sequence of it. The natural order of the comparison would be from B to C, the chronology being given. But we think it may prove more interesting in reviewing the entire range of art—in many portions of which we have no literary complement—to present the problem and seek the solution rather than to give the solution and create the problem.

From the study of variants, the following conclusions may be drawn:

(1.) That the conditions determining the forms of variants must be exceedingly diverse. A full series may be confined within the space of a sheet of manuscript—as is often the case in the Dresden Codex, or (as may be seen) in the ornamentation of a batch of earthen pots of the same baking. On the other hand, a series may extend through the entire art-range of a given people—and taken many years to have completed.

(2.) That it is necessary to remember that in some phases of variants, a single feature will be selected from a complex form and serve as the basis of a distinct series of changes. Thus the curve of the open mouth of the serpent seen in profile, and the rattle at the end of its tail, are often dismembered from the rest of the trunk, as though they were parts of a mosaic, and allowed to exist separately. The occurence of this dismemberment proves that the type is not concrete. One cannot imagine the Egyptian sign  (priest) being rendered by either  or  for one is as essential to the other as a cross is to the letter *t*. When, in speaking of a form, like the genus Hydra, which permits self-division, a likelihood exists of the severed parts surviving, a low type of organization is thereby implied.

(3.) As one in studying the water-lily, finds the petals gradually turning into stamens as he passes in observation from the margin to the centre of the flower, so we find strange transitions occuring in the many-times repeated objects of early art; transitions so strange that unless we carefully observe them we would have declared them to be improbable.

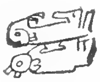
(4.) In Aztec design so vast is the labyrinth of shifting form, so slight the thread of consistency that guides us through it, so cumbersome, whimsical and tasteless, is much of its ornament, that it is no wonder that we are occasionally puzzled, and sometimes defeated in our attempts to identify its objects. The outline  for example, may stand for a human leg, a hand, and a human face seen in profile. In some instances we have been unable to name outlines, and guessed only at others. The latter we have withheld from the series illustrating Aztec design, and can conscientiously say of such what Prescott* would say of the whole,

* Conquest of Mexico, I, 104.

that "the fantastic forms of hieroglyphic symbols may afford analogies for almost anything."

Fig. 26.

Associated variants of parrot, Dresden Codex.

(5.) The often repeated signs of apparently the same value, so common in Aztec art, must express a repetition of the same idea. Were it otherwise, the ideographs would degenerate into the figures of a pattern. We must acknowledge that repetition is often a law of force. Such expressions as "Hail, hail, hail, Macbeth!" and "Holy, holy, holy, art thou Lord of Hosts!" are strengthenings,—the result of unions of simple factors. After the same method the parrot-head sign  of the Dresden Codex is emphasized by  as though the meaning were: "Great, great, is this symbol." But in a zoological sense repetition of similar parts—or, as it is technically termed, "vegetative repetition,"—is an evidence of low organization. An idea when repeated through its symbol is thereby emphasized, but when a form or part of a form not symbolic, is repeated, it remains the same, or exists with impaired vitality. Should this reflection prove true, we may determine the value of certain variants by their positions and number as well as by their form.

Before entering upon the subject of variants, a series of ultimates may be sought for among the higher phases of art-portraiture, the members of which may be termed "types." Thus the following ultimate forms of lion-heads of Asia, Egypt and Europe, are presented as art-types, many of which have never sat as models for lineal abridgments, or radicals.

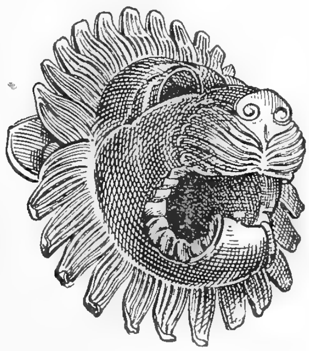
The full-faced Lion Head with muzzle lines. This series is designed to exhibit the style of lion-head marked by pronounced labiate or muzzle lines.

Lion with muzzle lines.

Fig. 27. (*)

Roman.

Fig. 28. (†)

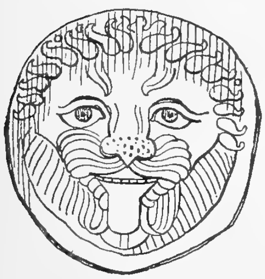


Etruscan.

Fig. 29. (‡)

Roman.

Fig. 30. (§)

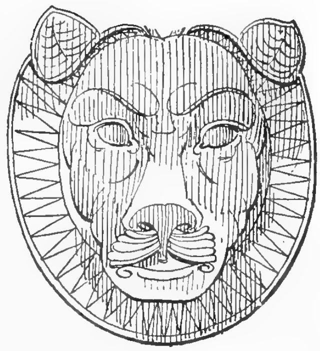


Etruscan.

Fig. 31. (‖)

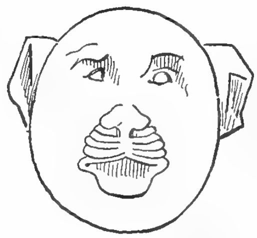
Greek.

Fig. 32. (¶)



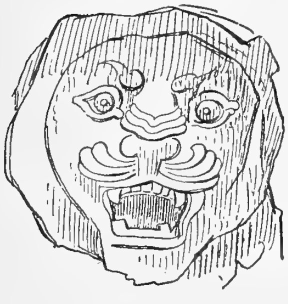
Egyptian.

Fig. 33. (**)



Egyptian.

Fig. 34. (††)



Assyrian.

Fig. 35. (‡‡)

Assyrian.

Fig. 36. (§§)

Persian.

* From a Roman sarcophagus.
† From an Etruscan bronze at the Campodoglio.
‡ Mus. Borbonico, VIII, tab. 61.
§ L'Italie avant la domination des Romains, M. J. Micali, Paris, 1826, pl. 92, 2.
‖ Mus. Borbonico, LXII, fig. 2.
¶ Hirt. Trans. Ber. Acad., 1821, pl. 4, fig. 35.
** Birch Selections of Egyptian Art in British Museum.
†† Botta, Monuments de Ninive, IV, pl. 151.
‡‡ Botta, Monuments de Ninive, II, pl. 47.
§§ Flandin et Coste, Voyage en Perse, pl. 102.

The Profile Lion Head. In a series of profile heads confined to Western Asia, it is probable that Fig. 37 was derived by abridgment from a model such as Fig. 41, or even 42, permitting Fig. 40, an Etruscan form, to come between. The pertinence of an Etruscan outline in a series of this kind, may be doubted by many. Is the resemblance between these heads any less exact than between many figures of Etruscan and Persian, and even Mesopotamian art, as seen in Micali and Lajard?

Fig. 37. (*)

Fig. 38. (†)

Fig. 39. (‡)

Fig. 40. (§)

Fig. 41. (‖)

Fig. 42. (¶)

In a second series of profile heads selected from Persian and Etrurian sources, we hope that the order of the figures, and the references at the bottom of the page will serve for sufficient explanation. It is highly instructive that the ultimate (Fig. 49) is the source of the abridgment (Fig. 43). At first sight, it would appear absurd to associate a Persian outline with another in Etruria. But a comparison between many figures of Inghrami, Micali and Lajard, must convince the observer that more than a superficial resemblance exist between Persian and Etruscan figures, however, the historian may explain it. And we assume from what we have seen in the lion heads (Figs. 28 and 30), as well as from the series to be presented, that the art-forms of Etruria were moulded upon types which originated in Asia and Egypt.

* Travels in Georgia, Persia, Armenia, Babylonia, &c., Sir R. K. Porter, Lond., 1821, opp., p. 424.

† Culte dè Mithræ, F. Lajard, pl. 37.

‡ Lajard, *l. c.*, pl. 25, fig. 6.

§ Micali, *l. c.*, pl. 24.

‖ Rawlinson, Anc. Mon., *l. c.*, III, 334.

¶ Layard, *l. c.*

Fig. 43. (*)

Fig. 44. (†)

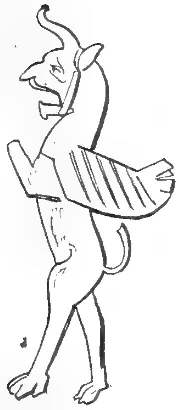


Fig. 45. (‡)

Fig. 46. (§)

Fig. 47. (‖)

Fig. 48. (¶)

Fig. 49. (**)

The transition is from hair-tuft 43 to Fig. 46, and from that to the horn of unicorn-like figures, Fig. 47 to 49.

The Greek Lion-Head. It is very evident from the above groupings of lion-heads, both full-faced and profile, that it would be a difficult matter to select any one head from the forms of a given art-fauna and proclaim for it representative features. Thorwaldsen, we are informed by his biographer, M. Theile, in modeling the lion-head for the Lucerne monument, carefully studied the antique form and the modern styles derived thence. (Fig. 50.) In another design of the same animal he as

* Lajard, *l. c.*, pl. 27.

† Lajard, *l. c.*, pl. 19.

‡ Flandin et Coste, Voyage en Perse, Paris, 1844, pl. 69.

§ An. Mon., Rawlinson.

‖ Lajard, *l. c.*, pl. 43.

¶ Lajard, *l. c.*, pl. 13.

** Inghrami, *l. c.*, II, pl. 158.

Fig. 50. (*)

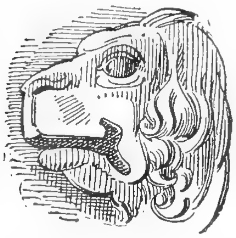
Thorwaldsen's lion, after the antique.

Fig. 51. (†)

Thorwaldsen's lion from nature.

carefully studied the natural model. (Fig. 51.) These two heads, therefore, are very fair examples of a conventionalized and natural art-form. The distinctions presented in the two figures are so great that comment is unnecessary. We allude to the subject to contrast Thorwaldsen's conception of the antique head with that of Ruskin's. (Fig. 52.)

Fig. 52. (‡)



Modern Lion-head.

Fig. 53. (§)

Lion-head, after Caylus.

Fig. 54. (‖)

Lion-head, after Hamilton.

This critic claims for Fig. 52 (to condemn it), that it represents a modern conventionalized lion-head treated after the Greek method. It surely belongs to the variety of the lion without muzzle lines which is not the typical Greek head, but rather an aberrant expression not often seen (Fig. 53), and is best marked on the vases—the source perhaps of the "reconstruction," criticised by Mr. Ruskin.

The Palm-Tree.

Section II. *The Palm-Tree.* The palm-tree is one of the most conspicuous figures in the art of Western Asia, and the countries bordering upon the Medi-

* Thorwaldsen and his works, edited by J. M. Theile, Trans. by Sindling, N. Y., 1869, II, pl. 108.

† Ibid, II, pl. 153.

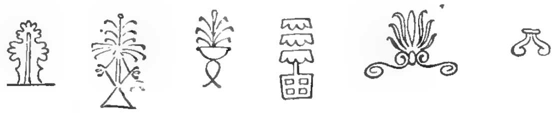
‡ Lectures on Art and Painting, John Ruskin, 1854, pl. 11, fig. 18.

§ Recueil d'Antiq. Egyptienne, Estrusques, Greques, et. Romaines, Caylus, Paris, 1761–67, I, pl. 56.

‖ Hamilton, Sir W. A collection of Etruscan, Greek and Roman Antiquities, London, 1797.

terranean Sea. Among the variants we have ventured to assign to this origin, there are at least six, which at first sight have no connection with one another:

Fig. 55.



A. (*) B. (†) C. (‡) D. (§) E. (‖) F. (¶)

(A.) The Sacred Tree of Assyria.

The *first* is seen upon the head-dress of Babylonian figures, and would appear from the following sequence to be a miniature representation of the Assyrian Sacred Tree.

Fig. 56. (**)

Fig. 57. (††)

Fig 58. (‡‡)

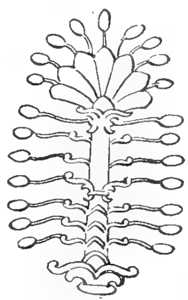


Fig. 59. (§§)

(B.) The Palm-Tree proper.

The *second* is a figure of the entire tree found upon a cylinder and securing for us through two variants, an origin in the conventional palm of Persia.

* From dress of Babylonian king, Rawlinson, Five An. Monarchies, III, 400.

† From Babylonian cylinder, Sabæan Researches, John Landseer, Lond. 1823.

‡ Egyptian hieroglyphic "Bunch of Dates," Bunsen, I, 521. This figure has not been faithfully rendered. In the main features, however, it is correct.

§ Persian figure upon coin. Wilson, Antiquities and Coins of Afghanistan, pl. 15, f. 23. The central shaft should unite all the transverse pieces. Prof. Lesley believes this to be of Egyptian origin.

‖ Greek honeysuckle ornament. Hope's Ancient Costumes, I, 72.

¶ Ornament upon Etruscan tablet. Dennis, Etruria, I, 52.

**-†† Same as fig. 1, from lower border of the king's dress.

‡‡ From Layard, *l. c.*, Rawlinson, ibid., II, 235.

§§ The Assyrian Sacred Tree, Layard, Nineveh and its Remains, II, 233.

Fig. 60. (*)

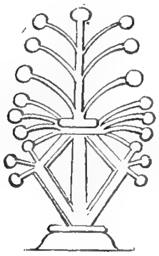
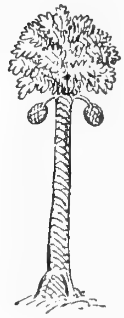


Fig. 61. (†)

Fig. 62. (‡)



(C.) The "Bunch of Dates."

The *third* bears in many respects resemblance to the above figures. It, however, is from an Egyptian source. It stands alone; no forms intervening between it and the Mesopotamian model aid us in its identification. Chronology here comes to our assistance. It is described by Bunsen as the bunch of dates.

(D.) The Greco-Persian Palm.

In the *fourth*, found upon a Persian tomb, we have an ultimate which may have originated in the transverse lines of Fig. 61. Development of this feature of the palm-tree illustration is conspicuously seen in Fig. 64; also of a Persian source,

Fig. 63. (§)

Fig. 64. (‖)

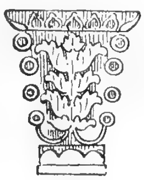


Fig. 65. (¶)

acquaintance with which introduces us to the elaborate and characteristic ornament of ancient Persia, Fig. 65, where the model is much disguised by Greek accessories. It is interesting to notice that this development, based as it is upon the acanthus leaf

* Same as B. Fig. 55 (enlarged).

† Persian palm-tree. Rawlinson, ibid., III, 342. See also Rawlinson I, 433.

‡ Persian palm-tree. Rawlinson, ibid., IV, 322.

§ Wilson, *l. c.*

‖ From Persian ornamentation. Travels in Persia, Porter.

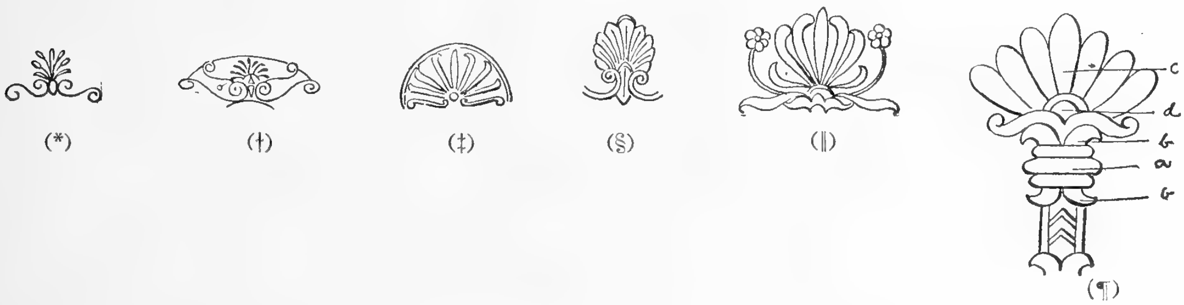
¶ Ibid., pl. 62. For the sake of convenience, but one half (the left) of this symmetrical design has been figured.

and bud, is here engrafted upon a purely Eastern stock, and yet preserving a curious mimetic relationship with the florid leaf and vine design so common in our own decorations, and which, as is well known, is almost exclusively of acanthian origin.

The remaining ultimates, *fifth* and *sixth*, find their respective models as *portions* only of the conventionalized palm. Thus the objects of Fig. 65 are derivative of the foliage of the Assyrian palm, while those from 65 to 73 inclusive are obtained from the so-called "ram's horn" of the Assyrian Sacred Tree.

(E.) The "Honeysuckle."

Fig. 66.



a, transverse bands; *b*, *b*, "ram's horn;" *c*, rays; *d*, base of rays.

The first four of these outlines are examples of the honeysuckle ornament which is so largely represented upon articles of Greek workmanship, and from these copied into later European art. No one design is more frequently seen. Under many graceful modifications we meet with it over our door-ways and upon the cornices of our dwellings and public buildings. It enters into our patterns of woven stuffs and wall papers. It is well nigh the universal basis for symmetrical design. One of the most striking of its modifications is the shell and acorn ornament abundantly used by Michel Angelo, on the ceiling of the Sistine Chapel at Rome.

We are indebted to Layard** for our knowledge of the influence exerted upon Greek design by the Assyrian monuments. According to this writer, the "similarity between the Assyrian and Greek ornament is not accidental. * * * It seems to be proved beyond a question, by the alternation of the lotus or tulip,†† whatever this flower may be, with the honeysuckle. * * * The same ornament occurs in India on a lath erected by Asoka, at Allahabad (about B. C. 250); but whether introduced by the Greeks—which, from the date of the erection of the monument, shortly after the Macedonian invasion, is not improbable—or whether derived from another source, I cannot venture to decide."

* Ornament on cuirass, Hope's Anc. Cost., I, pl. 72.

† Ibid., I, pl. 75.

‡ Layard, Nineveh and its Remains, II, 231.

§ Ibid., II, 231.

‖ Layard, from Allahabad. *l. c.*, 232

¶ Rawlinson, *l. c.*

** Layard, *l. c.*, II, 232.

†† We have ventured to call this caliciform.

(F.) *The "Ram's Horn."* While found together with much that is of Greek origin in Etruria, the honeysuckle variant of the palm is less frequently determined than that of the figure of the ram's horn. The point of greatest constancy here presented is the transverse band uniting a pair of horns which are so arranged that their convexities are opposed. In the model ¶ Fig. 66, this is conspicuous. In Figure 69 a single band is seen, as is also the case in the simple forms, Figures 67 and 68. The upper and lower portions of the horn-like figures are given in the last two of these; but the upper half of the design is absent in Figure 67.

Fig. 67. (*)

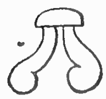


Fig. 68. (†)

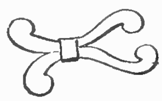


Fig. 69. (‡)

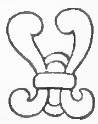


Fig. 70. (§)

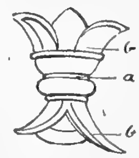


Fig. 71. (‖)

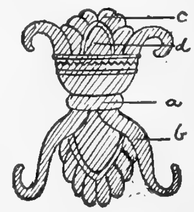


Fig. 72. (¶)

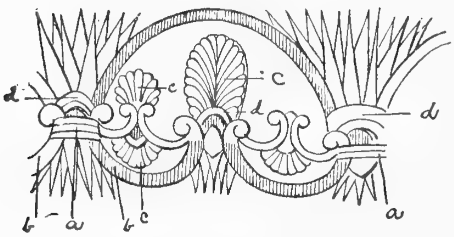


Fig. 73. (**)

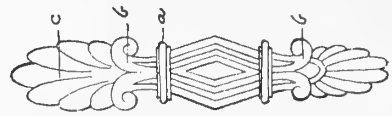


Fig. 74. (††)

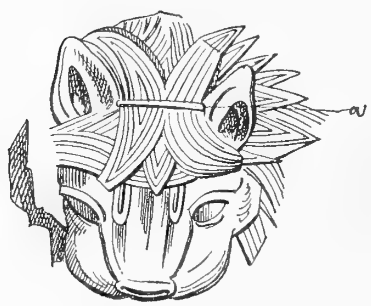
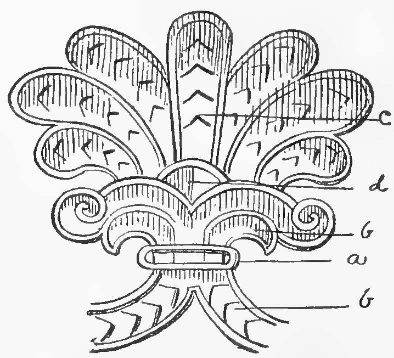


Fig. 75. (‡‡)



The lettering of Figs. 68 to 75 to be same as ¶ Fig. 66.

* Dennis, Etruria, I, 52.

† Dennis, Etruria, I, 52.

‡ Dennis, Etruria, 1, 52.

§ Micali, *l. c.*, pl. 73.

‖ Micali, *l. c.*, pl. 23.

¶ From ornament found at Praeneste. R. Garrucci, Archæologia, XLI, pl. 10, 206.

** Bone spoon found in Isis tomb. Dennis, Etruria, I, 424.

†† Ornament upon the head-dress of lion, found at Praeneste. R. Garrucci, Archæologia, LXI, pl. 5, 206.

‡‡ Ibid., with Fig. 21.

Fig. 76.

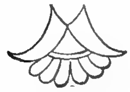


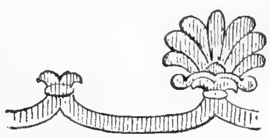
Figure 76 might also represent the lower half of either this (Fig. 70) or the one following, Figure 71. But here we are forced to remember the shape of the caliciform design found at Allahabad, Fig. 77, more particularly since no connecting band is seen in Figure 76.

Fig. 77.

Were the Asiatic model ever represented as duplicated above and below a given plane, which would thus serve as a base for both, we would feel inclined to refer Figure 70 to such. The absence of this band is in our judgment sufficient to prevent such reference. Were further defence of the position we have taken necessary, we could refer to the bisected ram's horn at base of Figure 58, which is almost an exact inverted counterpart of ultimate F. Fig. 55.

We conceive that the continuous ornament presenting the palm-tree foliage, so frequently met with in the remains at Nineveh, (Fig. 78,) is composed of the produced crescents of the ram's-horn figure turned upward from the vertical to a more horizontal position, while the upper of the three bands is alone retained.

Fig. 78.



In another variety of this ornament found at the same locality, we find that the fruit branches have been selected to give emphasis to the design. Thus Figure 79

Fig. 79.

is complete without the ram's horn appearing in any guise.

Now it is highly probable, judging from the designs here selected, that the Greeks choose for their continuous ornamentation (Fig. 80) the latter of these, viz., the fruit branches, while the Etruscans favored the former, viz., the ram's horn. (See especially Figs. 72 and 73.) In the first of these the larger crescents are apparently derived from an Asiatic source, while the smaller would claim for themselves a Greek origin.

Fig. 80.

Section III. *The Serpent.* We have abundant evidence that the serpent is an universal object of design with rude people, and a frequent one with advanced races. For consideration of this interesting subject we would refer the reader to the works mentioned below.* The radicals we have selected have been met with among the monuments of Central America and Peru. The motive which we assign to the artists of these countries for reproducing so frequently the ophidian shapes is easily found in their religion. Prescott† tells us that the serpent was an emblem common in sacred sculpture in Anahuac. The image of one of their deities was remarkable for the "huge folds of a serpent, consisting of pearls and precious stones which coiled round his waist." In the Aztec calendar the serpent typified time.‡ The most common representation of Quetzalcoatl was that of the serpent.

In Peru, in addition to the figure of the serpent being associated with images of the human form as attributes,§ it was at times of votive significance. When unable to procure an animal for sacrifice, such for example as the puma or serpent, the Peruvians offered a golden or silver image of the same.‖

We have in these statements sufficient reason for attempting to bring into a series of derivatives a few outlines which we may term *the radicals of the profile serpent-head.*

We find its variants scattered over tropical America in isolated inscriptions, in the florid picture-records, in the yet more obscure so-called hieroglyphic system, as well as discerned among the confusing elaboration of carved images.

* The Serpent Symbol, etc., E. G. Squier, New York, 1851; Myths of the New World, Brinton, *l. c.*; Tree and Serpent Worship, etc., Jas. Ferguson, Lond., 1868. Many other authorities might be quoted in this connection.

† Conquest of Mexico, II, 142.

‡ Ibid., I, 92.

§ Antiquities of Peru, Rievero, 107.

‖ Conquest of Peru, Prescott, I, 523.

The Radicals of the Profile Serpent-head.

Fig. 81.

A. (*) B. (†) C. (‡) D. (§) E. (‖) F. (¶) G. (**) I. (††)

Radicals of the Serpent-jaw from Aztec and Incarian sources.

Among these nine ilustrations which we have selected from the large number apparently of the same significance, we detect considerable dissimilarity. Yet they possess the common feature of presenting two more or less curved lines joined at an angle. Each of the outlines could be written without the pen leaving the paper. The angle is the result of a union between a vertically inclined member to one nearly horizontal. We will endeavor to show (in absence of a chronology, or the nomenclature of the artists themselves) that these signs represent the two main lines of the open jaw of the serpent-head seen in profile, and that they are as near letter-types, as it is impossible to be with figures derived from a protean model.‡‡

Fig. 82. (§§)

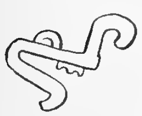


Fig. 83. (‖‖)

Fig. 84. (¶¶)

Fig. 85. (***)

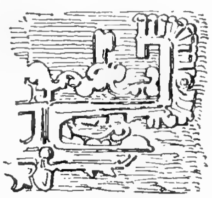
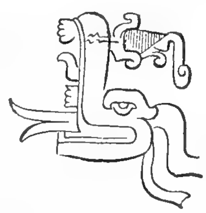


Fig. 86. (†††)



* Stephens, J. S., Yucatan, etc., 1843.

† Nicaragua, its People, Scenery, Monuments, etc., E. G. Squier, New York, 1852, II, 66.

‡ Ibid., 1852, II, 66.

§ Ibid., II, 66.

‖–†† From the Musca Alphabet, Humboldt, Vue de Cordilleras.

‡‡ Figure A of the above series although distinctive it is thought of the Aztec ophidian profile, is a natural curve and is seen elsewhere, in the art of various people, when it is desired to represent the open mouth of an animal. We find the same horizontal line representing the lower jaw joined to a curved upper jaw (the convexity of the curve standing for the fold of the upper lip overlying the tooth-line of the upper jaw) in Europe and Asia. See Archæologia XLII, pl. 17, 312, for the head of a panther or lion of the Saxon period.

§§ Incidents of Travel in Central America and Yucatan. Stevens, I, 1843, 309.

‖‖ Kingsborough Coll. (Dresden codex, 3d column.)

¶¶ Kingsborough Coll. (Dupaix.)

*** From photograph of Palencque cross ; see also Stephens, *l. c.*, II, 1842, 345.

††† Kingsborough Coll. (Borgian Codex.)

Fig. 87. (*)

Fig. 88. (†)

Fig. 89. (‡)

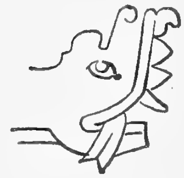
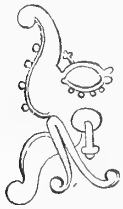
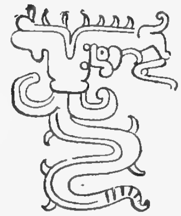


Fig. 90. (§)



(Fig. 91. (‖)

(Fig. 92. (¶)



Comparing the above series with the radicals we find that the first is evidently intended for the head of an animal, and that this figure gradually assumes a more snake-like expression until, in Fig. 92, we see an indubitable rattle appendage. That all the signs of Fig. 81 are derived from reduction of similar figures to those just given must of course be probable only. In our judgment it forms a probability that lacks but one degree of proof, namely, that derived from a fixed chronological status. This of course cannot be furnished.

Fig. 93. (**)

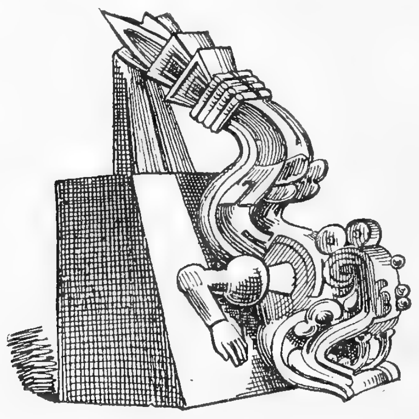


Fig. 94. (††)

* Kingsborough Coll. (Borgian Codex.) [1]

† Kingsborough Coll. (Borgian Codex.)

‡ Kingsborough Coll. (Borgian Codex.)

§ Voy. Pittor. et Archæol. dans la Province d'Yucatan, etc. Waldeck, Paris, 1838, pl. 13.

‖ From photograph of ruins at Monjas, Uxmal.

¶ Kingsborough Coll. (Dresden Codex, Col. 57).

** Six Months Residence and Travel in Mexico. W. Bullock, London, 1834, pl. 13.

†† Squier, Nicaragua, *l. c.*, 52 (from Zipatero).

([1]) In proof of the Crotalian significance of this form we add the caudal appendage : 

In Figures 93 and 94 (examples of a common variety in Aztec remains), we see the curves of the open jaw traced upon the side of a solid mass. There can be no reasonable objection to the conclusion that there is a close resemblance between Figure 93 of these series and the second of the radicals marked E, or between radical D and Fig. 94.

It is also more than suggestive that the apparently arbitrary design and others

Fig. 95.

found among an embarrassing fullness of illustration in the Borgian Codex (Fig. 95), represents the profile head of the serpent with the mouth partially closed. And may not the following figures have been suggested to a people who have been thoroughly acquainted with the profile lines already given?

Fig. 96. (*)

Fig. 97. (†)

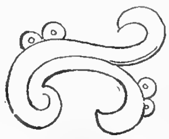


Fig. 98. (‡)

Fig. 99. (§)

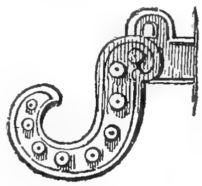
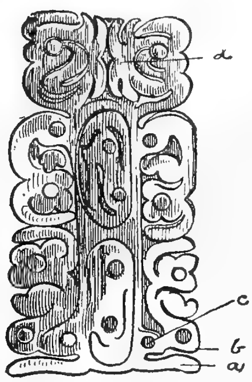


Fig. 100. (‖)

Fig. 101.



Symmetrical Snake Ornament, from Squier's Ancient Mon. of North America.
a, lower jaw ; b, upper jaw ; c, eye ; d, rattle.

Kingsborough Coll. (Tellerian Codex.)

† From portion of elaborate full-faced human head, Stephens, I, 1843, 170.

‡ Kingsborough Coll. (Borgian Codex,) p. 7 (human hand).

§ Stephens, *l. c.*, I, 171 (Architectural Ornament).

Kingsborough Coll. (Borgian Codex), p. 12 (pattern along a border).

Another serpentine form is seen to be the radical of the following sequence,

Fig. 102.

(*) (†) (‡) (§) (‖) (¶)

which may be called the series of the bound serpent. A third form belonging to the same group may possibly be indicated in the coiled serpent, which leads us to the figure found by Squier (Fig. 104) on a rock in Nicaragua,*

Fig. 103. (**)

Fig. 104. (††)

The Man.

Section IV. (A.) *The Head.* If among the forms capable of but a few expressions we find such variety, we may expect to meet in the human face with its increased motility a yet larger number. To understand their analyses, it is necessary to make ourselves familiar with the structures entering into the human face. The "countenance" of popular language answers to the facial region of the anatomist. The skull gives the main boundaries of this region, as well as valuable hints for its subdivision. It is clothed with muscles, which, surrounding to move the eyelids, nostrils and mouth, are conveniently arranged into the palpebral, nasal and oral groups. The main acts of expression pertain to the first and last of these; for the nasal group is composed of insignificant muscles both in form and function. Now it is a noticeable fact that the action of the palpebral muscles is one almost in

* Bartlett, I, 196. (From a rock carving in the Gila region.)

† Kings. Coll. (Dresden Codex.)

‡ Kings. Coll. (Dresden Codex.)

§ Troano Manuscript.

‖ Kings. Coll. (Dresden Codex, Col. 28.)

¶ Troano Manuscript.

** Senate Ex. Doc., 1st series, 31st Congress, No. 64, pl. 35. (Reconnoisance in New Mexico, Texas, etc). Report of Lt. Simpson.

†† Squier's Nicaragua, *l. c.*, I, opposite p. 406.

common with the muscles of the forehead. When the latter muscles contract the brows are raised, and when the palpebral muscles act, the brows descend and move toward the middle line of the face. This act, the result of the depression and adduction of the brows, gives a severe expression to the countenance,—a noble one when moderately pronounced, and to this end employed in the Jove-like heads of Greek art* (Fig. 105); but when exaggerated, leads to the grotesque, an advantage not neglected in many ancient ornaments and the tragic masks (Fig. 106).

Fig. 105.

Head of Apollo Belvidere.

Fig. 106.

Head from late Roman ornament (†)

The muscles about the mouth tend chiefly to draw the oral angle from the median line; hence any change, no matter how small at the angle, materially modifies the expression. "Give me a mouth," says Thackeray,‡ "with no special expression, and pop a dash of carmine at each extremity, and there are lips smiling." The inner extremity of the brow and the angle of the mouth may be called the centres of expression. The main face variants, in which these centres of motility have been recognized, are seen grouping themselves into the frowning set and the leering set, either with the mouth closed and the angles slightly elevated, forming "the eternal rictus" of the archaic "Greek" head (Fig. 107), or the lips parted and the teeth displayed, or the lower jaw depressed, with the tongue protruded. The so-called grotesques of Leonardo da Vinci (Fig. 108), and Durer (Fig. 109), appear to us to be experiments in facial motility, both in myology and general proportion. They are mere curiosities in construction. It is interesting to observe from the point of view

* Wincklemann, *l. c.*, II, 80.

† Mus. Borbonico, XI, tab. 28.

‡ Roundabout Papers, 375.

Fig. 107.

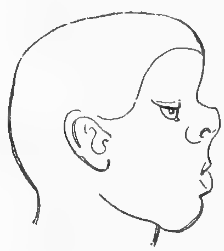
Phœnician Head from Cyprus. De Cesnola. (*)

we are now erecting, viz., the relations between an inventive and an imitative art, how exceedingly different these scholastic studies are from conventional art-types.

Fig. 108.

Grotesque from Leonardo. (†)

Fig. 109.



Grotesque from Durer. (‡)

The lines of the inferior border of the malar bone also serve as the basis of a series of variants both in Egyptian and Aztec art. In addition to these, we have in Aztec art the full-faced skull as a distinct model from that of the countenance.

In conclusion, we may say that the chief variants of the full-faced countenance are as follows:

The brow lines; the mouth lines, and the malar or transverse facial lines.§

* Harper's Mag., Vol. XLV, 195.

† From photograph.

‡ Four Books, etc., on Art Anatomy, Book III, 85. Trans. in French, 1557.

§ Tattooing. That the object of tattooing is to represent clothing is an idea commonly believed. That the objects employed for this purpose should have been patterns we can readily conceive. We have endeavored in vain to detect a relationship between the lines of tattooed skin and the normal folds and depressions of the face. The nearest approach to it known to us, is the head of the Feejian, figured in Owen's Grammar of Ornament, in which a symmetry of ornamentation has been preserved, suggesting the muscular structure of the face. But this is evidently a coincidence; for had natural lines been copied by the artist, the *wrinkles* would have appeared rather than the unrevealed fleshy masses beneath the skin. Now if this were the case the wrinkles would be placed *transversely* to the line of action of many muscles. We accept with some reservation, the statement of Lubbock (*l. c.*), that the inhabitants of Formosa "impress on their skin various figures of trees, flowers and animals."

We propose to trace in the following order a few of the variants of the face. Many of them that relate to expression are found in the best examples of Greek and Roman art, as well as in a few specimens of Aztec carving.

(*a.*) THE FULL-FACE.

(1.) *The Gorgoneion.* The radical of this series would appear to have no connection with the figures placed after it; yet we have ventured to hold as the ultimate the figure from which it is the probable abridgment,—the head of Phthah. In the absence of a corroborating prompter in history, these figures would teach us that the Gorgoneion was common to Egypt, Greece and Etruria. The symmetrical curved ornament at the lower portion of Figures 110–112, and the head-dress of Figure 113, are derived from the skin of the head and fore-feet of the lion. Can we go farther and trace from these derivatives the tongue-protruding heads of the Gothic style, or the Buddhistic Sinhas? It is difficult to answer these questions satisfactorily in the absence of all connecting links. More especially since we have no proof that they may not have originated in other countries. The New Zealander* carves a head with a lolling tongue on his temple column; the Aztecs† have repeated the same figure in stone. See also Fig. 126.

Fig. 110. (‡)

Etruscan.

Fig. 111. (§)

Etruscan.

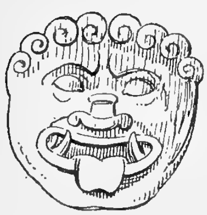
Fig. 112. (‖)

Greek.

Fig. 113. (¶)

Etruscan.

Fig. 114. (**)



Etruscan.

Fig. 115. (††)

Greek.

Fig. 116. (‡‡)

Greek.

Fig. 117. (§§)

Egyptian (Phthah).

* Natural History of Man, Wood, II, 180.
† Waldeck, *l. c.*; Squier, *l. c.*, I, 204 and 313; figure in centre of Mexican Zodiac.
‡ Micali, *l. c.*, pl. 46, Fig. 24. § Micali, *l. c.*, pl. 102, Fig. 10. ‖ Hamilton, Vases, *l. c.*, III, 60.
¶ Micali, *l. c.*, pl. 22. ** Dennis, Etruria, *l. c.*, II, 244. †† Hope's Ancient Costumes, 225.
‡‡ Handbook of Archæology, Westropp, 126. The tongue has been by an oversight omitted.
§§ Hirt. Trans. Berl. Acad., 1821, 115.

It is certain, however, that the Gorgoneion is very ancient. We suspect that the remarkable head from Nebbi Yunas (Fig. 118), may have had an origin from the Egyptian Phthah, the tongue being the only essential feature absent. A comparison of the Greek face (Fig. 112) with that of the Assyrian relic, points strongly to the conclusion that it has been wrought under the same influence that gave shape to the others; but the absence of the protruding tongue prevents us from giving it a place in the series.

Fig. 118. (*)

Assyrian.

(2.) *The Transverse Facial Line.* With regard to the series of the transverse facial line we present the following:

Types of Full-faced Human Head, with Transverse Facial Lines.

Fig. 119. (†)

Etruscan.

Fig. 120. (‡)

Etruscan.

Fig. 121. (§)

Egyptian.

From Mediterranean design.

* Layard, *l. c.*, pl. 95, Fig. 3 and 4. The treatment of the eye by numbers of concentric lines and an exaggerated internal canthus, is notably like the method of drawing this organ on Greek vessels.

† Hope's Ant. Cost. (from Caylus, VI, I, 44.) The repetition of the malar line is here conspicuous, see p. 290 of this memoir.

‡ Micali, *l. c.*, pl. 41, Fig. 4.

§ Birch, *l. c.*, in British Museum.

Fig. 122. (*)

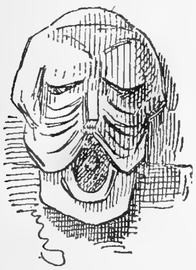


Fig. 123. (†)

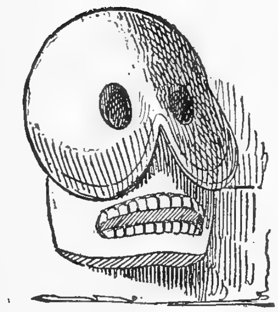


Fig. 124. (‡)

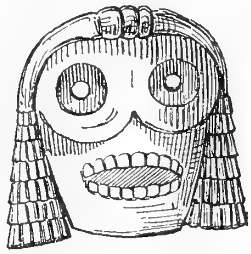


Fig. 125. (§)

From Aztec design.

The radical-like head (Fig. 119) succeeds to the fantastic head (Fig. 120), and both would appear to be derivatives of the Egyptian head (Fig. 121). The Aztec architectural (glyptic) radical (Fig. 122) is the ultimate abridgment of the full-faced human skull of which Fig. 125 is the fullest development. There remains no doubt that in this series the line of the lower border of the malar bones has been the line characterizing the variants of the Aztec skull as a similar line will describe the most prominent feature of the Egypto-Etruscan heads.

(3.) *The Radical of the Full-face.* But it is in the lower stages of art where we must seek for the best examples of face radicals. Large number of primal forms are found etched upon rocks, and have never passed beyond rude attempts at realism. Of these we do not now speak. But rather of the most persistent lines seen in an abridgment of a more elaborate model, itself an ultimate of unknown transitions from the primal shape. Thus in the comparatively modern attempt to depict the human countenance in metal, we may have face radicals rapidly eliminated.

The outline here presented we claim to be the most constant form in the following sequence of figures obtained from Celtic metal ornamentation (Fig. 126).

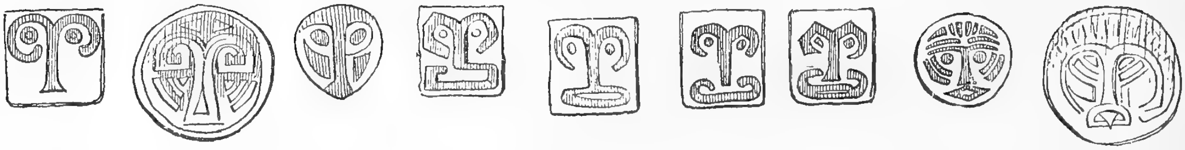
* Views of An. Mon. in Central America, etc., 1844. F. Catherwood, pl. 9.

† Ibid., pl. 9.

‡ Kingsborough Coll. (Dupaix.)

§ Stephens, *l. c.* (Capan), I, 135, 1841. The author supposes this to be a monkey's skull.

Fig. 126.



(*) (†) (‡) (§) (‖) (¶) (**) (††) (‡‡)

Full-face Human Face, from Celtic design in metal.

We have in such an arrangement the united brows forming the upper member of the radical, the vertical member of which is the nose.

In the same manner we may accept the outline of the above figure as one of the Buddhistic face radicals, judging from the following series of figures (Fig. 127), from East Indian coins. In this less perfect illustration, the brow line is separated from the nose, and the cruciform outline given is the result of changes in the nostrils. The figures  are all nose radicals, as well as  Can it be doubted that they have had their origin in the same natural model? Does not this simple contrast between the constant brow and nose radical of the Saxon series, and the varying separation of the brow and nose lines in the Indian series, as well as the variable shape of the nose in the latter group, indicate widely remote tendencies of art-growth in these two races?

Fig. 127.

(§§) (‖‖) (¶¶) (***) (†††)

Human figures of East Indian design, in metal.

* From a fibula found at Fairford, C. R. Smith, Archæologia, XXXIV, pl. 10, 82.

† Found in a cemetery of the Anglo-Saxon Period. J. Y. Akerman, Ibid., XXXVII, pl. 3, 97.

‡-†† Same as *.

‡‡ Figure upon a fibula found in Berkshire, Ibid., XIX, 352.

§§ Asiatic Researches, 1832, XVII, pl. 4, Fig. 89, H. H. Wilson.

‖‖ Wilson's Afghanistan, pl. 25, 26.

¶¶ Ibid, pl. 25, 26.

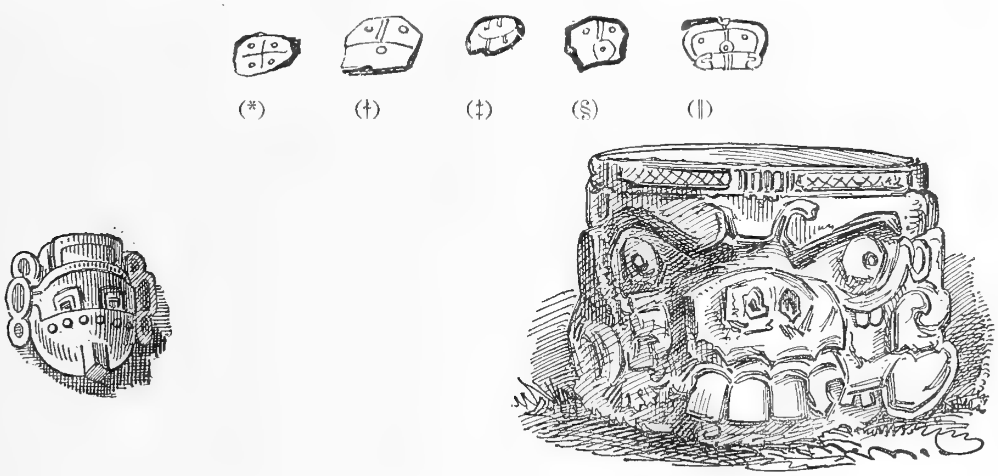
*** Ibid, pl. 25, 26.

††† Ibid, pl. 24, 26.

In looking through the radicals of the full-faced head in Aztec art and the sources tributary to it, we find a number of rudimentary outlines, many of which have had doubtless strictly limited significances attached to them. The majority of these we have selected from the Dresden Codex,—so remarkable among Aztec remains for the conciseness of outline, and relative absence of non-essential elements. The outline as seen in this Codex is proposed (+) as the radical of the front view of the human face. It is essentially the same as the Asian radical enclosed in a circle.

We present the following as a demonstration :

Fig. 128.



(*) (†) (‡) (§) (‖)

(**) (¶)

Full-faced skull radicals from Aztec design.

May we not assert, assuming the correctness of the above sequence, that these are but varieties of the full-faced symbol?

The radicals to be next described are those dependent upon the union of others. These are comprehensive types and are of unusual interest.

We are informed by Dr. Brinton†† that many of the designs of the American races have reference to the cardinal points. We hope to show that the cardinal points are often represented by four full faces, and that each face is represented by a well-defined radical. It might be expected that the radical already given, (+) would be the basis of this more complex design. Such, however, does not appear from the sequence here given.

*–‖ Kingsborough Coll. (Dresden Codex).
** Stephen, Yucatan, I, Frontispiece (Capan).
¶ Catherwood, *l. c.*
†† Myths of the New World, *l. c.*

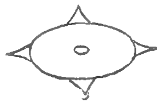
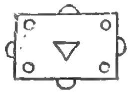
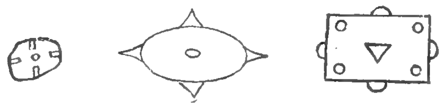
In the Landa (*l. c.*) alphabet there is a comprehensive figure  signifying "space." In the Algonquin Song of the Creation* there is seen the following symbols: 1st.  which is interpreted, "First being, Omnipotent;" 2d.  "All beings are friends." Arranging these in order, we have:

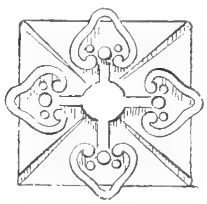
Fig. 129.



representing the radicals of the same composite type.

Now Dupaix figures a design attractive from its symmetry (Fig. 130):

Fig. 130. (†)



We cannot fail to recognize here a figure suggestive of the cardinal points, and the resemblance borne by each of the four component parts to Figure 131 is so strik-

Fig. 131. (‡)

ing that we are led to conclude that the Fig. 130 is a composition, resulting from the arbitrary use of face-radicals, alike to those of Fig. 131.

This point having been gained we are encouraged in believing that the radical

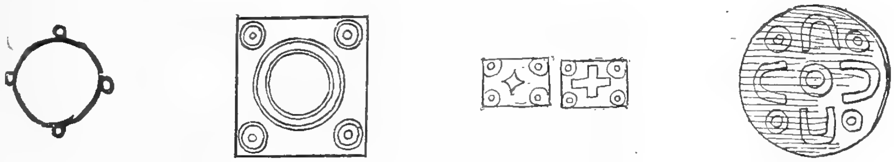
* Traditions of the Algonquins (pamphlet), E. G. Squier.

† Kings. Coll. (Dupaix.)

‡ Ibid. (Dresden Codex.) Many others similar to this could be given from North American design. See particularly Dresden Codex, and a rock near the Susquehanna river, Pennsylvania.

may be significant of the cardinal points, and to have a history something like the ensuing:

Figs. 132.



(*) (†) (‡) (§) Aberrant. (‖)

Composites suggesting the cardinal points, from Aztec design.

These are by no means rare signs in the Dresden Codex.

The use of the full-face radical as the head of the human figure, as seen in a column of the Codex (see Fig. 133) is almost conclusive as to its real significance.

Fig. 133. (¶)

We thus see that the full-faced Aztec radical may be either a Greek cross without eye and mouth dots; the latter, without the former, or both, or with the presence of the cross with dots placed in radii from its re-entering angles.

In illustration of the architectural radical being the result of a process different from one leading to a hieratic character, we present two representations of what we have interpreted to be full-face human head from the Aztec temples:

Fig. 134. (**)

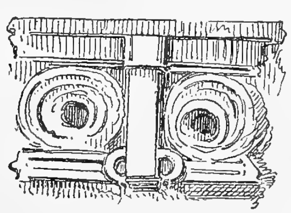
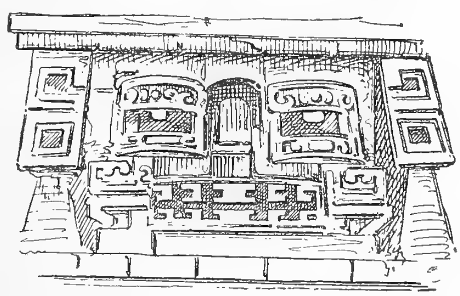


Fig. 135. (††)

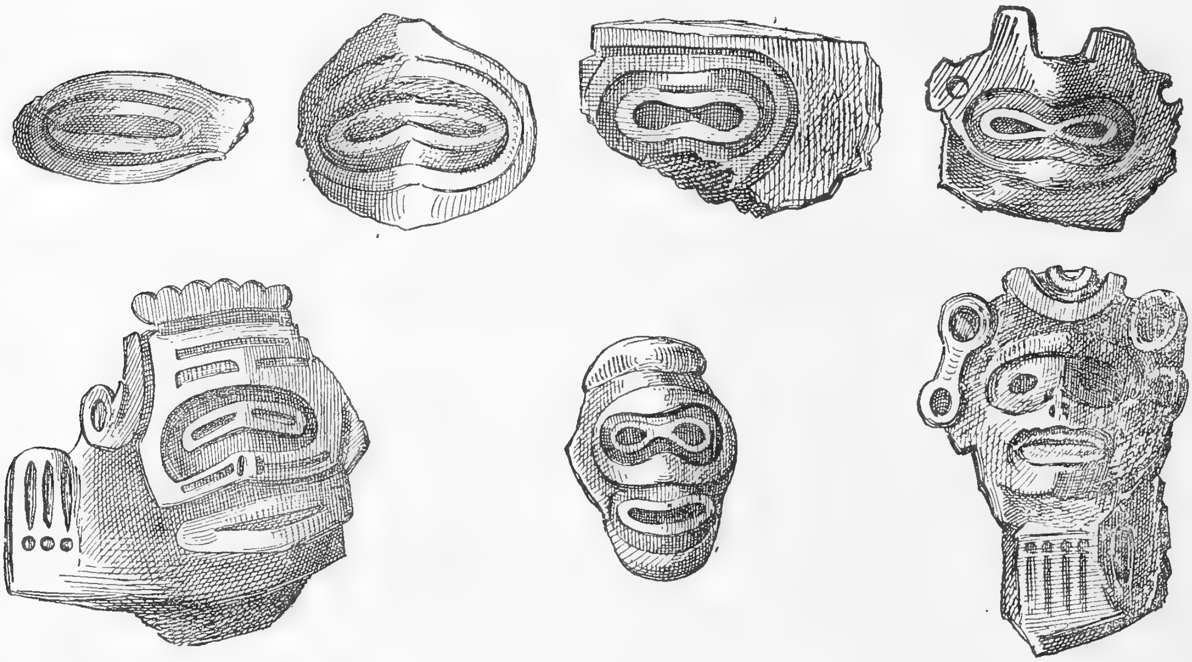


Full-faced human countenance in stone, from Aztec design.

* From squatting figure of a man in Kings. Coll. (Dresden Codex.)
† Kings. Coll. (Dupaix.)
‡ Ibid (Dresden Codex.)
§ Ibid.
‖ Schoolcraft, *l. c.* VI, 576.
¶ Kings. Coll. (Dresden Codex.)
** Catherwood, *l. c.*
†† Ibid. *l. c.*

We give here an example (Fig. 136) of a series of variants in pottery. The specimens were obtained at San Domingo, by Mr. William M. Gabb, late geologist to the San Domingo Government. The originals are in the National Museum at Washington. Our drawings were kindly made by Mr. Gabb. The first we accept as the radical of a full-faced human head, and proceed as follows:

Fig. 136.



Ceramic variants from San Domingo design.

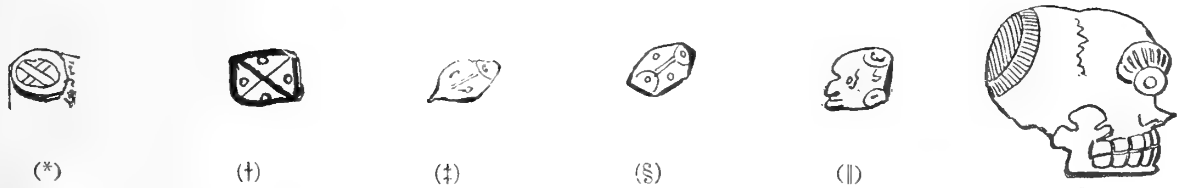
(*b.*) THE PROFILE.

(*b.*) *The Profile.* The profile human head has an entirely distinct history from the full-faced. We see some races very fond of reproducing it, as for example the Egyptians with whom the front view in drawings was phenomenally rare. The Assyrians also repeated the countenance in profile. With the North American Indians the profile is looked upon with contempt. Father Garnier of the Huron Mission, in writing home for supplies, says of certain pictures he needed, "they must be full face, and they must look directly at the beholder."* Mr. Catlin informs us that the Indians consider a profile as representing but "half a man." The Aztecs evidently entertained very different notions concerning the profile, and we find a fair sprinkling of its variants throughout their art. In marked contrast to the Aztec full-faced radical the profile is rarely or never inverted or otherwise changed in position. As in the case of the full-face we find the richest sequence of profiles in the Dresden Codex.

The radical (/) is here presented, and the probable sequence constructed thus:

* Parkman, Jesuits in North America.

Fig. 137.



(*) (†) (‡) (§) (‖) (¶)

Human Profiles from Aztec design.

Fig. 138.

The above is a short series selected from the Troano manuscript.

As an instance of the difficulty of the study of variants we select the following (Fig. 139) from the Dresden Codex, where the profile-face passes into a semblance of the full-face.

Fig. 139.

(**)

Or as is occasionally seen in the Troano manuscript, the oblique line of the

profile  passes into horizontally one  These are examples we take it of
simple carelessness in drawing. Yet we nowhere find so violent a

a change as  The outlines  and  never merge.

In reviewing the human face and its variants we can readily see why the full face should be represented by the Greek cross and figures growing out of it, and the profile by the cross of St. Andrew's, viz., by the repetition of the essential lines of both full-face and profile.

In the first place it is not the *crossing* of lines which is as essential as their positions. A vertical and a horizontal line are equally distinctive of a face whether crossed

* Kings. Coll. (Dresden Codex.)
† Ibid.
‡ Ibid.
§ From Dresden Codex.
‖ Kings. Coll. (Dresden Codex.)
¶ Ibid. (Borgian Codex.)
** Kings. Coll. (Dresden Codex.)

or not, as we have represented. So the oblique line is suggestive of the profile, although it may be isolated. But the vertical line of the nose needs but to be produced to cross the horizontal line of the teeth to give a radical notion of the most conspicuous facial lines; and thus serving as a model to the profile, which probably came later, and produced from the single natural line of the profile an artificial complement crossing it at the centre.

That the line drawn from the top of the occiput to the mouth is a true line of the profile can readily be seen by producing the corner of the mouth. The natural direction of the angle, as we have already seen, is upward and backward. Archaic types tend to emphasize this elevation, and primitive art to notably exaggerate it. Witness, for example, such variants as the following from the Troano Manuscript: (Fig. 140.)

Fig. 140.

(*) (†)

Let us suppose that in the first outline of this group the line had been extended to the crown we would have had the  of the Landa Alphabet and the Dresden Codex.

The architectural profile head, composed for the most part of peripheral exaggerations, is given with the following figures:

Fig. 141. (‡)

Fig. 142. (§)

Fig. 143. (‖)

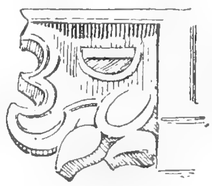
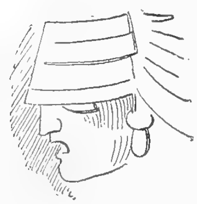


Fig. 144. (¶)

Fig. 145. (**)

Fig. 146. (††)



Human profiles from Aztec (glyptic) design.

* Troano Manuscript.

† Ibid.

‡ Troano Manuscript, pl. 23.

§ From Casa del Cober Nador, Catherwood, *l. c.*

‖ Ibid.

¶ Stephens, Yucatan, 1849, II, 292.

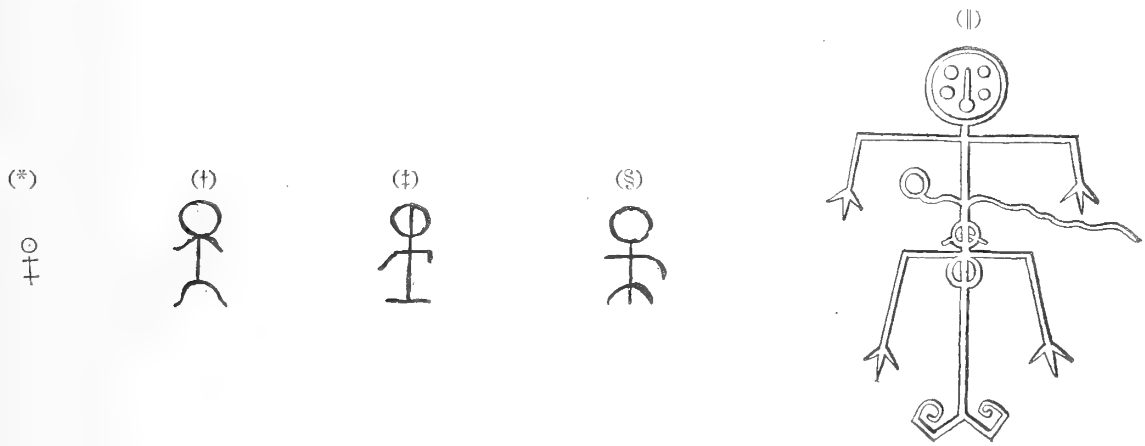
**–†† Kingsborough Coll. (Dupaix.)

(B.) THE RADICAL OF MAN.

As a cosmopolitan form the human figure presents features which are everywhere recognizable. One of its most ancient expressions is a linear vertical ending superiorly, either simply or by a rounded knob, and joined below the knob and at the lower end of the vertical, by two transverse bars completes the outline.

Let us compare a few of these from widely remote localities :

Fig. 147.



Are not these sufficiently alike to lead the observer to conclude that a kind of sequence in time might be traced from the Asiatic forms to the American? It is certainly curious that the figure from Pallas is a constant, invariable shape, which is often repeated on the rocks of Siberia, while that of the South American figure is equally distinctive of those found on the rocks of the valley of the Amazon.¶

Among other anthropoid radicals figured by Spix, is the following (Fig. 148), marked by the curved extremities of the vertical line as in Fig. 147.

* Lesley, *l. c.*, see also Sylvester's Paleographie, pl. 1, showing characters of ancient Chinese dialect of similar construction.

† Reise aus Siberien zurück an die Wolga in 1873. Pallas, Th. III, Zw. Buch., pl. 6.

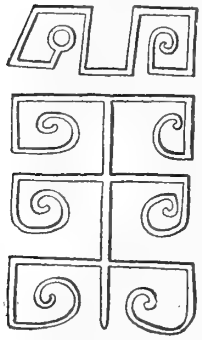
‡ Whipple, *l. c.*, from rock at Arch Spring, near Zuni, New Mexico.

§ Bartlett, J. R., Personal Narrative of Expl. and Incidents in Texas, New Mexico, California, Sonora, etc., New York, 1854. Sculptured rocks on the Gila, pl. 1, Vol. II, p. 196.

‖ Reise in Brasilien. Spix und von Martius—Atlas. Sculpturen auf Felsen am Rio Lapurà.

¶ See also Journal of the Anthropological Institute, London, III, 114, pl. 10, J. Whitefield. In this paper a number of linear signs are given from Ceará, Brazil.

Fig. 148.

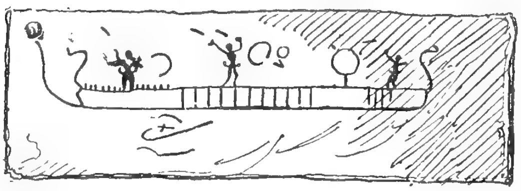


Without the aid of the one it would have been very difficult if not impossible to have determined the significance of the other. But with it and that of the variant of the human face, the determination becomes easy.

Of radicals in which the inferior extremities are marked by oblique lines, we have a large number of illustrations. The vertical may or may not be produced below the lower pair of divergent lines.

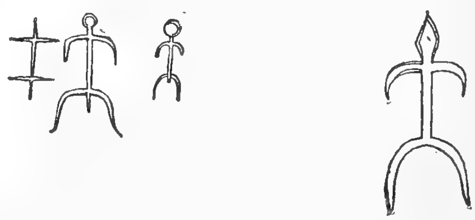
The apparent likeness announced in the above, forces us to ask ourselves the following question: Is the resemblance between outlines, selected from rocks scattered from Norway to South America, merely accidental? There is a drawing in Morillet from a rock in Norway* (Fig. 149); another group in Siberia† (Fig. 150); a third,

Fig. 149. (*)



Sculpture on rock in Norway.

Fig. 150. (†)



belonging to rocks of our Western plains‡ (Fig. 151); a fourth series is seen in the

* Morillet, *l. c.*, V, 535.

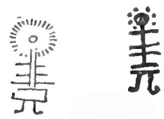
† Pallas, Reise, *l. c.*

‡ See also Journal of the Anthropological Institute, London, III, 114, pl. 10, J. Whitefield. In this paper a number of linear signs are given from Ceará, Brazil.

Fig. 151.

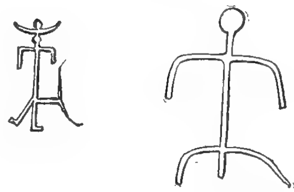
(*) (†)

Fig. 152.



(‡) (§)

Fig. 153.



(‖) (¶)

Aztec manuscript (Fig. 152); and a fifth, upon the rocks of Nicaragua and South America (Fig. 153).

It is decided at first sight that these resemblances are nothing but the natural results of simplifying the easily-copied human form—and that rude artists could with difficulty avoid producing figures which would closely resemble one another. Thus the Asiatic, European and American tribes must have produced results such as those represented above. The lamentable instance of the Abbe Domenick, who mistook a German school-boy's copy-book for a collection of pictures by North American Indians, to say nothing of the more magnificent follies of Brasseur de Bourbourg, are calculated to warn the student against any attempt at generalization even from genuine material. We, however, doubt whether any other than a South American aborigine could have told what Fig. 148, was intended to represent, much less could we expect an Indian, or a school-boy to draw such a form for *man.* The very shape of such an outline is proof of its being an ultimate modification from a pre-existing form. Its presence at once suggests *experience* as a necessity to its existence. No child could possibly conceive of it—and no adult trace it unless he had become acquainted with the traditions and conventionalities of which it is the result.

Again, such a radical as  is seen on a photograph of a rock in the Western United States to represent man, as can be shown in the following sequence (Fig. 154):

* Report of the Indian Tribes of New Mexico, Lt. A. W. Whipple. From rock at Ojo Pescado. Lt. Whipple in speaking of this says, "the figure might be pronounced to be centuries old."

† Simpson's Report, *l. c.*, pl. 25, fig. 2. See also in this connection a photograph of a rock opposite Parawan, Utah, in series published by U. S. Government (Wheeler's Expedition, 1872). The sign  from Painter Creek, New Mexico, figured by Whipple, *loc. cit.*, has the lower part, recalling the figure from Brazil (see Spix and von Martius). It is described as being very old and much effaced. May not the transverse lines have been obliterated in time?

‡ Kingsborough Coll. (Dresden Codex.)

§ Troano Manuscript, Paris, 1869, pl. 35. This sign is represented in the manuscript as inverted.

‖ Squier, Nicaragua and her People, II, pl. 1, 24.

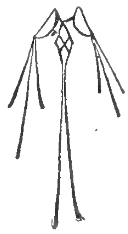
¶ From original drawings by A. Fendler, in library of Acad. of Natural Sciences of Phila. The rocks are near San Esteban, S. A. (See Smithsonian Rep., 1857, 218.)

Fig. 154.

(*)

Now if the last of the series be man, it is highly probable that the preceding three have been derived from it, and that the first is its radical. If it be so, the following Figure 155, will be composed of two anthropoid outlines on either side of a central object.

Fig. 155. (†)



Squier.

Let us take this object of Fig. 155 and endeavor to fix its value.

Fig. 156.

Fig. 157. (‡)

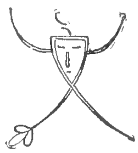
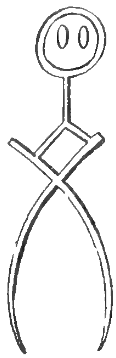


Fig. 158. (§)



Figures 157 and 158 are probably representations of man, and we are lead to believe that Fig. 156 and the central portion of Fig. 155 have the same value. We have already seen the probable bearing of the cross marking within these two figures.

Assuming the correctness of the conclusion that the figure is anthropoid, we have to explain the connection between it and the two inclined figures on either side.

* Simpson, *l. c.*

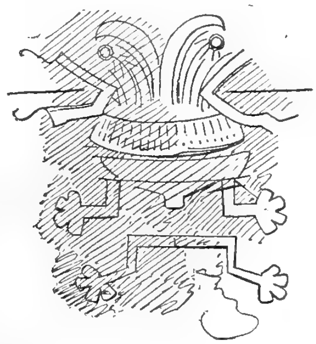
† Squier, Nicaragua, *l. c.*

‡ Ibid. *l. c.*

§ Spix, und v. Martius, *l. c.*

This may be done, we think, by fixing the concrete symbols representing, it is thought, the cardinal points. We would place the figure in the same category with the symbols there figured, and present in the same connection such forms as Figure 159, interpreting the side pieces as human faces with chins directed to the side of the full-faced countenance: *

Fig. 159.



Anthropoid outline with symmetrical face-radicals, of Aztec design.

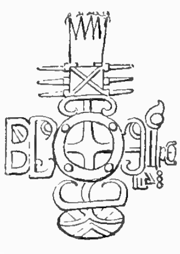
Could any of the above lines be accidental? Could any of them have been forgot by the dishonest, or imitated by novices? Or, could any school-bred scrawler, boy or man, have made them? May we not place in the same connection this piece (Fig. 160) of Haidah (Babine) carving?† In speaking of this, Mr. Wilson

Fig. 160.

Full-face human countenance with complex lateral face radicals, of Haidah design.

aptly remarks: "I was struck with a certain resemblance to the peculiar style of ancient Mexican and still more of Central American art."

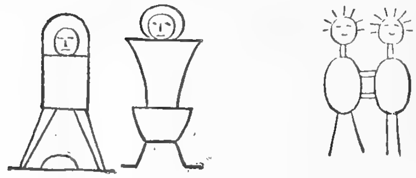
Fig. 161. (‡)



Symmetrical composite of Aztec design, showing an arrangement of full-face and profile radicals.

* Squier, *l. c.*, I, 406. † Prehistoric Man, Daniel Wilson, Lond., 1862, II, 21. ‡ Humboldt, Vue de Cordilleras.

Fig. 162.

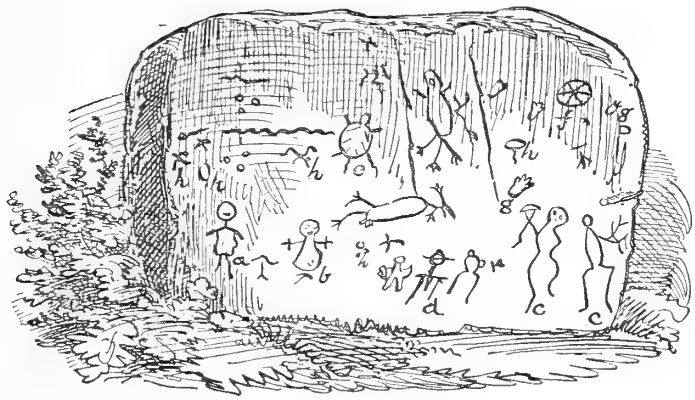


Algonquin sign of man.

The above outlines (Fig. 162) are copied from an authentic Algonquin song, figured in the pamphlet already noticed, by Mr. Squier, by whom they are termed "*mnemonic symbols.*" Mr. Squier, who is an eminent authority, believes the figures trustworthy. He states (page 7), "that with a view of leaving no means unemployed to ascertain its (the manuscript's) true value, I submitted it without explanation to an educated Indian Chief (Kah-ge-ga-gah-bowh), George Copway, who unhesitatingly pronounced it authentic, in respect not only to the original signs and accompanying explanations in the Delaware dialect, but also in the general ideas and conceptions which it embodies. * * * I feel I am not obtruding the coinage of a curious idler, nor an apocryphal record, but presenting matter deserving of attention, and of important bearings upon many interesting questions connected with the history of our aboriginal nations."

There can be no doubt, therefore, that these figures represent the Algonquin method of representing man. In no one of them do we recognize the linear radical already considered, nor any outline which would be liable by abridgment to run into it. When we remember the fact that the song is entitled The Creation, the figures employed in illustrating it were probably of fixed value and of considerable antiquity. Mr. Schoolcraft informs us that the Indian picture-characters were, among the Ojibways, "taught to the young as carefully as our alphabet." We have no reason to suppose but that they have preserved their present appearance for a long time. Is it assuming too much from our premises to suggest that the outline *a* (Fig. 163) is an Algonquin sign of man, and that *c* is an imperfect form of the same? If this be conceded and internal evidence given that the drawings were made at about the same time, may we not call the inscription Algonquin, and that the signs have some relation to Fig. 162?

Fig. 163.



An Algonquin Rock-carving.*

a—Algonquin sign of man.
b—Anthropoid (?).
c—Anthropoid of the type-figured.
d—An unfinished, or an effaced figure.
e—Turtle.
g—Hand.
h—Unknown.

Fig. 164.

(†)

If such be granted the above sign (Fig. 164) from a rock in Kansas will be placed in the same group. The entire absence of Aztec-like signs in such a series of pictographs and inscriptions is suggestive.

The same cannot be said of some other inscriptions, as for example the Parowan inscription in Utah. Here amid signs suggestive of influence which the Aztec people, or the unknown South American tribes had in common, appear others such as Fig.

Fig. 165.

165, which so intimately resembles the genuine Algonquin, that we can have no doubt of their identity. Here we have, we may say, a modern savage making

* Squier's Ancient Monuments, Smithson. Cont., vol. I, 298.

† Indian Inscription Rock at Indian Cave, on Mulberry Creek, Kansas. (From photograph, by A. Gordon, Washington, D. C.)

his mark among the ancient signs that attracted his attention, as a modern tourist might scratch his name upon a slab of Egyptian hieroglyphics.

This marking of new signs over and among older ones must always remain a confusing element to the student of inscriptions. Man is inherently a scrawler and something among his attempts at artistic outlines must be attributed to that same desire which marks certain uncultured persons who cannot resist the tendency to carve rude figures, or write their name at noted localities.

In the Dresden Codex we have a sequence of the squatting human figure (Fig. 166) unlike anything yet seen.

Fig. 166.

Squatting Anthropoids, of Aztec design.

The difficulties attending the study of the human figure are very great. We will present two of the more prominent of these. What is to prevent, for example, some of the outlines marked by the produced vertical axis representing a tailed quadruped? (Fig. 167.)

Fig. 167.

(*) (†)

This is not a little puzzling, particularly since we are informed of the value attached to the reptilian batrachian forms in Anahuac chronology. While acknowledging the suggestiveness of the produced vertical, we nevertheless find the figures of quadrupeds to be such as  of Pallas. Thus proving the absence of quadrupedal type comparable to an anthropoid type, and also that although it is not impossible that the produced vertical line may at times mean "tail," it is not *probable* that it meant anything of the kind.

* Kingsborourgh Coll. (Codex Vaticensis.)

† Bollaert, *l. c.*

‡ Pallas, *l.* c.

Fig. 168. (*)

This figure (Fig. 168) from Bartlett is here given to show the radical of man, as we have determined it, in the act of driving an animal.

In some outlines from the Gila region, by the same authority we have a man-like figure with produced vertical associated with one in which it is absent. If, as may be suggested, that the line has a sexual significance, its absence would indicate the companion figures to represent female forms.

Another great difficulty, determining the man-radical is that in countries, where the inhabitants have been under Christian influence, the vertical and transverse lines have originated in crude imitations of the Latin cross. Such influence undoubtedly exists in the design of our Indians, especially among those who have been brought in association with Jesuits. The following signs from Jonathan's Cave, near Fife, Scotland, are certainly very suggestive of the series on p. 333, and we are only deterred from so placing them from the other evidences in the same locality of modern influences.

Fig. 169. (†)

As has already been observed, the position of accessory signs more than their shape determine their significance.

Of the sign

(‡)

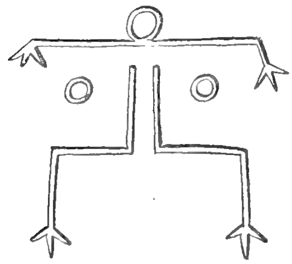
it would be difficult to prove that it was not a face, and the symmetrical dots eyes, except by comparison with the following from a rock in the same country (Fig. 170):

* Bartlett, *l. c.*, I, 206.

† Simpson, J. Y., Archaic sculpturing of cups, circles, etc., Edinburgh, 1867.

‡ Near Colonia Touar, A. Fendler, *l. c.*

Fig. 170. (*)



when it is at once shown that the entire figure is represented, and the symmetrical markings are not eyes but mammæ.

Fig. 171.

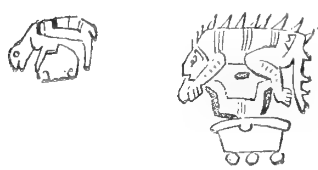
A curious figure in the Borgian Codex, showing the produced vertical and transverse lines of the ancient radical of man.

SECTION V. *Other variants from the Dresden Codex and other sources, of North American design.*

Fig. 172.

The Breastplate.

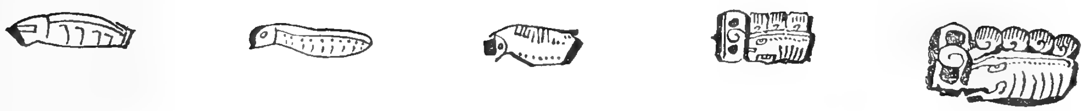
Fig. 173.



The Lizard.

* From Rock on Rio Lapuná, Spix und v. Martius, *l. c.*

Fig. 174.



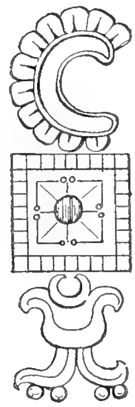
An unknown animal.

Fig. 175.

(*)

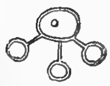
(†)

The Ear-ring.

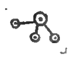


(‡)

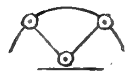
Fig. 176.



(§)



(‖)



(¶)

"The Three Balls."

SECTION VI. *Difficulties met with in analyzing the Life-form.* We have now given a number of examples of the plan proposed for the study of variants, sufficient we hope for the demonstration of the object in view. The reader has doubtless observed that the fields from which the figures in the different series have been gleaned have varying degrees of probability. In some, as in those from the Dresden Codex, we find all the outlines secured from a single manuscript. In others the radical may be found in the manuscript, but the intermediate-forms are scattered in the sculpture and rock-pictures of Central America. In another group again these shapes are sought for on the rocks of Utah—the carvings of the Frazer

* Ribeiarao (Bolivia), Harp. Mag., Vol. XLIV, 502.

† Kings. Coll. (Dupaix).

‡ Stephens, *l. c.*

§ From U. S. photograph, rock opposite Parowan, Utah. Wheeler's Expedition.

‖ Jones, Southern Antiquities, 378.

¶ Squier, Traditions of Algonquins and Song of Creation.

River natives—or even, as in the first mentioned human-figure-series, from Asia and Europe. We have in every instance simply placed the objects in the order they appear to make for themselves, indifferent to the localities in which the objects have been found. In many instances, as with Central American design, the sequence of the outlines are promptly confirmed by our knowledge of chronology. In others this chronology has not been made out. With such we leave the forms to speak for themselves. We certainly are not anxious to establish any theory, and have purposely placed all material which would appear to point to any definite lines of migration in the form of queries.

As may be readily seen the entire study is fraught with difficulty. Particularly is this the case in the field of Central American design. Fancy is here continually dulling the ear of judgment; and the student, as he turns the pages of the Kingsborough volumes, is more often tempted to weave little fictions about the gaudy "grotesques" before him, than remain content to be guided by the truth that so evidently underlies them. We have endeavored to keep free from all weakness of this kind, and to leave to others the interpretation of the grinning skeletons, the priestly sacrifices, the murderous assaults, the mysterious pot-boilings, that so plentifully bestrew the Codices.

A difficulty of another kind is met with in the variants of art-forms of older and more cultured races than the American. The higher the art and more concrete the style the less satisfactory becomes the interpretation of variants. Cardinal Wiseman* has justly said: "Great caution should be used in judging characteristic form from works belonging to the higher department of art. No nation long possesses the art of representation, without forming to itself an ideal, abstractive type; and the caution to be used should necessarily be doubled, where the art and their types are borrowed." The fact that scarcely a single art-form in the entire range of Indo-Germanic art—nay even within that larger area of Mesopotamia and Egypt—can be quoted, which does not exhibit in its history the traces of mutual influence, is sometimes sufficient to cast a doubt upon the arrangement of form in a supposed succession, even when the chronicles of the nations yielding them have been fixed.

Let us, for example, suppose that a cylinder has been found at Babylon, which is determined to belong to the late Babylonian empire. Now the Assyrian influence upon the art of this empire is conceded, and we should seek for the source of the conventionalisms upon the cylinder to their associated variants among the alabasters of Khorsabad or Nimroud. Could we stop here the search would be easy. But we are informed by Rawlinson that Assyria itself is a northern branch of the

* Science and Revealed Religion, I, 251.

Chaldean stock, and although its art is in a great measure indigenous, its germs were imported from the ancient Babylon, and in some instances have simply returned to that source after undergoing changes due to their prolonged expatriation. If in addition to this the influence exerted by Egyptian form upon the later Assyrian figures be acknowledged, it makes the task of arranging in a chronological sequence a series of Mesopotamian variants an exceedingly difficult one. We think that the internal evidence furnished by the objects themselves is a much easier and in the end as satisfactory a guide.

That archæologists have *not* studied primitive art-form by this internal evidence, or, as a naturalist would express it, by seeking for a standard of grouping by comparisons of the actual forms, can be at once seen by quoting a few examples.

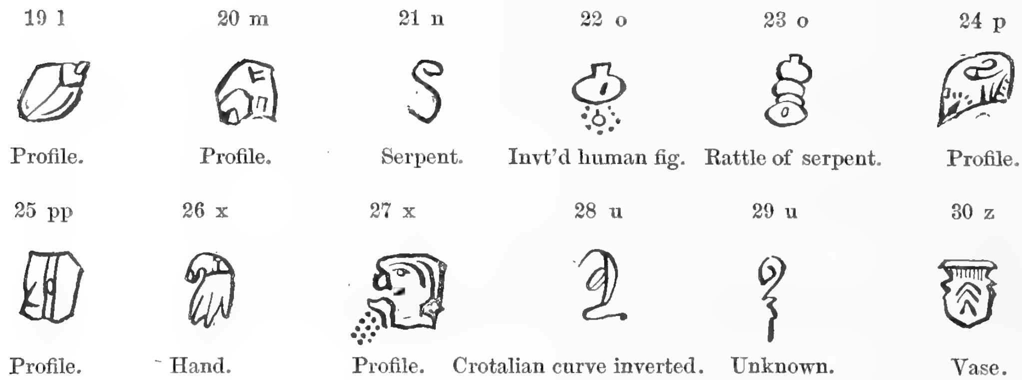
The first we propose mentioning is the attempted interpretation of the Landa Alphabet. Dr. D. G. Brinton, in an interesting pamphlet entitled "The Ancient Phonetic Alphabet of Yucatan,"* has printed this alphabet which, as we are informed by Dr. Brinton, "was unearthed in a library in Madrid—that of the Royal Academy of History," by the Abbé Brasseur de Bourbourg. It was contained in an unpublished description of Yucatan, composed by Diego de Landa, the first bishop of the country. This alphabet is given below (Fig. 177) with indications of the objects by ourselves.†

Fig. 177.

* New York, 1870, J. Sabin & Son.

† It is necessary to mention that we had not seen the Landa alphabet until this essay had been nearly completed.

Fig. 177—*Continued.*



According to this interpretation, out of the thirty figures composing the alphabet,

18 are from portions or combinations of portions of the human frame, viz., Nos. 3, 6, 7, 8, 9, 10, 11, 14, 15, 16, 18, 19, 20, 22, 24, 25, 26, 27.
3 are from birds, viz., Nos. 1, 2, 4.
2 from serpents, viz., Nos. 21, 23.
1 is from unknown animal, 17.
2 are from plants, viz., 12, 13.
1 is a vase, 30.
3 are from unknown objects, viz., 2, 5, 29.
—
30

According to Dr. Brinton, *l. c.*, the meaning of the objects of this alphabet should be something as follows:

a. Nos. 1, 2, and 4 are representatives of the heads of some animals; No. 2 being evidently the head of a bird, with a long curved beak, probably a species of parrot. No. 3 has been supposed to represent a leg or a boat of some kind, but is probably also a rude figure of a head.

b. Both these letters are supposed to represent a path or way bearing the marks of foot prints indicated by the small figures inside the circle.

c. This letter * * * * is imagined to represent a mouth displaying sharp teeth.

ca. Is explained as the jaw of an animal thickly set with teeth; but a careful examination of its variations leads to the belief that it is a representation of an eye-lash.

cu. This has never been identified.

t. Signifies space, the four marks leading toward the centre, representing the four cardinal points.

e. Probably a front view of the human face, surmounted by the hair, the dots marking the eyes, nose and mouth.

h. Nos. 12 and 13, variations of the same, represents a joint of bamboo. No. 14 represents a flowing stream around some objects.

i. No satisfactory analysis has yet been offered of this letter. It seems formed after the analogy of *c.*

k, ku. The *k* is beyond doubt derived from a head seen in profile. The upper figure within the circle is the closed eye with its lashes (compare No. 8); that below on the right is the ear (compare No. 28); that on the left is the mouth. The *ku* is supposed to be a drawing of the sacred "medicine bag."

l. Neither of these have been resolved.

m. This also is the figure of a head. It is distinguished from the *k* from the eye being open, from the *p* by the absence of dots around the mouth.

n. Possibly the figure of a serpent.

o. Variations of the same, of uncertain origin.

p, pp. Again the face in profile.

x. The figure is easily recognized as the human hand, the second as a face in profile emitting breath from the mouth.

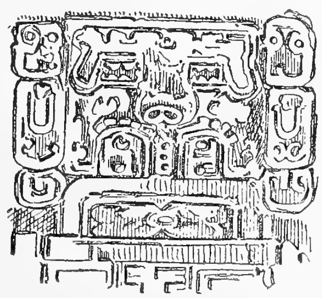
u. The first sign represents the ear, the second is of uncertain derivation.

z. This seems to be a vase of some kind.

We think we can fairly claim to have improved upon the above identifications; how much, we must leave to others to decide.

For another example we will take that of the Palenque cross. We have already indicated that the ornament on the ends of the horizontal bar of the cross are profile rattlesnake heads. The object (Fig. 178) (evidently of animal origin) upon which rests the vertical bar, has been called by Dr. Brinton* a rattlesnake head. Our comparisons lead us, however, to conclude that the object is not a rattlesnake head but a full-faced human skull. With this opinion, Dr. Brinton informs us he now concurs.

Fig. 178.



"Full-face" rattlesnake head, from Aztec design.

* Myth of the New World, *l. c.*

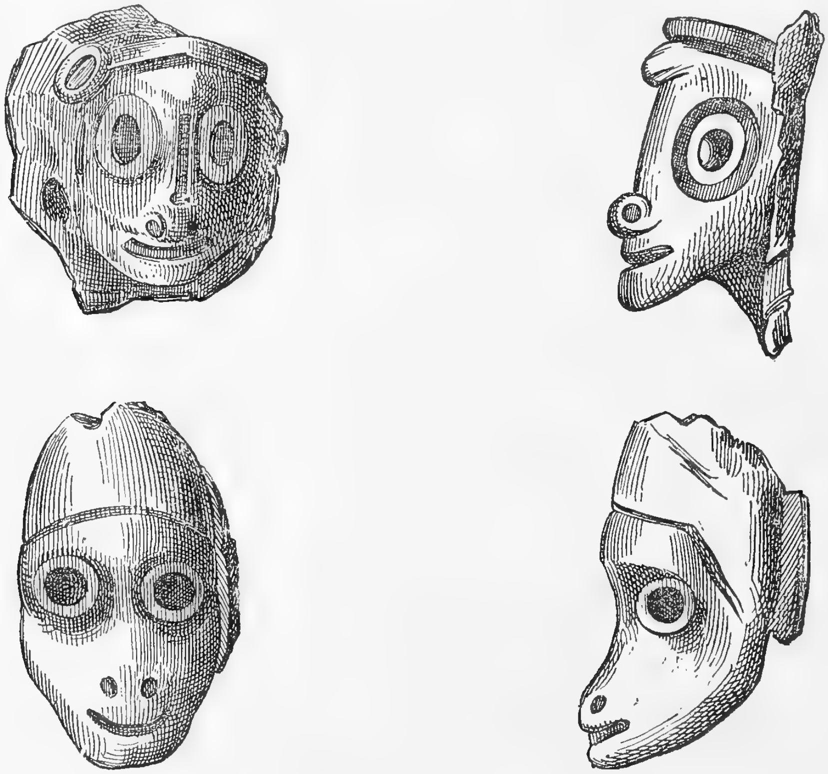
In Mr. Gabb's collection of fragments of San Domingo pottery already mentioned, occurs the following:

Fig. 179.

Front. Profile.

This has been denominated by Mr. G. and others, a "bird head." We, however, conclude from associated fragments that it was not a bird head but a variant of a monkey head, thus:*

Fig. 180.

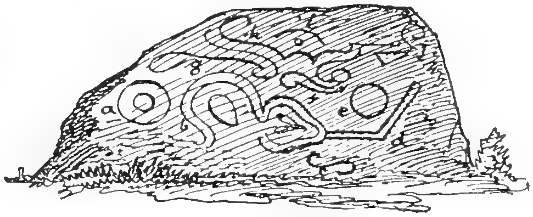


SECTION VII. *Method of studying Rock Inscriptions and Pictographs.* Applying

* For rather free identification of Polynesian forms, see the hieroglyphics of Easter Island, Journal Anthropological Institute of London, III, 370, pl. 20.

the conclusion we have attempted to educe that before naming an object of primitive art, it is necessary to *prove* its identity by intelligent comparison, rather than to *guess* at it, we submit a few specimens of rock carvings, and propose to name their several outlines.

Fig. 181.



Inscription at Zipatero, Nicaragua.*

a. Is composed of a pair of circles, one enclosed in the other. We have mentioned on p. 280 our reasons for doubting the exact indentification of this and analogous signs as the one at *e.* They may be representations of the innumerable roundish natural objects.

b. However, is much more definite. Referring to the variants, these are observed to be like a pair of brows; the enclosed objects probably answering to eyes.

c. Is probably serpentine.

d. Unknown.

f. The modified crotalian curve.

h. Forehead ornament.

i. Unknown, probably an ornamentation about an eye.

j. A variant of the crotalian curve.

Fig. 182.

Inscription in New Mexico. (Gila Region.)†

a. Ancient sign of man. (Turanian distribution?)

b. More modern sign of man.

* Squier, Nicaragua, II, 69.

† Bartlett, *l. c.*, II, 216.

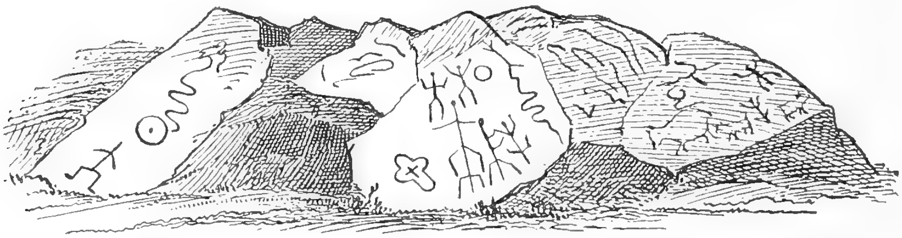
c. Probably derived by imitation by some nomad who has seen the sign of human profile on an Aztec monument.

d. Modern sign of quadruped, mounted by man.

e. Quadruped sign.

f. Unknown.

Fig. 183.



An inscription showing examples of the ancient anthropoid sign. *

A knowledge of Central American design has rendered the task easy of proving that the markings (Fig. 184) had been made by some one under the influence of the art of the region in which they were discovered, and we have no hesitation in naming it Aztec.

Fig. 184.

Aztec Inscription. (†)

a. Profile crotalian jaw curve.

b. Upper member of a variant of same.

c. Closed variant of the same.

d. Probably a bifid tongue protruding from a Crotalus head.

e. Unknown.

f. Same as *b.*

g. Simplified crotalian curves.

* Emory's Report, 1848, p. 90. (Near Gila River.)

† Stephens, *l. c.*, 1849.

h. Rattles of rattlesnakes. The letter is placed between two figures of the same value.

i. Unknown.

j. Unknown.

l. Mouth with teeth.

m. Human foot with rattlesnake—rattle ornament as anklet.

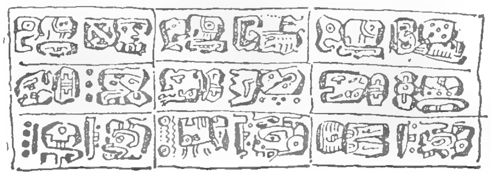
n. Serpentine curve.

o. Unknown symmetrical design.

Such are some of the conclusions to be derived from the study of the life-form in art! We pause in the midst of an endless theme, with the mind thronged with strange shapes that arrange themselves into groups of imperfectly-defined limits.

As we acquaint ourselves with these attempts of man to record his thoughts in carvings and painted images, we are partakers of the pleasures of the naturalist. Man in establishing fashions of love-making and house-building is an object of the same sort of interest as the bird or the bee. The method of study adopted in each case should be the same, however we may be influenced by importance of the results thereby obtained.

Fig. 185.



Specimen of the characters of the Dresden Codex.

ERRATA.

Fig. 2, p. 285, is most probably the *Odontophorus* of Tschudi.
For Mephistophøles on p. 298, read Mephistophęles.
For Thack*a*ray, p. 300, read Thack*e*ray.
For Fig. 25, p. 300, read 25a.
For *figures* on twelfth line, p. 302, read *fingers*.
For Palencque, p. 315, read Palenque.
For *to* on fifth line, p. 315, read *and*.
For *impossible*, ninth line, p. 315, read *possible*.

The illustrations of this Memoir have been executed by the photo-electrotype process, by Messrs. F. A. Wenderoth & Co., of Philadelphia, from drawings by Mr. Hermann Faber.

CONTENTS.

PART I.

General Considerations.

PART II.

The Study of Variants.

ERRATA

In Article IV, Volume XV, Part I. On the Topography and Geology of Santo Domingo, by William M. Gabb.

Page 55, 7th line	Sa*r*aneta	should read	Sa*v*aneta.
" 58, 1st " 2 par.	*third*	"	*blind*.
" 59, 8th " from bottom	Pulgari*si*	"	Pulgari*n*.
" 63,	Guaraguan*o*	"	Guaraguan*ó*.
" 64, 8th " " "	channel *or* the	"	channel *on* the.
" 85, 10th " " top,	*probably* like	"	*properly* like.
" " 12th " " "	brownish *limestone*	"	brownish *hornstone*.
" 86, middle of page,	has been *cemented*	"	has been *converted*.
" 87, 16th line from top,	gasteropod*ous*	"	*gasteropod*.
" " 6th " " bottom,	commission*er*	"	*commission*.
" 88, last line (note),	*tile*-shaped	"	*lily*-shaped.
" 112, 15th line from bottom,	*crystallic*	"	crystall*ine*.
" 114, 10th " " "	*outside* of the trail	"	*aside* of the, &c.
" 116, 15th " " top,	*caps*	"	c*u*ps.
" 116, 14th " " bottom,	*cassara*	"	cassa*v*a.
" 117, 4th " " top,	har*d*	"	han*d*
" 120, 7th " " bottom,	Loma de l*o*s Minas	"	de l*a*s
" 133, 17th " " top,	*cross* grained	"	*coarse* grained.
" 135, 15th " " "	*whose* conifers	"	*where* conifers.
" 137, 5th " " "	Yam*oso*	"	Yam*asá*.
" 138, 12th " " "	*hojo*	"	*hoja*.
" 139, 2d " " "	brought *on*	"	brought *me*.
" 144, 14th " " "	Miocene *sandstone*	"	*limestone*.
" 145, 15th " " "	*towns*	"	*homes*.
" 149, 16th " " bottom,	little *outline*	"	*outlier*.
" 151, 6th " " top,	calcareous *limestone*	"	*sandstone*.
" 154, last line,	*of* Dajabon	"	*to*.
" 163, 2d line from top,	*beach*-mark	"	*bench*-mark.
" 166, note,	Mount Mura*ss*	"	Mura*so*.
" 177, 15th line from top,	little *outline*	"	*outlier*.
" 183, 14th " " "	*exploration*	"	*exploitation*.
" 185, 12th " " bottom,	Ji*r*aná	"	Ji*v*aná.
" 186, 12th " " top,	*every* place	"	*one* place.
" 186, 2d " " bottom,	l*a*s Platan*as*	"	los Platan*os*.
" 190, 9th " " top,	*dips*	"	*dip*.
" 191, 3d " " "	*brakes*	"	*bushes*.
" 201, 9th " " bottom,	*being* a similarly shaped	"	*having*.
" 204, 1st " " top,	number *or* whorls	"	*of*.
" " 3d " " "	great *variety*	"	*rarity*.
" 219, 17th " " bottom,	among 7 shells	"	among *these*.
" 221,	Strombina *gradate*	"	*gradata*.
" 226, 11th line from bottom,	*Plochela*	"	*Plochelæa*.
" 227, 17th " " "	last *fine* whorls	"	*five*.

" 246, 6th & 7th, I inadvertently say, "I have never seen it from other localities." This is incorrect. I have collected it on the Savana la Mar Pass, as will be seen in the text.

" 249, 8th line from bottom, C. *pappia* should read *paphia*.

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ARTICLE VII.

ON THE CONTENTS OF A ROCK RETREAT IN SOUTH-EASTERN PENNSYLVANIA.

BY S. S. HALDEMAN.

Read before the American Philosophical Society, June 21, 1878.

The retreat or shelter in question is in the anticlinal axis at the base of a cliff of Potsdam Sandstone (quartzite), fronting the river Susquehanna at the iron manufacturing village of Chickis, named from a stream (the Chikiswalungo), which enters the Susquehanna at this point, about 390 yards north of the retreat. See Plate XV.

A traveler by the railway, which passes in front, may observe a vaulted recess open to the light of day, where formerly the occupation of arrow-making was followed. It is about seven feet high in the middle of the arch in front, whence it slopes north, south, and east, to the ground, much as an oven declines in all directions from the mouth, the space occupied by the recess being about ten by fourteen feet in extent, and here most of the implements were found; but some from the earth a few feet beyond the opening have been included as pertaining to the general deposit, for a fragment of pottery occurring within the recess would be matched by one or more pieces from the outside. The cavity is due to the falling away of stones forming the anticlinal curve, several of which were removed in clearing the space, and, to prevent accident, one which seemed ready to fall was detached from the roof. No stalagmitic material was present.

This paper being devoted chiefly to a detailed illustration of the implements found, the reader is referred to a preliminary sketch of the retreat and its contents, sent to the Société des Américanistes in 1877;* and to a verbal communication made to the Academy of the Natural Sciences, Philadelphia, in March 1876, from both of which, necessary material will be reproduced, adding the results of later researches.

Such stone implements as are found singly on the ground, or are turned up by the plow, are regarded by Sir John Lubbock (Prehistoric Times, 1875, p. 105), as of "comparatively little scientific value: it is only when they occur in considerable numbers, and especially when associated with other remains, that they serve to throw much light on the manners and customs of ancient times." The Chickis retreat has

* Published 1878, in the Compte-rendu, vol. 2, pp. 319–327, with a figure of the Retreat.

these advantages, the relics being numerous, varied, and illustrative of a restricted locality, occupied perhaps not less than two thousand years, if we may judge from the thirty inches of black mold formed by decaying vegetation,* and the corroded condition of many of the arrow-heads and chisels occurring at various depths.

The place was adapted for the residence of savages. The base of the cliff at the river margin left a defensible passage-way; on the north the land spread into arable soil; a large spring about 170 yards north of the shelter offered good water, and near it was a trap (dolerite) bolder of the drift of several tons weight (from the Conewago Hills ten miles to the north)—with a depression adapted for grinding corn—perhaps in part artificial, or deepened by use. Here then were shelter, defense, convenience, planting, hunting, boating, fishing in two streams, and forest.

Residing at the locality, it had been my intention for more than forty years to search the recess for relics, and at length, in January, 1876, I began scraping with a garden hoe, and soon turned up five fragments of pottery from the depth of a few inches. The next day a workman dug for me, but objects were scarce, the first being an unbroken pebble adapted for throwing, of a kind of which many afterwards occurred, either entire, or with a chip broken off (Pl. 12, Fig. 8), as if to try the texture for arrow points. An idea soon spread that the search was for money, which caused a rush and prevented the proper investigation by strata. However, as there was about the ordinary type of Pennsylvania forms, the result has not been materially altered.

Although hammer-stones were possibly the first stone implements, yet from the importance of a cutting edge, we may be allowed to surmise that the choosing of a sharp fragment, the forming of a sharp margin, at first by blows, subsequently by rubbing, and (not to lose the result of his labor or the independent use of his hands) the supplying it with a pocket, suggested proprietorship to the savage, and made the fiscal idea the first condition of civilization.

CHAPTER I.

KNIVES. PL. 1.

Stone implements which require a cutting or scraping edge, whether knives, chisels, scrapers, borers, or arrow-heads, are of several kinds; the first includes naturally sharp fragments, of which Fig. 16 may be an example; the second variety

*The stain of the black mold is still visible upon the rock, and I have indicated its limit by lines of red paint, for future reference. Dr. Abbott (Am. Naturalist, Feb., 1876, p. 67) estimates that it requires thirteen centuries to accumulate ten inches of vegetable mold.

has the form and edge roughly shaped by a few blows (Fig. 15, 17); the third variety includes such as have an edge formed by fine chipping, as in Fig. 4, the left side of which is a cutting edge, and the base a scraper; Fig. 5, delicately chipped on one side, the other flaked into a bevel at the same angle; and Fig. 14, with a cutting and scraping base, the edge transversely curvilinear. (Figures 13–17 represent specimens made of white quartz.) The fourth variety is made up of flakes struck from a hard material, such as porphyry (Fig. 1, 11), trap (Fig. 3), indurated clay* (Figs. 6, 7, 8), jasper (Figs. 4, 9), or cherty limestone (Fig 5). Finally, the fifth variety is due to rubbing or grinding (Pl. 2, Fig. 4), and polishing (Pl. 2, Fig. 8).

As the rock of the locality is a dense quartzite with occasional large veins of white quartz, any unworked specimen of either, occurring in the Retreat, might be due to a fall from above, or other accident, even after the inhabitants had left, and on this account I have collected but few of such doubtful specimens. On the other hand, as there is no sign of a drift deposit in the retreat (except perhaps the unmixed yellow sandy clay of the foundation), human occupants must have introduced stones of other material, such as indurite, jasper, sandstone, chert, siliceous slate (Fig. 12), and limestone, the last being vicinal, but as it does not take a good edge, it was not much used.

The sharp edges of the examples figured indicate that they were knives; the obtuse and transversely curvilinear edges indicate scrapers; Figs. 1, 2, 3, seem to have been pointed for the additional function of boring; and the grayish-white quartz specimen Fig. 13, 13*a*, has been carefully chipped into a concavo-convex form narrowing to a lateral point; with an edge on each side, constituting a kind of knife (perhaps used with a handle), the curvature of which suggests that it was a skinner. Compare Evans, Stone Implements, p. 317, Fig. 268.

In the knife, Fig. 12, the inferior or convex margin forms the edge, which continues to the narrower end, the upper, concave margin being obtuse, and at right angles with the sides: material gritty slate.

The bur which often appears at the point where a sudden blow is given in breaking off a flake, is seen at the upper or narrow end in Fig. 10; and curved forms from the same cause appear in the trap specimen, Fig. 3, in the porphyritic specimen, Fig. 11 (a point of which I have polished to exhibit the material), and in the indurite (indurated clay), examples Figs. 6, 7, 8.† The last mentioned material pertains to the Drift, and came from the Conewago Hills ten miles north. The name indurated

*For convenience, this rock will be called *indurite* in these pages. It will include baked (but not vitrified) clays, often due to the vicinity of trap masses, and usually hard enough to scratch glass.

†See Lubbock, Prehistoric Times, p. 85–89, on similar forms, and the mode of making them in Australia.

clay might imply lack of hardness, but the material has been metamorphosed by the Conewago trap, which seems to be present in the flake, Fig. 3. This indurated clay is black when fractured, and gray when weathered.

Some of the knives figured exhibit great age, particularly the trap or dolerite, Fig. 3. Of Figs. 6, 7, 8, the first has the sharpest lines, while they are least distinct on Fig. 8, representing probably one of the oldest of the specimens found, as it occurred not only below the thirty inches of black mold, but below the surface of the yellow clay. Occurring with cognate forms and material, and among the results of human skill, its reference to the hand of man rests on a different basis from that of a chance specimen from field or shore.

CHAPTER II.

CHISELS. PL. 2.

What are here called chisels are also known as Celts—a term which should be restricted to the people who bear this name.

Figure 1 represents a rude implement of gray sandstone, probably from the mountains north of Harrisburg. Apparently shaped from a river pebble; one end has a straight edge suited for cutting, the other is obtuse and curved, adapted for scraping, both ends coarsely shaped by hammering, and inefficient from the first, unless spoiled by use. Greatest thickness about an inch, and the thickest specimen of those figured. Hard enough to scratch glass.

Fig. 5, a hard, fine-textured, pale, bluish, siliceous shale, flake-shaped by hammering; margined with a sharp but irregular edge. Less rude than Fig. 1; average thickness about half an inch.

Fig. 6, a well-finished chisel of ruddy quartz; without polish, but the marks of chipping scarcely apparent: edge in good condition; sides sharp; base truncate. It has no indication of age, and I think it occurred about a foot from the surface.

Figs. 2 and 7, apparently of Conewago dolerite; each originally finished with a rubbed or ground edge, which, with the entire surface, has become roughened and gritty by long corrosion. In 2, the edge surfaces are slightly convex.

Fig. 3, of indurite; the rubbed or ground edge of its early state, and the entire surface, have become harsh (but not gritty) from corrosion, which has removed part of the original surface, leaving fine veins and small nodules of a harder material to project from the new surface. When similar objects occur in fields or along rivers, the wear of the surface is attributable to friction and erosion; here, the action is not mechanic but chemic.

Fig. 4, sandstone; some evidence of the rubbed edge remains.

Fig. 8, a rather regular chipped chisel; terminal edges and a medial portion from end to end polished: one edge in good condition, the other battered. Although the edge surfaces seem too convex for serviceable cutting, the skill of the workman appears (as in modern axe-grinding) in the uniformity of the surface. A dense indurated clay, scratching glass, and admitting of a fine polish: no indication of age: thickness about two-fifths of the width.

CHAPTER III.

SCRAPERS. PL. 3.

We must not suppose that primitive utensils were restricted to special uses, like the varied contents of a modern workshop, a primitive axe being at hand to do duty for a hoe, a net-sinker to act as a hammer—* yet knowing the habits of modern savages, and judging the capabilities of an implement, we will seldom fail in assigning it to its proper use. While many knives and scrapers may be used indifferently, in most cases we may be allowed to separate them—hence the present section.

Figs. 1, 2, represent what I suppose to be natural spalls of quartzite, of which sharp fragments were always procurable at this locality.

Figs. 5, 6, of indurite, with little or no work after being severed: both marked with yellow clay.

Figs. 4, 16, white quartz, the latter one from the black mold. The edge of No. 4 is thin and sharp, it includes the rounded extremity, about half the convex and one-third of the concave margin.

Fig. 10, thick at base, thinner towards the point, chipped from a black chert pebble.

Figs. 11, 15 (both from the black mold), and 19 are of hard cherty stone. In No. 11, the convexity of the edge is slight, in others much greater.

Figs. 3, 7, 8, 12, 13, 14, red jasper of various tints. A remarkably large bur ("bulb of percussion") appears on No. 3, which has a perforation due to a drusy cavity.

Fig. 7, a beautiful, bright, polished, red flake, beveled by chipping along the right margin: a less abrupt bevel on the narrow part of the left side: inferior or flat surface slightly concave. Compare Reliq. Aquitanicæ, A, Pl. X, Fig. 5; and Evans (Stone Implements, Fig. 397), who remarks that, "Such scrapers also occur in most of the caves which have furnished implements in France and Belgium, and usually in much greater proportional abundance than has been the case in Kent's Cavern.

* "I admired the cleanness and flatness of all their yards. The ground is first covered with a soft wrought clay, and smoothed by rolling hard clay vessels over it."—Rev. John Campbell. Travels in South Africa, vol. 1, p. 244, 1822.

* * * * They appear to me to have served for other purposes besides that of dressing skins—one of the uses to which such instruments are applied by the Esquimaux of the present day." p. 455.

Fig. 8, reddish-brown, jasper flake; flat surface (upon which it probably reposed) retaining some of the natural polish of the fresh fracture, which is scarcely present on the upper side. Probably from the yellow clay.

Fig. 9, yellow jasper retaining polish; chipped on both sides: apex adapted for boring: lateral notch seemingly for scraping sinews, intestines, and arrow-shafts. (See my "Gleanings," in Peet's Am. Antiquarian, July, 1878, p. 81, and Reliq. Aquitanicæ, A. Pl. 35, Fig. 4.) Found June 1, 1876.

Figs. 11–15, all show marks of chipping; 14 probably required a handle, it resembles an arrow, blunt arrows having been in use. (Am. Antiquarian, 1878, p. 79.) Fig. 11 has one edge beveled by chipping; from the black mold.

Jasper occurs sparsely among the pebbles of the Susquehanna, and seems to have been selected as much for its beauty as for its utility.

Figs. 17, 18, chipped from small black flints of which part of the original surfaces remain. They bear some resemblance to gun-flints.

Fig. 21, represents one of the best finished objects found. It is of gray chalcedony, and might be regarded as a gun-flint, such flints being sometimes found at localities occupied by the former natives. The present object is neatly chipped into convexity on both surfaces, but not the short truncate base; the margins have cutting edges, that in front being concave and adapted for scraping objects like arrow-shafts.

Fig. 20, a thin piece of gray shale, the edge of the wider portion retaining the general thickness, and polished as if by scraping a concave surface—hence judged to be a pot-scraper. Another example occurred which resembles the wider half of this one.

Fig. 22, pale chalcedony with a rose tint: well finished, base abruptly chipped; inferior surface flat; scraping edge straight. See Rau, Archæological Collection of the U. S. National Museum, 1876, Fig. 38.

Fig. 23, impure limestone; probably combining the functions of arrow-scraper, borer, and small fish-spear.

Fig. 24, apparently quartzose limestone: chipping coarse: thickness nearly one-fifth of the length.

The Retreat has not afforded specimens of scrapers formed of broken arrow-heads by adding a new edge, although they occur in the vicinity.*

*Mr. Amos H. Gottschall has sent me a Dakota scraper he found in use (April, 1878) for removing fat and flesh from hides; it is a semi circular stone flake about $1\frac{3}{4}$ inch long and $2\frac{1}{4}$ wide, resembling the base of Dr. Abbott's Smithsonian Figure 38, but the surface and edge worn smooth. The skin to be cleaned is spread and fastened between two

CHAPTER IV.

BORERS. PL. 4.

Some of the specimens here figured as borers (as Fig. 1–9) may be regarded as equally representative of primitive arrow points, before these took regular forms.* (Compare C. C. Jones, Pl. 9, Figs. 31, 32.)

Of the borers represented, Figures 1-5, 12–15, 20, 24-26, are of white quartz (12, 14, 20, are marked with the black mold); 6, 11, 17, 18, 19, 21, 32, are quartzite of the locality, some of each material being mere spalls, but the points of 11, 14, 17, 18, 21, show marks of sharpening or use. Compare Reliquiæ Aquitanicæ, of Lartet and Christy, Figs. 23, 52, 55, 56, and A Pl. II. 1875.

Fig. 7, yellow jasper; 8, black chert; 9 pale argillaceous chert.

Fig. 10, indurite, with the surface soft from decay: probably from the lower or yellow clay stratum.

Fig. 16, a spall of red sandstone, but with an artificial notch on the right side.

Forms like Figs. 11, 12, 31, 32 (without a broad base), were probably provided with a handle of bone or wood. (Compare Sven Nilsson, Habitants primitifs de la Scandinavie, Pl. 2, Fig. 25.) Akin to these are the neatly chipped specimens, Figs. 22, 23, 27, of which Fig. 22 represents a common form, inasmuch as it is a fragment without a base—a part inferrible from that of Fig. 23, which has a sharp chisel-shaped edge—or from Fig. 30, which has an edge dulled by decay, and basal projections. A second specimen like Fig. 23 was found.

In Figures 13, 14, 15, 17, 19, the base has been left more or less wide for easy manipulation.

In Figs. 18 and 21, a short point is suddenly contracted from a wide base, left in its rough condition as a handle. (Compare Evans, Stone Implements, Figs. 227, 229; Jones, Pl. 16, Fig. 5.)

The white quartz specimens, Figs. 20, 24, 25, 26, and the slaty examples, Figs. 30, 33, 34, have the base more or less widened on one or both sides, as if to form a handle. (Compare C. C. Abbott, Smithson. Report for 1875, Figs. 142, 143, 149–153; and Evans, Stone Implements, Fig. 230.)

Fig. 28, has two lateral and tapering projections near the base, perhaps intended for additional borers. (Compare Jones, Pl. 9, Figs. 11, 12; and Pl. 16, Fig. 4.)

upright poles sunk in the ground, and having a cross-pole above. The Rev John Campbell (Travels in South Africa, 2, 72), saw natives making various kinds of skin thin for cloaks, by scraping them with a small iron adze. Heckewelder (Indian Nations, 1876, p. 202), says hair was removed with the ribs of deer, &c. "Even now, they say that they can clean a skin as well with a well prepared rib-bone as with a knife."

* Some of these could be used in tattooing, for which, according to Heckewelder (p. 206), "sharp flint stones" or "sharp teeth of a fish" (perhaps the pike or the lucioperca) were used.

Fig. 29, I take to represent a borer, probably intended to be inserted in a handle. (See Abbott, Fig. 145.)

Figs. 35, 36, represent flattened awls, both sharply pointed when found, the blunt extremity polished, apparently by being held between the fingers in some such use as sewing.

Figs. 37-40, awls of bone, of which Fig. 40 shows scratches of the implement used in shaping it.

CHAPTER V.

ARROW-HEADS. PL. 5, 6.

Arrow-heads seem, upon both continents, to be the most common of all definite stone implements. The Chickis Retreat furnished about four hundred entire or fragmentary examples, excluding mere spalls and counting the many worked fragments which belong to this type.

The material used includes quartzite (Pl. 5, Fig. 15, 16; Pl. 6, Fig. 31), and white quartz (Pl. 5, Figs. 17, 18, 21; Pl. 6, Figs. 1, 2, 7, 8, 16, 18, 20, 21), both minerals of the locality; limestone of the vicinity (rarely used); and minerals selected from the pebbles and fragments along the shore and bed of the Susquehanna, such as red jasper (Pl. 6, Fig. 10), yellow jasper (Pl. 6, Fig. 22), chert, trap, indurite (indurated clay); and siliceous shale (Pl. 5, Fig. 22, 23, 25, 26; Pl. 6, Fig. 13, 23, 29, 32), hard enough to scratch glass.

The numerous broken specimens and the abundance of chips, suggest that the retreat was occupied by generations of arrow-makers; and it might be expected that four hundred specimens from the same work-shop, would exhibit many stages of the manufacture, and Plate 5 represents such an illustrative series. A pebble having been selected, and perhaps tried as to texture by detaching a chip, as in Pl. 5, Fig. 1, the next step is to break it in two, as in Fig. 1 and 2, of which the opposite half was possibly used, as the surface seems to present a favorable texture, particularly that of Fig. 2, which retains the fractural gloss, and the edge of both is sufficiently sharp to allow them to be used as scrapers. In Fig. 3 and 4, part of the unwrought surface of the stone or pebble remains, and a slight advance is made towards the final arrow form, an advance which appears in most of the figures. Fig. 5 may be a mere chip whose irregularity of fracture would have caused its rejection.

Figs. 11 and 14, may have been intended for borers.

Fig. 12, may represent the head of a fish-spear: with a good outline, the form is thick, and the work coarse.

Fig. 13, represents a flake of hard reddish-brown indurite, with a pale brown, decayed exterior, and harder resisting points projecting on the inferior flat surface: upper surface with the two rectilinear margins beveled, apparently by rubbing, but the lines marking the limits of the beveling are obsolete from decay: base broken. An interesting specimen.

Figures 15 and 16, represent quartzite points judged to be of great age from the dull surface and weather-beaten aspect in so hard a mineral.

Most of the specimens here figured indicate that the point was the first part finished; and in the quartz example Fig. 21, and siliceous shale, Fig. 22, an unremoved mass of the material remains at the base. Figures 24 and 25 indicate that the basal notches were the last parts made.

The form of Fig. 25 is unusual, but it occurs in Pennsylvania. Dr. Rau (Archæol. Coll. 1876, Fig. 47), figures a specimen from Georgia.

ARROW-HEADS. PL. 6.

Figures 1, 2, 7, 8, 16, 18, 20, 21, white quartz, all seemingly from the black mold except the leaf-shaped, Fig. 16, with which compare Jones, Pl. 9, Fig. 3; Abbott, Fig. 101; Rau, Fig. 4.

Fig. 2, has a good outline, but each surface has a rough medial projection indicating an unfinished condition: the surface has lost most of the fractural gloss.

Figs. 3, 17, chert or black flint: glossy and neatly finished. Compare Abbott, 1875–6, Fig. 83; Jones, Pl. 9, Fig. 26; Rau, Fig. 6.

Fig. 4, chert: marked "Chickis? recess, March 26, 1877." I have several New Jersey specimens of this form from Mr. Wm. Klingbeil. Rare in Pennsylvania; less rare in Georgia, whence I have examples from my friend Dr. J. L. LeConte, of various sizes (some more slender), with the base more deeply emarginate than in Fig. 4.

Figs. 5 and 6, chipped from hard gray quartzose material: fracture glossy. See Abbott, Fig. 82.

Fig. 9, pale bluish-gray chalcedony. Arrow-heads of this material occur rarely in the vicinal fields, also in the next County of Chester, and in East Tennessee.

Fig. 10, dark-red chipped jasper with a fresh surface: a handsome specimen found in the earlier period of the excavation—probably about ten inches from the surface.

Fig. 11, edges serrulate; material cherty, surface dull.

Figs. 12 and 23, have the lozenge shape, which is rather rare in the vicinity. Compare Evans, Stone Implements, Figs. 296–7.

Fig. 14, bluish, resembling a cherty, shaly limestone: scarcely hard enough to scratch glass. Rudely made by the removal of flakes, as in the hard shale specimen, Fig. 29.

Figs. 11, 12, 13, 25, 26, 32, are of a black cherty material without gloss.

Fig. 19, light brown jasper; neatly chipped; unsymmetric.

Fig. 20, base bifurcate, adapting it to a corresponding part in the terminal notch of the shaft, to prevent lateral motion, as shown in recent stone-tipped arrows from Utah. Form widely spread, but not common.

Fig. 22, a delicate thin specimen of yellow jasper; the slight gloss upon one surface is due to brushing. Found March 6, 1876. I have the form from New Jersey, East Tennessee and Texas, from the size of a small arrow-head (about $1\frac{1}{2}$ inch long, $\frac{3}{8}$ wide, sides sub-parallel), to that of a spear-head.

Figs. 24 (blackish), 33 (black), 34 (yellowish), apparently of indurite, have the appearance of great age; surface of 24, 34, much corroded.

Figs. 25, 26, 27, 32, cherty, without lustre: 26 is obtuse-angled, the sides being unequal—a form of which white quartz examples occur in the next County, Chester.

Fig. 28, a broken specimen, pale bluish, resembling cherty limestone; shape of the base unusual.

Fig. 30, of black gritty stone: old and irregular.

Fig. 31, quartzite of the locality, of two colors, pale gray and pale ferruginous: presumed to be old.

Fig. 35, represents a thin regular metallic arrow-head of a coppery appearance, but yellow on a new surface, and presumed to be European brass, therefore within the historic period, with brass dishes occurring in graves. It was found outside of the retreat.

CHAPTER VI.

SPEAR-HEADS. PL. 7.

Except in size, there is little difference between spear-heads and arrow-heads; and there is probably no difference between the heads of spears, whether used for thrusting or for throwing.* Certain broad, triangular forms (as Figs. 11, 12), seem intended for fish-spears, the barbs being sufficiently broad to hold in the soft muscle of fishes.

Of the specimens illustrated, Figs. 1, 2, 4, 5, 7, 11, show marks of age and decay.

*Dr. Abbott distinguishes between a lance and a spear, assigning to the spear-head "a notched or stemmed base, or both, which features singularly or together characterize the spear-head proper, which, also, are smaller as a class than lance-heads, but too large to be of use if placed at the end of an arrow."—Stone Age of New Jersey, Smithsonian Report for 1875, p. 269.

Figs. 1, 4, indurite; surface pale greenish, with hard projections left by decay; a chip from No. 4, shows a black interior. When entire, the length of this specimen may have been about five inches.

Figs. 3, 9, 13, resemble cherty limestone, but do not effervesce with acid: No. 9 and 13 are pale bluish, No. 13 darker.

Fig. 5, dark indurite, gritty from decay and having several projecting nodules, like No. 1 and 4: surface greatly decayed.

Fig. 6, a pale brown grit; robust, chipped coarsely but with skill; lines of fracture distinct, a sharp medial ridge on the inferior surface, extending about three inches from the point: length 4, greatest thickness $\frac{5}{8}$ inch.

In Fig. 7. the surface is like that of No. 5: robust; length 4, breadth $1\frac{1}{2}$, greatest thickness $\frac{7}{8}$ inch, due to a bulge on the upper surface.

Fig. 8, material cherty, black, without gloss (resembling Figs. 11, &c. of Pl. 6): edges finely chipped and somewhat serrulate towards the apex: ridges or fracture distinct: length 4 3-16, greatest thickness $\frac{3}{8}$ inch. A second example was found.

Fig. 9, thin and delicate, inferior surface flat, upper surface shaped with a few flat chips: length $3\frac{3}{4}$, greatest thickness less than $\frac{3}{8}$ inch, due to a bulge near the base.

Fig. 10, a black glossy chert or flint, but less glossy than Figs. 3 and 17 of Pl. 6: both sides neatly worked; ridges of fracture low but distinct: length $2\frac{7}{8}$, greatest thickness $\frac{1}{4}$ inch. A well finished and rare specimen, one of the finest found, which might, perhaps, be classed with arrow-heads. I have seen a specimen very like it, found in Ohio.

Fig. 11, pale bluish, surface roughened and lines of fracture lost by decay.

Fig. 12, a coarse specimen of rough grit; old, but lines of fracture apparent.

Fig. 13, represents the apical portion of a broken lance-head somewhat resembling No. 7, but of a kind wider and flatter, leaf-shaped or oval, with a rounded base, of which Dr. Abbott's Fig. 38 (1875) is an average form on the Susquehanna, and of which the Retreat furnishes a fragment (rather more than the basal half) which scarcely differs from the corresponding part of Abbott's figure. Its material is that of Figs. 3 and 9; its greatest thickness about $\frac{3}{4}$ inch.

CHAPTER VII.

HOES AND DIGGERS. PL. 8, 9.

As the arrow-head passes into that of the spear, so when the form classed with spear-heads is regarded as too large for this weapon, its function is, with probable reason, considered to be that of a hoe. But the Retreat has not yielded an example of the lance-head form (such as Abbott's Fig. 37), large enough to be classed as a hoe, although the form occurs in the vicinity, and on the Forge islands seven miles above. A specimen was found about 170 yards north of the Retreat.

Fig. 1 (Pl. 8) is adapted for digging, and may be termed a hoe: it is formed of a gritty flat river stone; upper and lower surfaces nearly parallel; left margin flat and vertical; right margin coarsely chipped to a medial edge; point similarly chipped: part of the base wanting; present length about $6\frac{3}{4}$, thickness $1\frac{1}{4}$ inch.

Fig. 2 (Pl. 8), a flat oval sandstone pebble; one edge broken as if for a handle; one end apparently broken by use; greatest thickness about $1\frac{1}{8}$ inch.

Fig. 3, described at the close of the chapter on hammers.

Pl. 9, Fig. 1, represents the only distinctly grooved implement found, a river pebble with an original thickness of about two inches: groove pecked in the upper surface, not reaching the margins: edge narrow and flat, formed by removing a few large chips from both surfaces: a very large spall has been split from the basal portion of the lower surface, leaving a plane about 4 inches long and 3 wide. The spall may have been split off intentionally for the purpose of adapting a handle at right angles to the cutting edge.

Pl. 9, Fig. 2, dolerite, rough and gritty from decay, exterior particles so slightly attached as to be removable in handling, showing the absence of abrasion during the period of decay in the soil of the Retreat. There is some appearance of a notch and groove, which point to a war club. Base $1\frac{3}{8}$, narrowing to $\frac{5}{8}$ inch thick at the opposite extremity; no edge remaining.

Pl. 9, Fig. 3, a quartzite digger, the handle trimmed and well adapted for holding: greatest thickness $1\frac{1}{4}$ inch. Probably intended for taking up roots.

CHAPTER VIII.

SINKERS. PL. 10.

It has been customary to regard certain notched stones as net-sinkers, and at the Centennial Exposition at Philadelphia in 1876, there was a wide-meshed seine (I believe from Northern America) made of narrow thongs, the lower edge of which was weighted with such stones. Some of the larger examples of these stones may have been used as weights to the vines with which streams were swept to drive the fish into weirs, or as anchors to long lines (out-lines) set during the night, with attached shorter lines or links bearing the hooks.

Figures 1, 3, 5, represent rough specimens made of the quartzite of the locality.

Fig. 1, is distinctly notched upon one margin, the other being nearly in its natural condition: margins with a sharpness seemingly due to natural fracture, except that which forms the top of the figure, which has the appearance of being artificially rounded and provided with the cutting edge of an axe, of which it may be a rude specimen. Thickness $1\frac{1}{8}$ inch.

Fig. 2, a river pebble with a rough notch on each lateral margin: thickness $1\frac{3}{4}$ inch: might pass for a hammer: found January 17, 1876.

Fig. 3, a single notch broken from the thin edge of a natural fragment.

Fig. 4, flat, gritty slate; the commoner form in New Jersey and Pennsylvania, —rare in the vicinity. The specimen occurred in digging outside of the Retreat, May 26, 1876. Compare Abbott, Fig. 204; C. C. Jones, Pl. 19, Fig. 11; Rau, Arch. Coll. Fig. 112.

Figs. 5–9, probably fishing-line sinkers, of which 6, 7, 9, are made of river pebbles.

CHAPTER IX.

HAMMER-STONES. PL. 11.

The Retreat furnished about fifty stones, mostly river pebbles, varying in form and size, some marked, others unmarked, the latter of which, if found with river gravel, would not be entitled to mention here, but being placed by human hands in a human habitation, they are to be classified as implements. All of the specimens figured except Fig. 2, are of sandstone, and all have marks of adaptation or use.

Fig. 1, was probably at first intended for something like the chungkee stone of the Cherokees and other tribes, and afterwards broken in being used as a hammer: both faces have the central depression for the thumb and middle finger: the edges of the cavities left by the removal of several marginal chips above, have lost their sharpness and the depressions have the dullness of the general surface, but a later chip from the lower surface exposes a fresher fracture with a well-defined margin. Brown sandstone: greatest thickness $1\frac{3}{4}$ inch.

Fig. 2, resembling a fine-grained graywack; much decayed: apparently from the yellow clay.

Fig. 3, a brown ferruginous sandstone pebble: upper, or less convex surface, with a slight depression formed by pecking: lower end broken, lines of fracture sharp.

Fig. 4, a pecked spot on the upper surface: marks of usage at three or four points of the margin: a chip removed from below, leaving a sharp margin: greatest thickness about $1\frac{7}{8}$ inch.

Fig. 5, subtriangular, with marks of usage: a single, coarsely made, medial depression: greatest thickness $1\frac{1}{2}$ inch. Compare Abbott's figure 217.

Fig. 6, an irregular ball, each extremity slightly roughened as if by pecking, or by use as a hammer. Balls of stone occur in the vicinity, and among the Western and Southern Indians. A sandstone specimen from a field in the vicinity of the Retreat, is about $2\frac{7}{8}$ inch in diameter, and another of quartz is about 3 inches; a third from the Forge islands seven miles north, of a siliceous material, measures $2\frac{1}{4}$ inches, and is the most regular of these. More nearly spherical is a small one ($1\frac{5}{8}$ inch) from East Tennessee, sent to me by Mr. F. A. Stratton. Probably from the absence of better material, balls of burnt clay were made in Florida, of which I have fragments indicating a diameter of about two inches.

Pl. 8, Fig. 3, represents a brown sandstone muller or paint grinder, as shown by the red material in crevices at the base.

The Retreat furnished no pestles, but a neatly finished brown sandstone example was found about 170 yards north of it; length $10\frac{5}{8}$, diameter $1\frac{7}{8}$ inch.

CHAPTER X.

I. TOMAHAWKS OF HONOR. PL. 12, FIGS. 1–4.

Parts of five examples of these light, perforated tomahawks (banner-stones, sceptres, or badges of authority) were found in the Retreat (Figs. 1–4), of which two of the halves (Fig. 4) belonged to one implement.

Fig. 1, siliceous slate with minute micaceous specks: hard enough to scratch glass: surface retaining some polish: ridges of fracture sharp: a small biconic perforation countersunk from each side. It retains some of the yellow clay in which it was buried, its position having been pointed out to me by the boy who found it, February 19, 1876, and unless his account was false, this is one of the oldest objects found. What is left of the perforation for the handle, has the striæ marking the boring, and some gritty projecting particles.

Fig. 2, material a yellowish steatite.

Fig. 3, of black slate: a doubly countersunk perforation from face to face (as in No. 1), through the thickest part of the fragment. These perforations are rather common, and seem adapted for dressing bow-strings.

Fig. 4, of black slate: the medial part is flat and angular on the side figured, and curved on the other: the margin of the right wing has one notch above and two below, the left wing three above—probably mnemonic. The half of a nearly similar specimen was present.

These implements usually occur broken at the eye, where the material is thin. The breakage may be due to a tightly fitting handle, to wedging a loose one, to its expansion from moisture, or to the fact that in some cases the perforation was made after the completion of the exterior.

II. PIPES. PL. 12, FIGS. 5–6.

Fig. 5, represents a taper steatite pipe, flat below and convex above: bore mostly uniform, but funnel-shaped at the larger extremity, and about as wide as the dimensions admit: a V-shaped excision at the larger end of the flat surface, and a fragment broken from the end of the convex surface. Resembles a modern cigar-holder, and is judged to be a smoking pipe, of which the figure probably represents about the original size.

Fig. 6, part of a pipestem of clay, slightly burnt: from the upper part of the black mold.

III. CORES AND CHIPS. PL. 12, FIG. 7.

Fig. 7, represents a gray indurite, of which the fresh fracture is black, an object which may be termed a core, as it shows that several flakes or chips have been removed from it of the kind which furnish cutting edges.

As part of the business of the Retreat was making stone implements, particularly arrow-heads, an abundance of chips and spalls occurred, many of foreign material, and with delicate points and edges indicative of manufacture on the spot, and subsequent repose.

IV. PEBBLES. PL. 12, FIG. 8.

In Chapter V, allusion is made to trying the texture of pebbles selected for making arrow-heads, by striking off a chip, and such a one is represented in Fig. 8. The chips varied in size from one-fourth of an inch to half the pebble, and sometimes the marks of two or three appear: in most cases the line of fracture is sharp, but in a few the sharpness has disappeared. The size of the pebbles is from about $1\frac{1}{2}$ to 2 or $2\frac{1}{2}$ inches; the form approaches to oval or spheric, but is sometimes round and flat, adapted for throwing, and perhaps collected (together with the smaller hammer-stones) for defence as well as for other purposes, but they did not occur in masses. Omitting doubtful specimens, the Retreat has furnished 455 of these pebbles, of which 160 are entire, the large number of 295 being chipped. Other chipped and unchipped examples, also some probable hammer-stones, borers, and scrapers, occurred from ten to thirty yards beyond the Retreat, and chiefly south of it.

Pebbles about half an inch in size (larger and smaller), perhaps collected for rattles, or due to ice; but river gravel does not appear in the soil, which has been recently (May, 1878), dug up for twelve yards in front of the Retreat to form a garden, the chief mineral present being small angular fragments of the quartzite of the vicinity, with an occasional entire or chipped pebble of the kind already mentioned.

A smooth flat river-stone, with vertical sides and rounded angles, occurred in the recess, and may have served for preparing food, for a baking-stone, or for a seat: 14½ inches long, 3 thick, 7½ to 8 wide.*

V. SHELLS. PL. 12, FIG. 9.

Several species of Unio inhabit the Susquehanna, and the shells occurred sparsely in the Retreat, mostly fragmentary and in a state of decay (as in Fig. 9, probably *U. radiatus*), but a more recent valve of *Unio complanatus* was found. The molluscs were probably eaten; the shells used for scrapers and tweezers;† and fine fragments are visible in the clay of some of the pottery found. Neither perforated specimens nor univalve species were observed.

VI. BONES. PL. 12, FIGS. 10–16.

Bones in various stages of decay or conservation were rather abundant; the hollow ones, such as Figs. 14, 15, are split, according to the habit of modern savages, who eat marrow.‡ Several of the specimens figured (Fig. 10–14) have been selected as probable awls, in addition to those of Plate 4. The originals of Figs. 13 and 14 are much decayed, and the latter is slightly notched on both sides, as if for the attachment of a string.

*I have from Mr. A. H. Gottschall a lenticular pebble, about 6½ inches across and 2¼ high, which he found in use by Sioux as a base upon which to pound flesh with a stone hammer.

†Heckewelder, Indian Nations, Hist. Soc. Penna., 1876, p. 205.

‡My friend, Prof. E. D. Cope, finds remains of the following species in the Retreat: *Cariacus virginianus* (common deer), bones abundant; *Sciurus hudsonius* (red squirrel); *Didelphys virginiana* (possum); Tortoise, species not determined; *Meleagris gallopavo* (turkey, a beak); and perhaps the domestic dog and sheep.

CHAPTER XI.

POTTERY. PL. 13, 14.

About 300 fragments of pottery were found within, or outside of the Retreat, and in some cases a piece apparently thrown out when a vessel was broken, could be fitted to another found inside; the finest example (Pl. 14, Fig. 9), was in four pieces, one from the inside and three from the earth outside.

The kinds are all more or less burnt; in some the burning from the inside is blackened for some depth, when the outside is reddish or yellowish, like a slightly burnt brick. Brown of various shades is a common color, and seems to belong to the more highly burnt, the thinnest, and most delicately made variety.

The material is clay alone, or clay mixed with finely broken mussel shells (Pl. 13, Fig. 1 and 21), or with grains of broken quartz (Pl. 14, Fig. 1).

In a few cases the exterior is smooth (Pl 13, Fig. 1), but the upper part of most of the vessels was marked with impressed lines and dots variously arranged for ornament, drawn before drying, apparently with the end of a small stick, quill, or bone; or impressed at right angles as with cords and knots (Pl. 14, Fig. 2), giving a netted appearance; also with a row or several rows left standing on an ear of maize (Pl. 14, Figs. 3, 4), or perhaps with the cob or spike. The inside of the margin or lip is rarely marked or ornamented (Pl. 14, Figs. 8*b*, 9*b*), and when the extreme edge is thick enough to admit of it (as in Pl. 13, Fig. 22, Pl. 14, Figs. 3, 4, 5, 7), this part may have ornamental impressions.

When a fragment wants the original margin, its upper part can be sometimes told by a curve indicating a widening towards the mouth, as in Pl. 13, Figs. 1, 3, 4, 5, 6, 8, 10, 11.

The margin is present in Figs. 9, 12, 13, 16, 19, 20, 22, of Pl. 13; and in 1, 2, 3, 4, 5, 7, 9, of Pl. 14. The presence of part of the margin shows the direction of the lines in Pl. 13, Fig. 20, but nothing remains to indicate that they were horizontal in the fragment Fig. 21.

The external impressions on the specimen Pl. 13, Fig. 12, resemble the row on the inside margin of Fig. 2*a*, Pl. 14.

The thickness of the pieces varies from $\frac{1}{8}$ to about $\frac{3}{8}$ of an inch: the somewhat irregular curve of a large fragment indicates a vessel 13 inches in diameter—a size which Pl. 14, Fig. 1, 2, 10, may have reached. Pl. 14, Fig. 6, represents a pot about 7 inches in diameter, and Pl. 14, Fig. 9, one of about $5\frac{1}{2}$ inches.

PLATE 14.

Figure 6, represents a piece of reddish, under-burnt pottery, with two perforations countersunk from the outside, and being intended for the reception of carrying-strings, they are frequently or mostly placed at a different level, to divide the strain and prevent the separation of the rim—as shown in modern practice. In most cases they seem to be bored after the vessel has been burnt.

Figures 1, 7, 9, represent an uncommon style of ornament, consisting of a row of small cylindric holes near, and around the margin, pushed almost through the material, and appearing in elevations or pimples on the opposite side. In some vessels the holes are impressed from the inside (Fig. 1), in others (Figs. 7, 9) from the outside. In Fig. 5 the surface is ornamented with circular holes irregularly distributed.

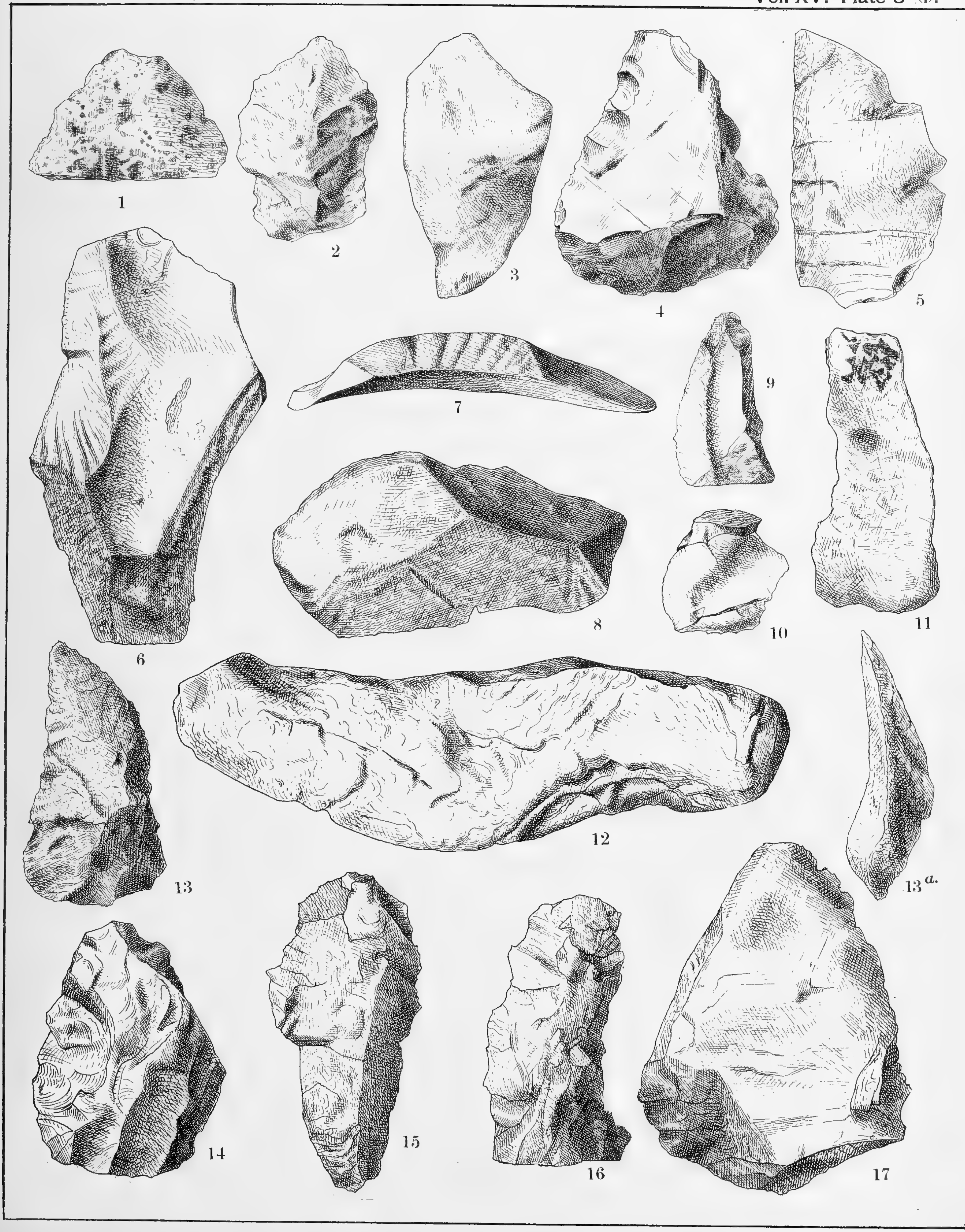
The lip of Fig. 2*a* has the inside marked with a row of impressions: Fig. 8 is marked outside (*a*), and inside (*b*): the section of Fig. 9 appears at (*a*), and the inside of the lip is represented at (*b*.) The flat lip of Fig. 7 (*a*) is ornamented with a series of transverse lines resembling the impressions made with a string of several small beads, both string and beads being impressed. The surface ornaments have this bead character. The pattern is composed of a series of horizontal lines alternating with others at an angle of 45 degrees, disposed thus:

The lines of some specimens are zigzagged vertically, as in Pl. 14, Figs. 3, 4, 9; others horizontally, like the large one referred to as having had a diameter of about thirteen inches.

The Retreat furnished a single rough fragment of steatite pottery about four inches across and one inch thick—perhaps brought in its broken condition to cut into ornaments. About 175 yards north of the Retreat an old steatite dish was found, with a projecting ear at each end: length of the interior $4\frac{1}{2}$, breadth 4, depth $2\frac{1}{2}$ inches. Fragments and vessels of steatite are widely spread, occurring in California.

Besides the brass arrow-point mentioned (Pl. 6, Fig. 35), the connection with the historic period is marked by a leaden rifle bullet, and four glass beads found outside, three greenish, spheric and corroded, the other blue, cylindric and polished.

Some fragments of two kinds of mineral paint were present, one red, the other black.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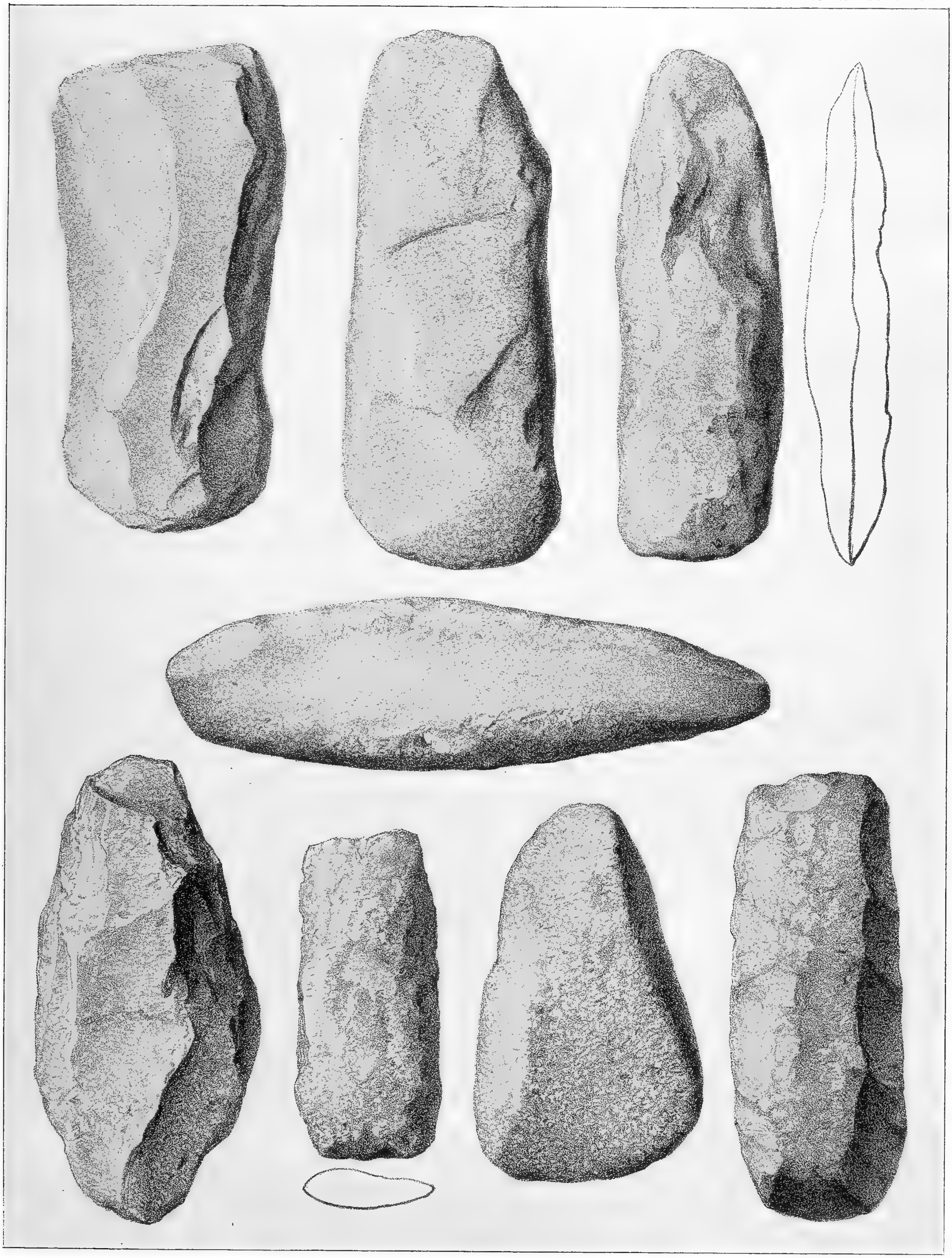

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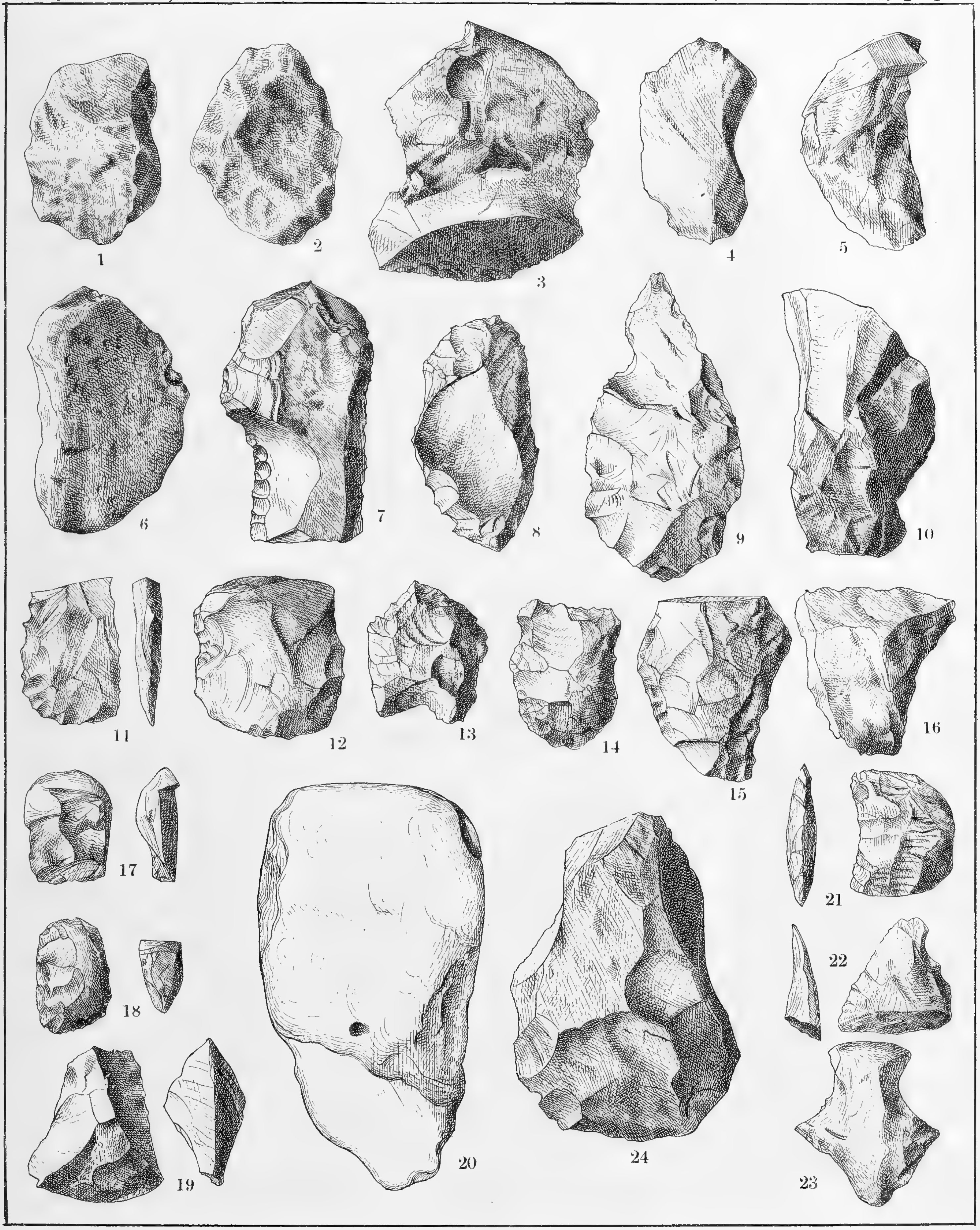
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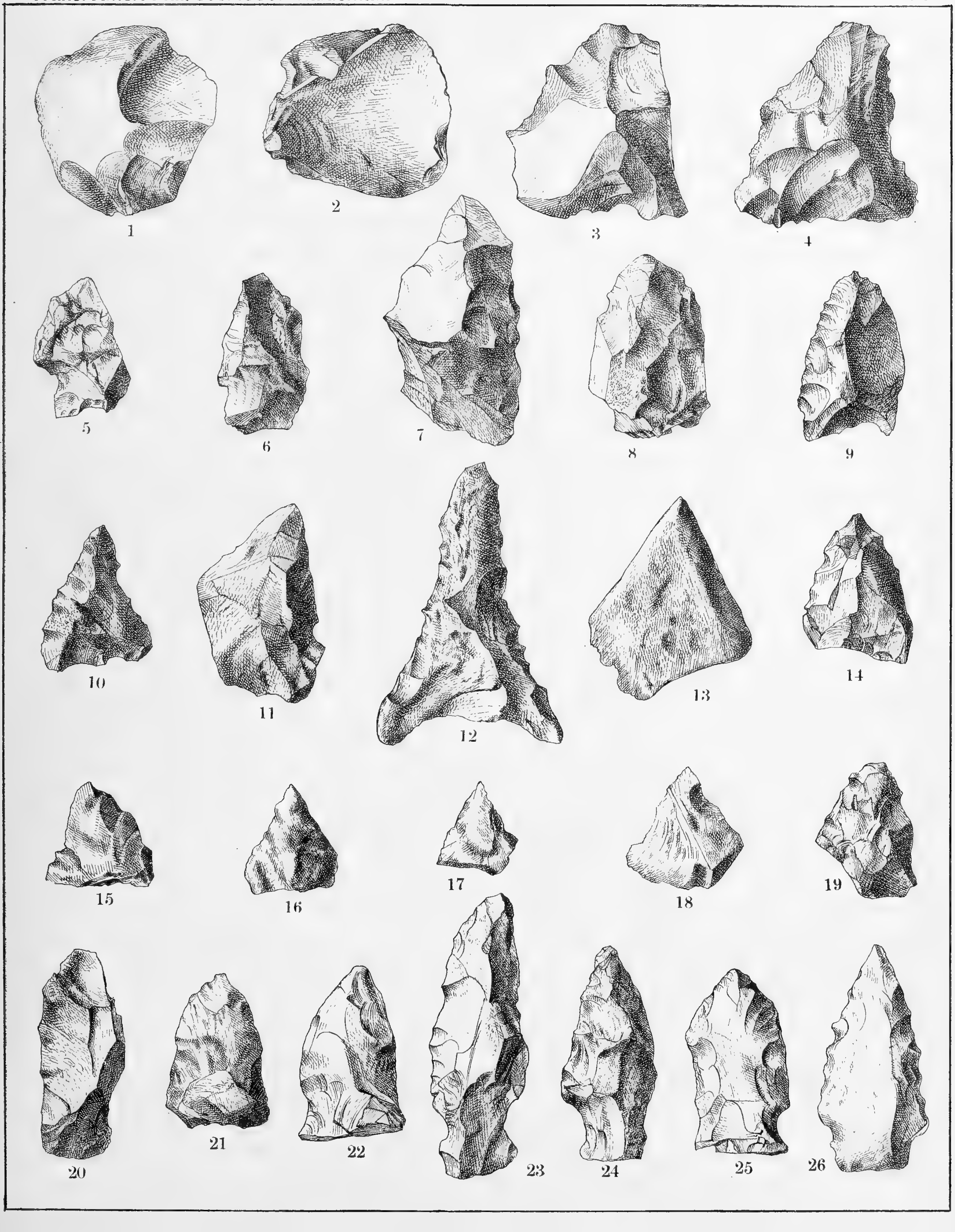
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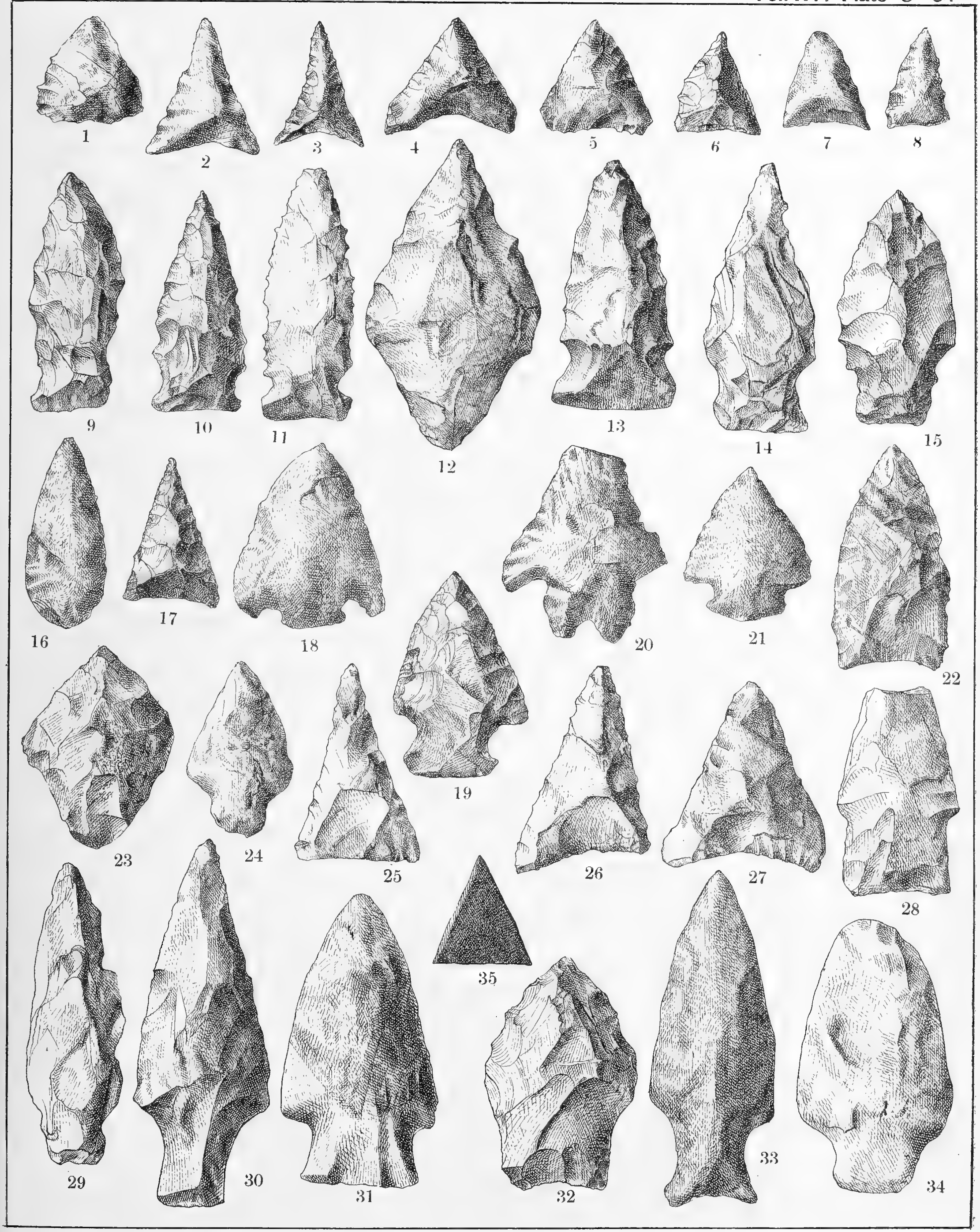
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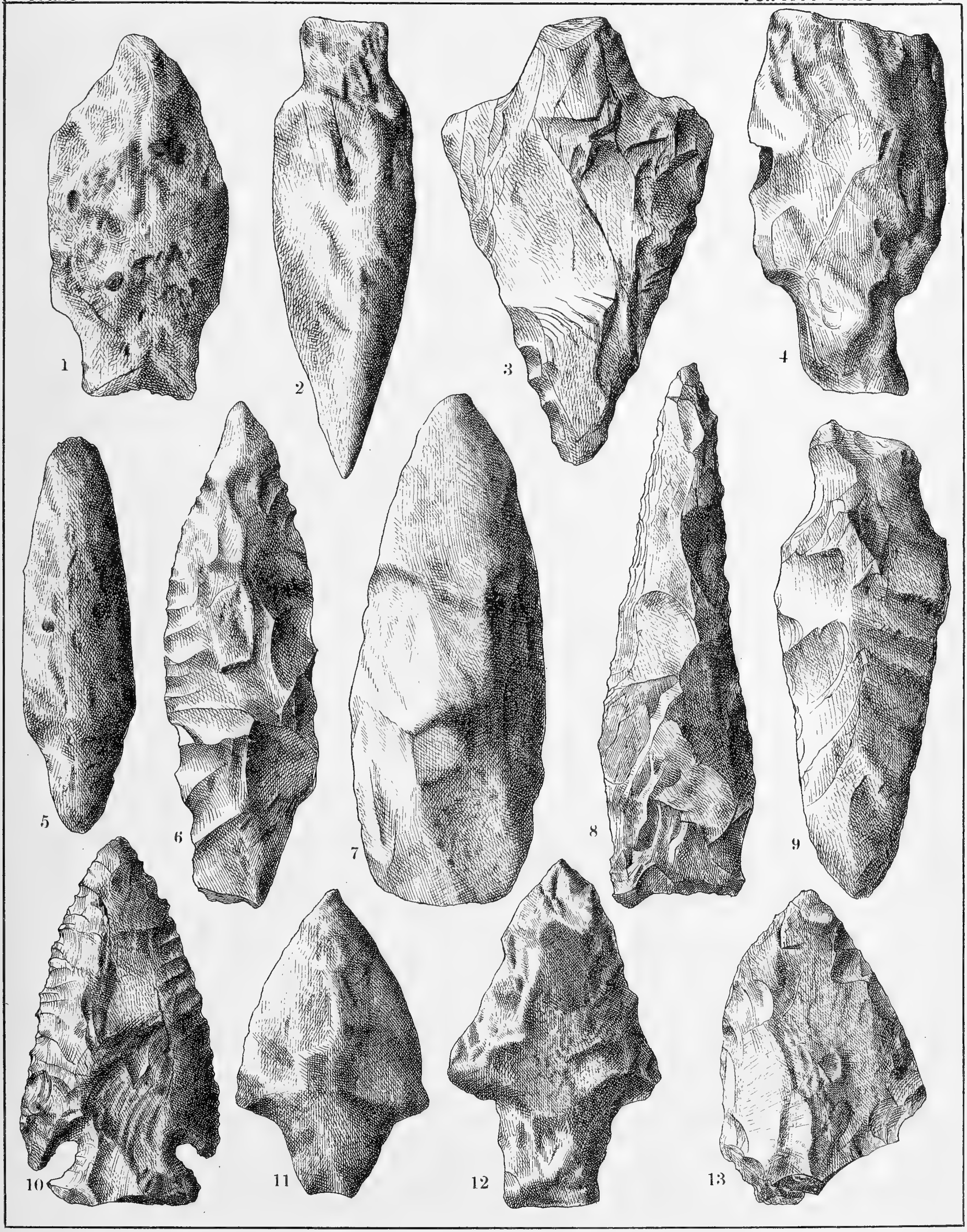
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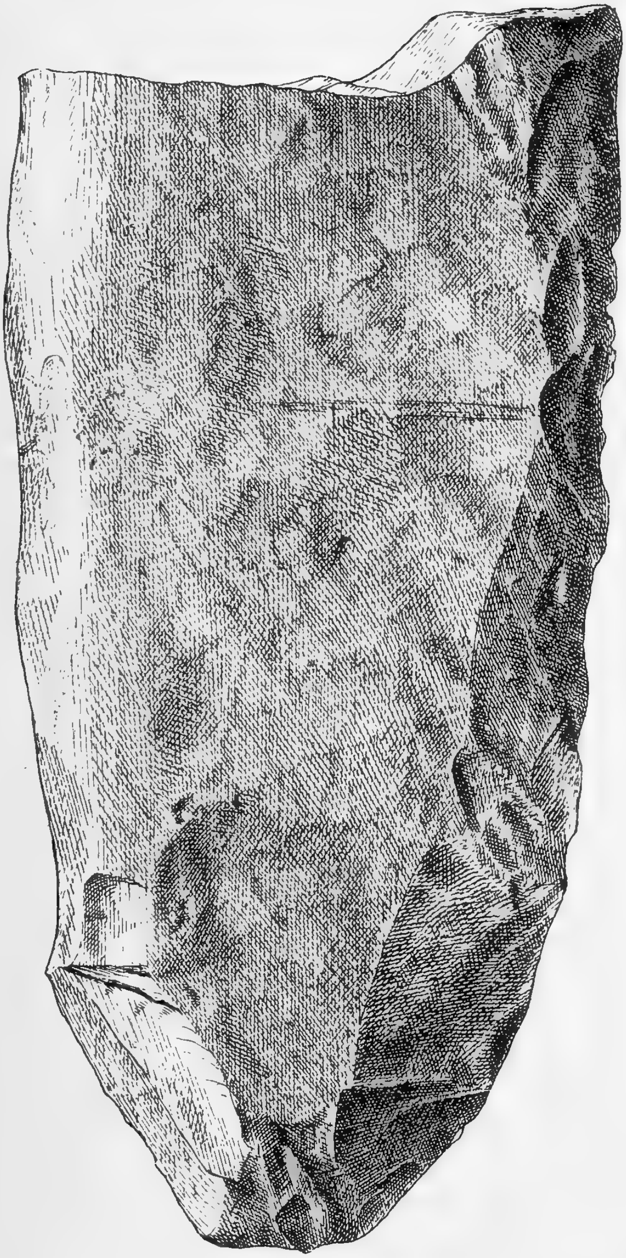

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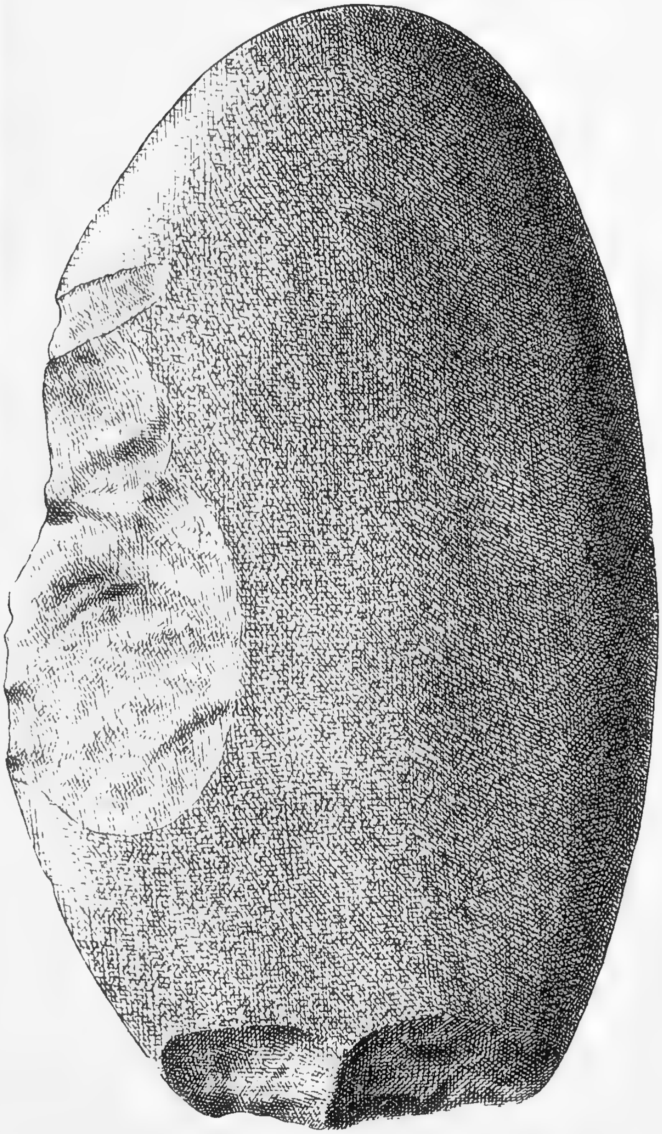

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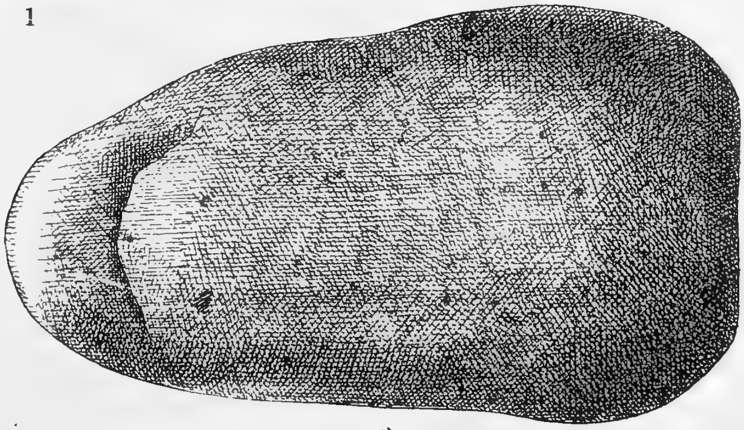

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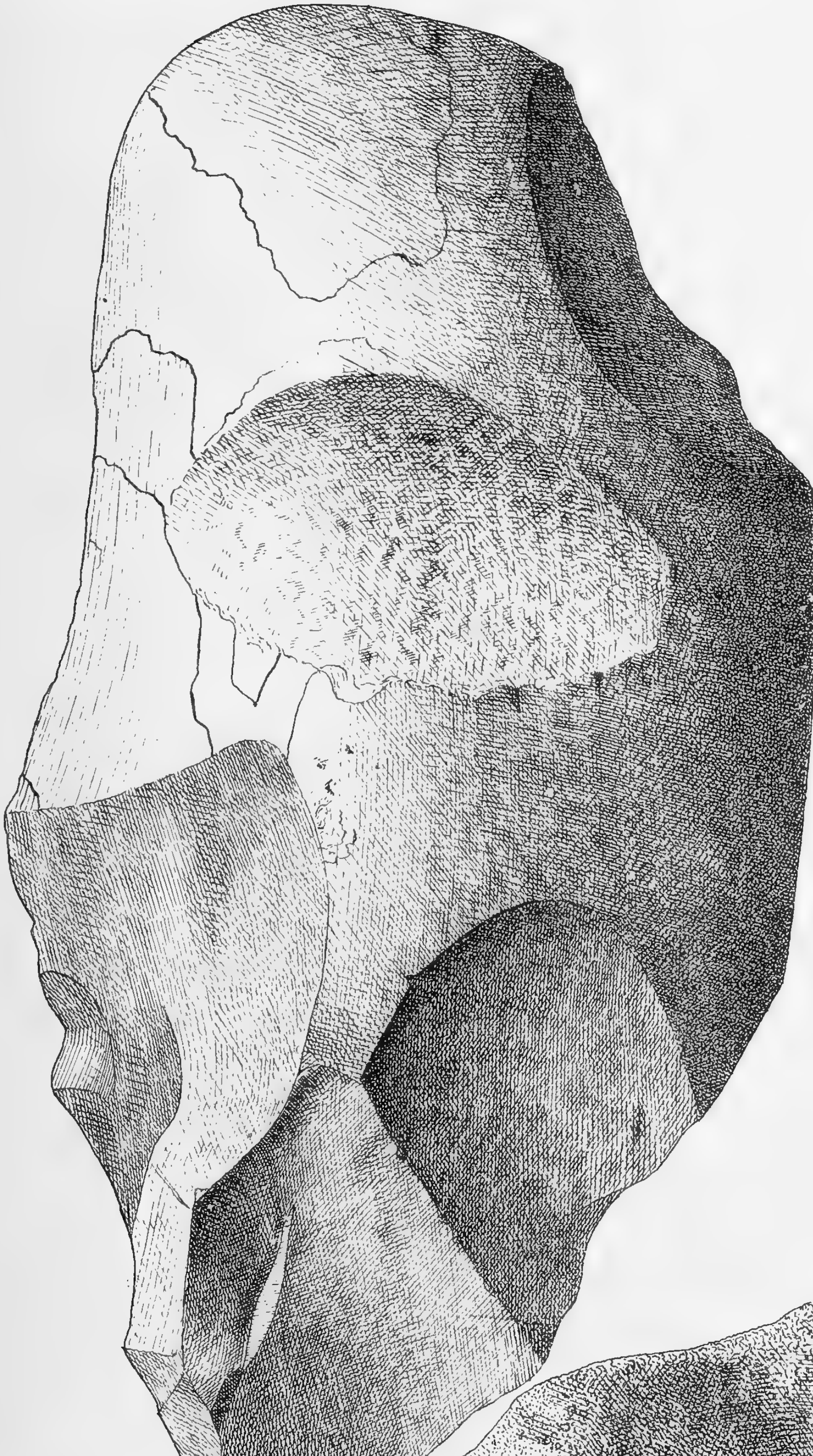

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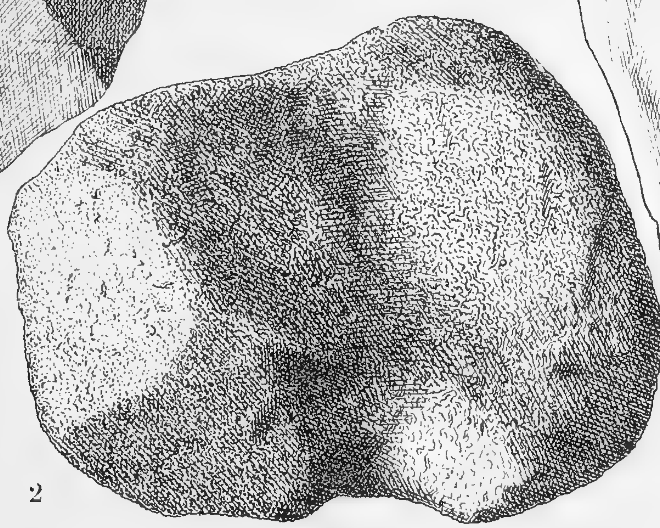

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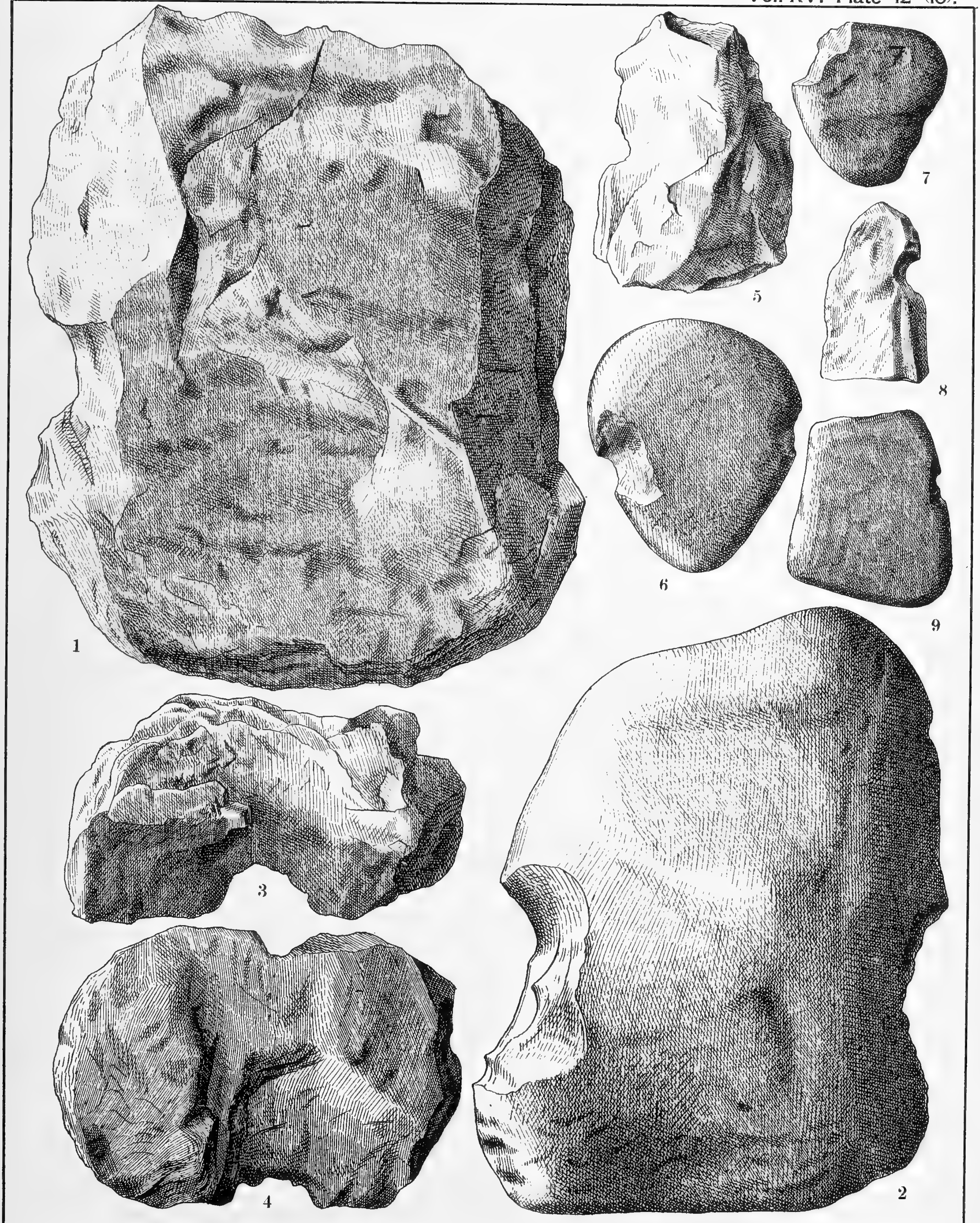
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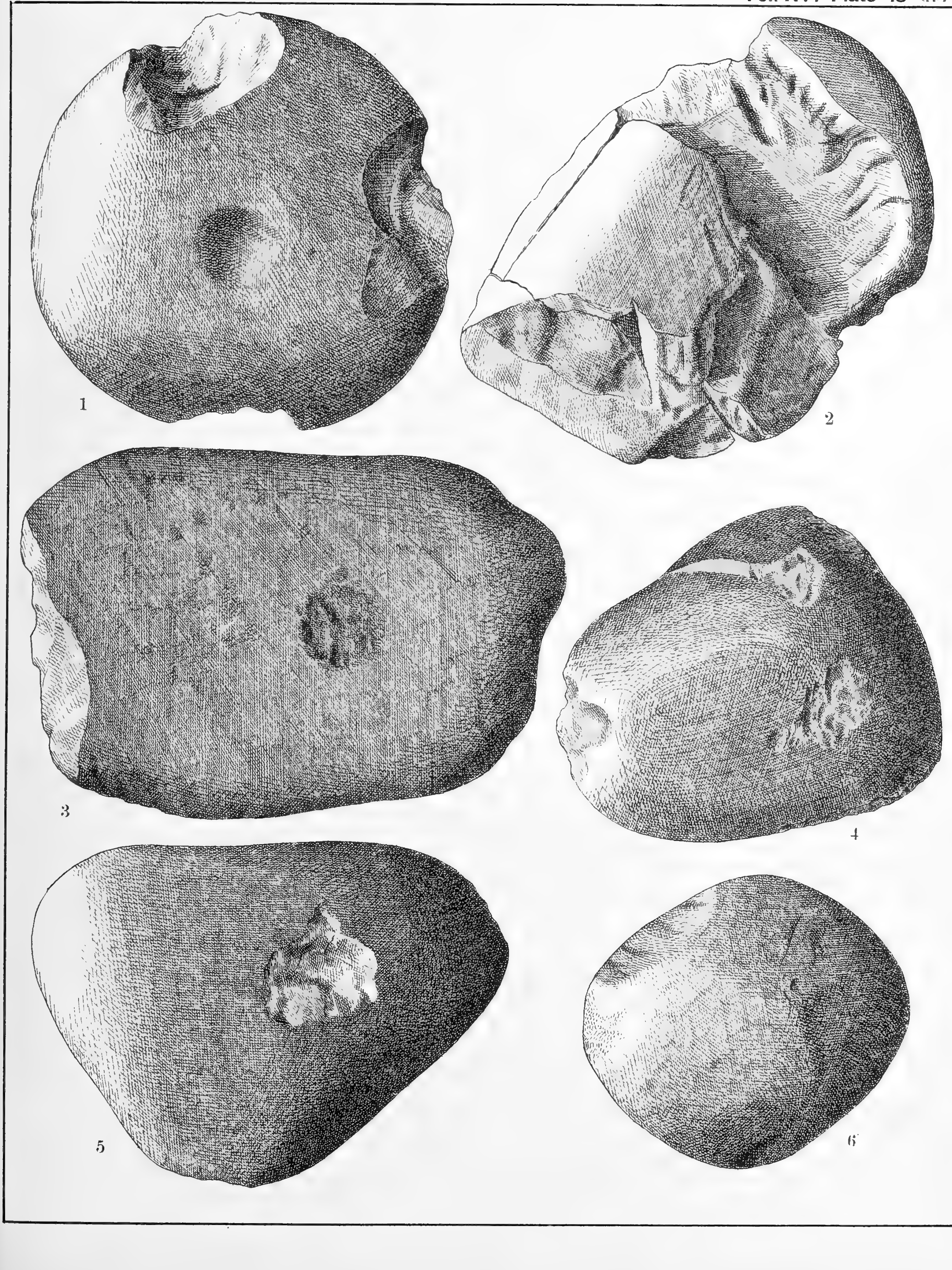
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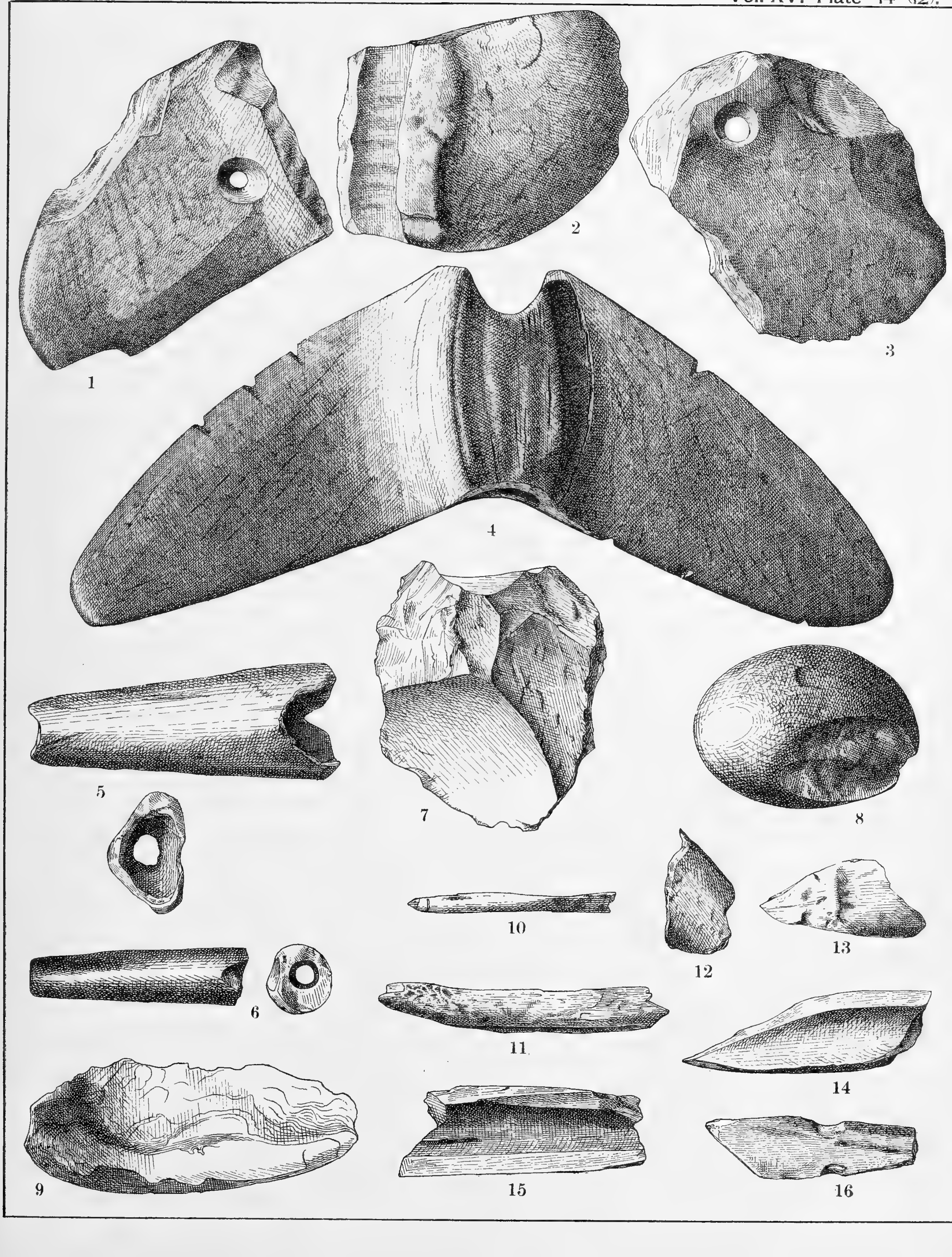
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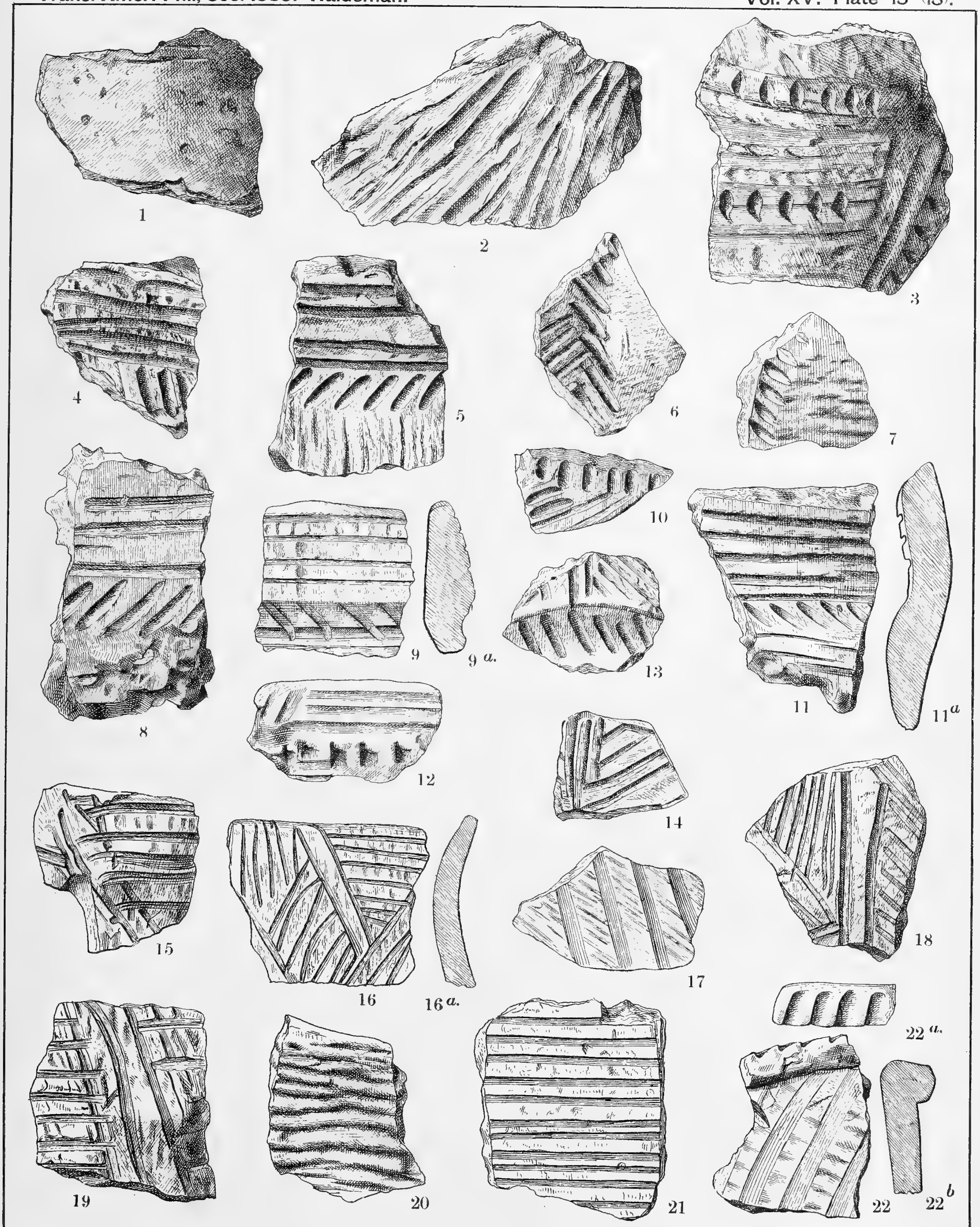
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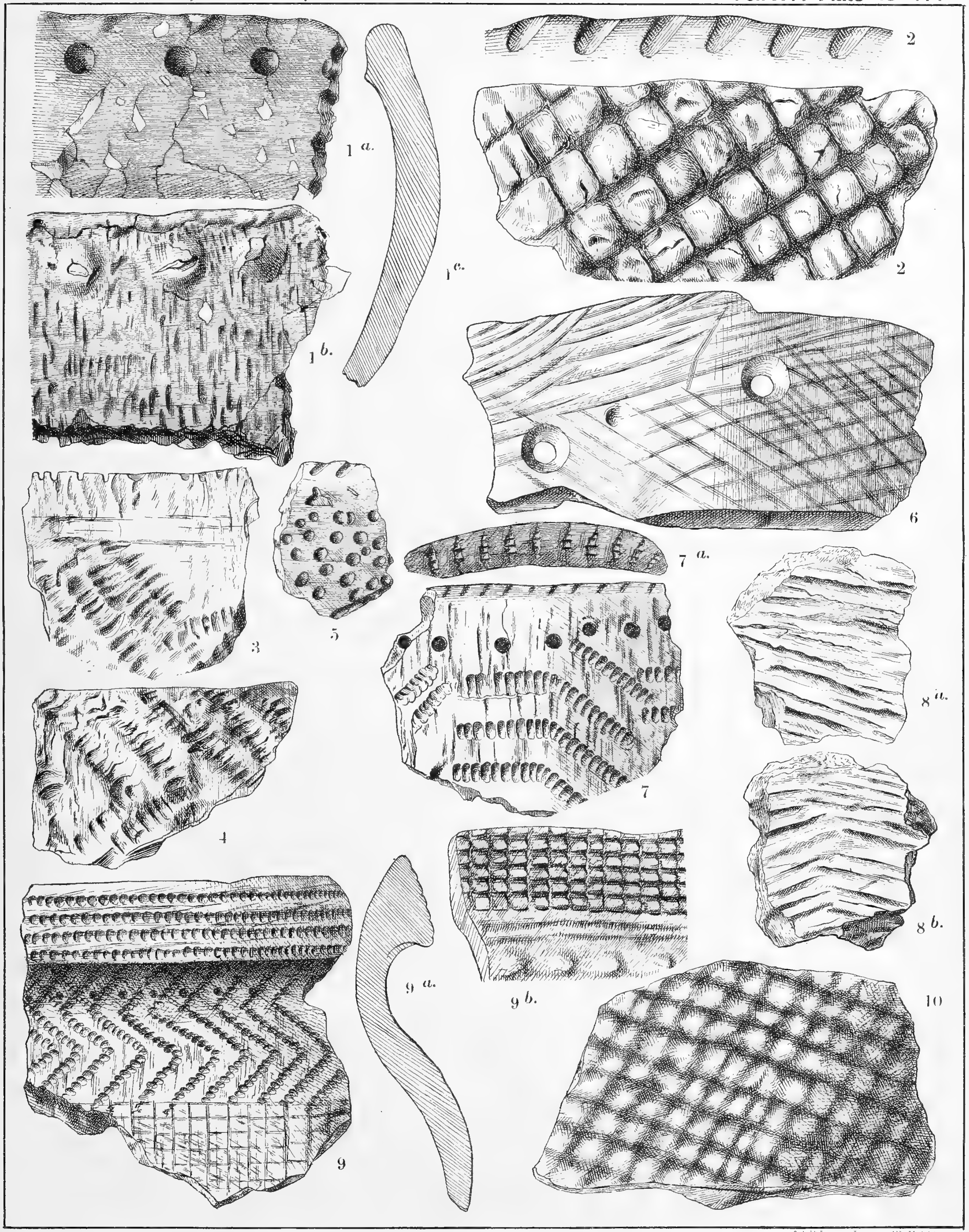

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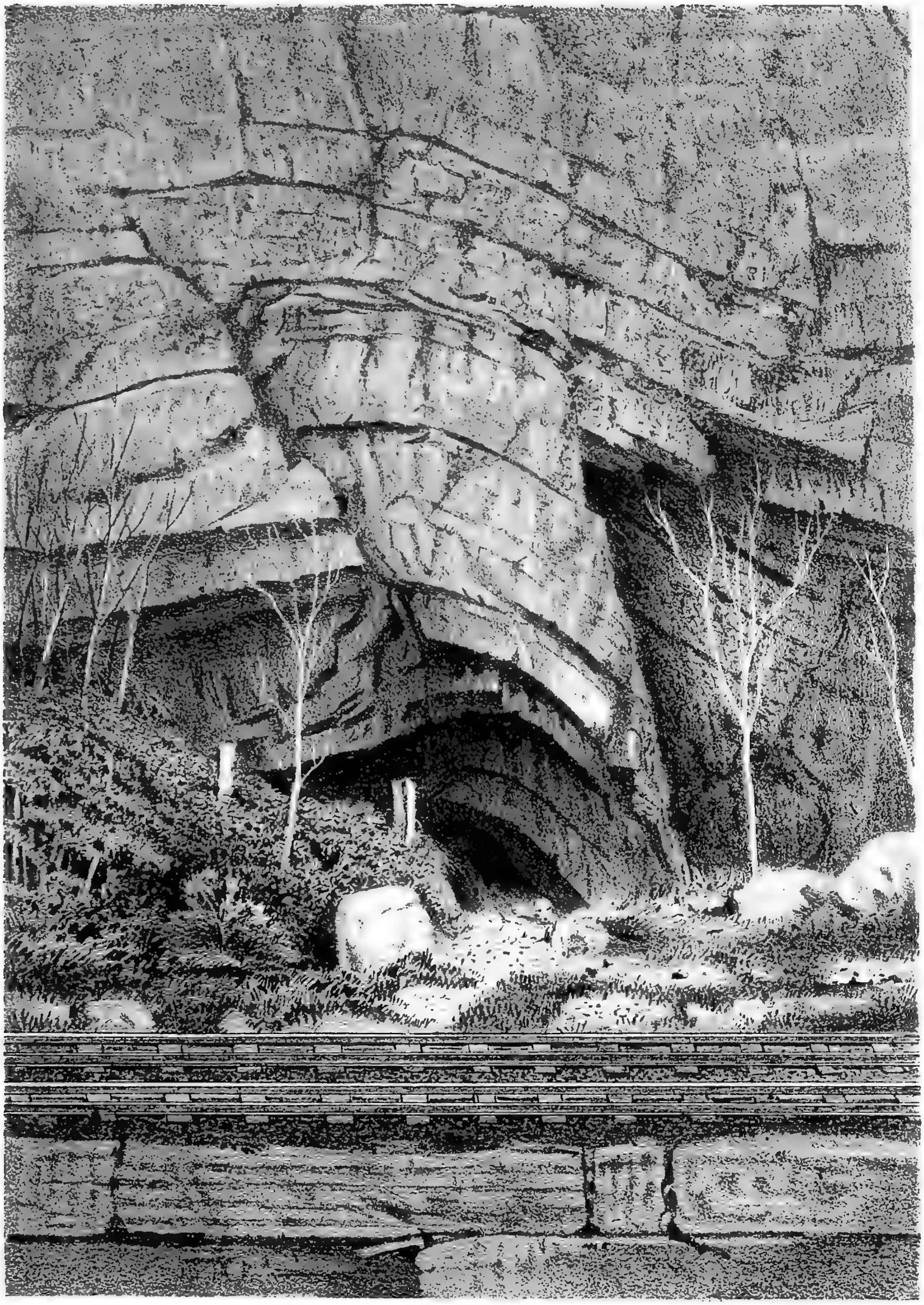

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