FLORIDA GEOLOGICAL SURVEY

NINTH ANNUAL REPORT

1917

FLORIDA STATE GEOLOGICAL SURVEY.

E. H. SELLARDS, PH. D., STATE GEOLOGIST.

NINTH ANNUAL REPORT.

PUBLISHED FOR
THE STATE GEOLOGICAL SURVEY.
TALLAHASSEE, 1917.

LETTER OF TRANSMITTAL.

To His Excellency, Hon. Sidney J. Catts, Governor of Florida:

Sir:—In accordance with the Survey law I submit herewith my Ninth Annual Report as State Geologist of Florida. The report contains the statement of expenditures by the Survey for the year ending June 30, 1916, together with those investigations by the Survey that have progressed far enough to be available for publication.

Very respectfully,

E. H. SELLARDS,

State Geologist.

THE E. O. PAINTER PRINTING CO. DE LAND, FLA. No 12047

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ADMINISTRATIVE REPORT.

EXPENDITURES OF THE GEOLOGICAL SURVEY FOR THE YEAR ENDING JUNE 30, 1916.

The total appropriation for the State Geological Survey is $7,500 per annum. No part of this fund is handled direct by the State Geologist, as all survey accounts are paid upon warrants drawn upon the Treasurer by the Comptroller as per itemized statements approved by the Governor. The original of all bills and the itemized statements of all expense accounts are on file in the office of the Comptroller. Duplicate copies of the same are on file in the office of the State Geologist. The warrants when paid are on file in the office of the State Treasurer.

LIST OF WARRANTS ISSUED DURING THE YEAR ENDING JUNE 30, 1916.

July, 1915

William J. Gerhard, publications	$ 1.65
T. J. Appleyard, printing	40.00
American Peat Society, subscription	3.00
Southern Express Company	6.26
H. & W. B. Drew Company, supplies	4.70
Glen Photo Stock Co., supplies	.98
Board of Public Works, supplies	18.20

August, 1915

E. H. Sellards, expenses, August, 1915	15.93
Southern Express Company	19.51
Alex McDougall, postage	27.10
Miss W. Wellborn, services	3.03
Wrigley Engraving Company, engravings	8.41
Maurice Joyce Engraving Company, engravings	168.40

September, 1915

E. H. Sellards, State Geologist, salary for quarter ending September 30, 1915	625.00
E. H. Sellards, expenses, September, 1915	10.05

Herman Gunter, assistant, salary for quarter ending September 20, 1915	375.00
Laura Smith, services	87.00
Ed Lomas, janitor services	30.00
S. A. L. Railway, freight	47.93
E. O. Painter Printing Company	1,426.34
W. E. Knibloe, services	25.00
Alex McDougall, stationery	109.68
H. & W. B. Drew Company, supplies	3.38
Dan Allen, freight and drayage	5.00

October, 1915

E. H. Sellards, expenses, October, 1915	96.65
Herman Gunter, assistant, expenses, October, 1915	68.89
Southern Express Company	9.77
Alex McDougall, postage	123.40
T. J. Appleyard, printing	28.00
Keystone Supply Company, supplies	5.30

November, 1915

E. H. Sellards, expenses, November, 1915	71.38
Herman Gunter, assistant, expenses, November, 1915	25.37
Southern Express Company	6.05
Letter Shop, supplies	2.25
Underwood Typewriter Company, supplies	54.58
Dan Allen, freight and drayage	1.45
Jules Eliott, supplies	60.00

December, 1915.

E. H. Sellards, State Geologist, salary for quarter ending December 31, 1915	625.00
Herman Gunter, assistant, salary for quarter ending December 31, 1915	375.00
Laura Smith, services	90.00
Ed Lomas, janitor services	30.00

January, 1916

E. H. Sellards, expenses, December, 1915, January, 1916	63.47
Herman Gunter, expenses, January, 1916	21.00
Southern Express Company	6.23
W. H. Lowdermilk & Co., publications	5.50
American Peat Society, subscription	3.00
Alex McDougall, postage	26.00

Groover-Stewart Drug Company, supplies	2.35
Abercrombie & Fitch Company, supplies	31.80
American Journal of Science, subscription	7.00

February, 1916

E. H. Sellards, expenses, February, 1916	108.02
Herman Gunter, expenses, February, 1916	79.58
Southern Express Company	6.96
S. A. L. Railway, freight	7.71

March, 1916

E. H. Sellards, State Geologist, salary for quarter ending March 31, 1916	625.00
E. H. Sellards, expenses, March, 1916	92.00
Herman Gunter, assistant, salary for quarter ending March 31, 1916	375.00
Laura Smith, services	118.00
Ed Lomas, janitor services	30.00
The MacMillan Company, publication	2.12
McGraw-Hill Book Company, publication	2.00
H. & W. B. Drew Company, supplies	13.22
G. E. Stechert & Company, publications	4.82
Southern Express Company	11.44
Economic Geology Publishing Company, subscription	3.00
Alex McDougall, postage	10.00

April-May, 1916

E. H. Sellards, expenses, April-May, 1916	83.25
Herman Gunter, expenses, April	33.26
S. A. L. Railway, freight	12.86
Southern Express Company	20.21

June, 1916

E. H. Sellards, State Geologist, salary for quarter ending June 30, 1916		625.00
Herman Gunter, assistant, salary for quarter ending June 30, 1916		375.00
Laura Smith, services		116.00
Ed Lomas, janitor services		30.00
Total expenditures for the year ending June 30, 1916		$7,685.44
Appropriation for the year	$7,500.00	
Balance from the preceding year	7.49	
Overcharge	177.95	—$7,685.44

PUBLICATIONS ISSUED BY THE STATE GEOLOGICAL SURVEY.

The following is a list of the publications issued by the State Geological Survey since its organization:

First Annual Report, 1908, 114 pp., 6 pls.
Second Annual Report, 1909, 299 pp., 5 text figures, and one map.
Third Annual Report, 1910, 397 pp., 28 pls., 30 text figures.
Fourth Annual Report, 1912, 175 pp., 16 pls., 15 text figures, one map.
Fifth Annual Report, 1913, 306 pp., 14 pls., 17 text figures, two maps.
Sixth Annual Report, 1914, 451 pp., 90 figures, one map.
Seventh Annual Report, 1915, 342 pp., 80 figures, four maps.
Eighth Annual Report, 1916, 168 pp., 31 pls., 14 text figures.
Ninth Annual Report (this volume), 1917.
Bulletin No. 1. The Underground Water Supply of Central Florida, 1908, 103 pp., 6 pls., 6 text figures.
Bulletin No. 2. Roads and Road Materials of Florida, 1911, 31 pp., 4 pls.
Press Bull. No. 1. The Extinct Land Animals of Florida, February 6, 1913.
Press Bull. No. 2. Production of Phosphate Rock in Florida during 1912, March 12, 1913.
Press Bull. No. 3. Summary of Papers Presented by the State Geologist at the Atlanta Meeting of the American Association for the Advancement of Science, December 31, 1913.
Press Bull. No. 4. The Utility of Well Records, January 15, 1914.
Press Bull. No. 5. Production of Phosphate Rock in Florida during 1913, May 20, 1914.
Press Bull. No. 6. The Value to Science of the Fossil Animal Remains Found Imbedded in the Earth, January, 1915.
Press Bull. No. 7. Report on Clay Tests for Paving Brick, April, 1915.

DISTRIBUTION OF REPORTS.

The reports issued by the State Geological Survey are distributed upon request, and may be obtained without cost by addressing the State Geologist, Tallahassee, Florida. Requests by those living outside of the State of Florida should be accompanied by postage or if desired the reports will be sent express collect.

MINERAL INDUSTRIES OF FLORIDA DURING 1916.

BY E. H. SELLARDS.

CONTENTS.

MINERAL INDUSTRIES OF FLORIDA DURING 1916.

E. H. SELLARDS.

The value of minerals produced in Florida during 1916 shows an increase over that of the preceding year. The total mineral production during 1915 is valued at $5,035,010, while that for 1916 is valued at $5,859,821.

BALL CLAY OR PLASTIC KAOLIN.

Three plants were engaged in mining ball clay in Florida during 1916. These were the Edgar Plastic Kaolin Company, Edgar; the Lake County Clay Company, Okahumpkee; and the Richmond China Clay Corporation, Okahumpkee. The ball clays of Florida are white burning, refractory clays notable for their plasticity. They occur in association with sand from which they are separated by washing. The value of the ball clay produced, although not separately given, is included in the total mineral products of the State.

BRICK AND TILE.

The total number of common brick manufactured in Florida during 1916 was 31,029,000. In addition to building brick there was produced also drain-tile and fire-proofing brick. The total value of brick and tile products for the year 1916 was $226,362.

The following firms in Florida reported the production of brick during 1916:

Barrineau Brothers, Quintette.
Campville Brick Company, Campville.
Clay County Steam Brick Company, Green Cove Springs.
Florida Industrial School for Boys, Marianna.
Gamble and Stockton Company, 108 West Bay St., Jacksonville.
Glendale Brick Works, Glendale.
G. C. & G. H. Guilford, Blountstown.
Hall and McCormac, Chipley.
Keystone Brick Company, Whitney.

O. O. Mickler Brick Company, Callahan.
Lee Miller, Whitney.
Platt Brothers, South Jacksonville.
Tallahassee Pressed Brick Company, Havana.
Dolores Brick Company, Molino.

FULLER'S EARTH.

The total production of fuller's earth in the United States during 1916, as reported by the U. S. Geological Survey, was 67,822 short tons, an increase over the preceding year of 19,921 tons. In addition to that produced there was imported into the United States during 1916, 15,001 short tons. Some fuller's earth in former years has been exported from the United States, although the amount can not be determined owing to the fact that this product is not listed separately from other clays.

The States producing fuller's earth during 1915 were Arkansas, California, Florida, Georgia, Massachusetts and Texas. Of these Florida is the chief producer, the output from this State amounting to more than three-fourths of the whole output for the United States. The value of the fuller's earth produced in the United States during 1916 was $706,951.

The production in Florida, although not separately listed, is included in making up the total mineral production of the State.

The following companies were engaged in mining fuller's earth in Florida during 1916: The Floridin Company, Quincy and Jamieson; the Fuller's Earth Company, Midway, and the Manatee Fuller's Earth Corporation, Ellenton.

ILMENITE AND MONAZITE.

The minerals ilmenite and monazite have been produced to a limited extent for the first time in Florida during the past year. These minerals are obtained from the beach sand at Pablo Beach in Duval County. The firm operating there is Buckman and Pritchard.

Ilmenite is a constituent of the sand on the Atlantic Beach as far south as Miami. It is found also very generally in the sands in the lake region of Florida, and is present to some extent throughout the State. The distribution of monazite is less well known, since it is present only in very small amounts, and is not detected in the sand except by a very careful examination.

LIME AND LIMESTONE.

The total quantity of quick and hydrated lime made in Florida during 1916 amounted to 8,666 tons, valued at $49,536. The lime produced in Florida is chiefly quick lime, although some hydrated lime is being made.

The total amount of limestone produced in Florida for all purposes except that of burning for quick lime, including building, road making, railroad ballast and agricultural limestone, is valued at $479,837. The following companies in Florida have reported the production of lime or limestone for the year 1916. The first three companies named produced both lime and limestone, the remaining companies of the list produced limestone:

Florida Lime Company, Ocala.
Marion Lime Company, Ocala.
Standard Lime Company, Kendrick.
Blowers Lime and Phosphate Company, Ocala.
Brooksville Stone and Lime Company, Brooksville.
Crystal River Rock Company, Crystal River.
Live Oak Limestone Company, Live Oak.
Florida Crushed Rock Company, Montbrook.
Florida Lime Company, Ocala.
Manatee Limestone Company, Manatee.
E. P. Maule, Ojus.
R. L. Nunn, Brooksville.
Palmetto Rock Company, Riverland.
Pineola Lime Company, Pineola.
Stone Products Company, Bartow.
George Sykes Company, Miami.
A. T. Thomas & Company, Ocala.
White Rock Quarry Company, Naranja.

OIL PROSPECTING.

Oil prospecting in Florida is being carried on at the present time to a limited extent, and test wells for oil and gas are now being drilled in Gadsden, Wakulla, Osceola and Brevard counties. Test wells of moderate depth have previously been drilled in Escambia, Washington, Citrus and Sumter counties. None of the wells thus far drilled have been successful, although showings of oil have been reported in some of them.

There is a constant demand for information in regard to the possible occurrence of oil and gas in Florida; this demand is met so far as possible by the Survey. No geologic problem, perhaps, presents greater difficulties than the search for oil and gas. This is particularly true in Florida, where the surface is prevailingly level or but moderately hilly, and where good continuous surface exposures of the underlying formations are not numerous. However, even in a flat country the underlying structure may in a measure be determined through the aid of the occasional surface exposures of recognizable strata supplemented by well records. This problem of structure in Florida is receiving attention through co-operative study between the State Geological Survey and the Federal Geological Survey and the results will be published as soon as they can be made available. From the reports of the Survey already issued much information may be obtained regarding the geologic structure of the State.

PEAT.

Peat is being produced in Beswick, Florida, by the Ranson Humus Company. This being the only plant in operation in the State, the production is not separately listed. The peat produced by this company is placed on the market in the form of prepared humus and peat litter.

PHOSPHATE.

Notwithstanding the interruption of normal export shipping conditions the production of phosphate rock in Florida during 1916 shows a slight increase over that of the preceding year. The total shipment of phosphate rock in Florida during 1916, as reported by the producers, was 1,515,845 long tons. Of this amount 1,468,758 tons were land pebble phosphate, the remainder being hard rock and soft phosphate. Of the total shipments only 200,472 tons were exported, or slightly less than during the preceding year. The domestic shipments, on the other hand, were in excess of those for the preceding year, both for hard rock and for land pebble.

The value of the phosphate shipped from Florida during 1916 was as follows: Land pebble, $3,847,410; hard rock, $295,755; total, $4,170,165. The value of the total shipments during the preceding year was $3,762,239.

Summary of shipment of phosphate in Florida from 1913 to 1916, inclusive:

	1913.	1914.	1915.	1916.
Pebble Rock—				
Exported	887,398	625,821	185,846	172,427
Domestic	1,168,084	1,203,381	1,122,635	1,296,331
Total Shipment	2,055,482	1,829,202	1,308,481	1,468,758
Hard Rock—				
Exported	476,898	303,172	43,314	28,045
Domestic	12,896	6,517	6,816	19,042
Total shipment	489,794	309,689	50,130	47,087
Pebble and Hard Rock Combined—				
Exported	1,364,296	928,993	229,160	200,472
Domestic	1,180,980	1,209,898	1,129,451	1,315,373
Total shipment	2,545,276	2,138,891	1,358,611	1,515,845
Total shipments from beginning of mining in 1888 to 1916, inc.				31,120,449

LIST OF PHOSPHATE MINING COMPANIES OF FLORIDA.

Acme Phosphate Company ------------Morriston, Fla.
Amalgamated Phosphate Company------Richmond, Va., and Brewster, Fla.
American Agricultural Chemical Company ------------2 Rector St., New York, N. Y., and Pierce, Fla.
Armour Fertilizer Works ------------Union Stock Yards, Chicago, Ill., and Bartow, Fla.
P. Bassett (Successor to Central Phos. Co.) ------------Newberry, Fla.
Peter B. and Robert S. Bradley--------92 State St., Boston, Mass., and Floral City, Fla.
J. Buttgenbach & Co. ------------Holder, Fla.
C. & J. Camp ------------Ocala, Fla.
Charleston, S. C., Mining and Manufacturing Company ------------Richmond, Va., and Ft. Meade, Fla.
Coronet Phosphate Co. ------------99 John St., New York, N. Y., and Lakeland, Fla.
Cummer Lumber Co. ------------Jacksonville and Newberry, Fla.
Dominion Phosphate Co. ------------Bartow, Fla.
Dunnellon Phosphate Co. ------------Rockwell, Fla.
Dutton Phosphate Co. ------------Gainesville, Fla.
Export Pohsphate Co. ------------53 State St., Boston, Mass., and Mulberry, Fla.
Florida Mining Co. ------------61 Broadway, New York, N. Y., and Mulberry, Fla.
Florida Phosphate Mining Corporation-Dickson Bldg., Norfolk, Va., and Bartow, Fla.
Franklin Phosphate Co. ------------Newberry, Fla.
Holder Phosphate Co. ------------21 W. Ninth St., Cincinnati, O., and Ocala and Inverness, Fla.

International Phosphate Co.	27 State St., Boston, Mass., and Ft. Meade, Fla.
Interstate Chemical Corporation	21 Broad St., Charleston, S. C., and Bowling Green, Fla.
Istachatta Phosphate Co.	Istachatta, Fla.
Lakeland Phosphate Co.	Lakeland, Fla.
Leland Phosphate Co.	Croom, Fla.
Mutual Mining Co.	102 E. Bay St., Savannah, Ga., and Floral City, Fla.
Meredith-Noble Phosphate Co.	Somerville, N. J., and Morriston and Romeo, Fla.
Palmetto Phosphate Co.	812 Keyser Bldg., Baltimore, Md., and Tiger Bay, Fla.
Phosphate Mining Co.	55 John St., New York, N. Y., and Nichols, Fla.
Prairie Pebble Phosphate Co.	61 Broadway, New York, N. Y., and Mulberry, Fla.
Schilmann & Bene	Ocala, Fla.
Societe Franco-Americaine des Phosphate de Medulla (Successor to Standard Phosphate Co.)	Christina, Fla.
Societe Universelle de Mines, Industries Commerce et Agriculture	Paris, France, and Pembroke, Fla.
Southern Phosphate Development Co.	Ocala and Inverness, Fla.
Swift & Co.	Union Stock Yards, Chicago, Ill., and Bartow, Fla.
T. A. Thompson	Ft. White, Fla.

SAND AND GRAVEL.

The sand produced in Florida is used for building and paving and for railroad ballast. The gravel produced finds its chief use for road making and for road ballast. The total production of sand and gravel for 1916 was 86,452 tons, valued at $42,352.

The companies reporting the production of sand and gravel in Florida during 1916 are the following:

Atlantic Coast Line Railroad Company.
Interlachen Gravel Company, Interlachen.
Lake Wier Sand Company, Ocala.
Logan Coal and Supply Company, Jacksonville.
Tampa Sand and Shell Company, Tampa.
A. T. Thomas Company, Ocala.

SAND-LIME BRICK.

Four companies were actively engaged in the manufacture of sand-lime brick in Florida during 1916. The total production during 1916, including common and front brick, was valued at $90,794. The companies reporting the production of sand-lime brick in Florida during 1916 are as follows:

The Bond Sandstone Brick Company, Lake Helen.
The Composite Brick Company, 425 St. James Bldg., Jacksonville.
The Valrico Sandstone Company, Valrico.

WATER.

The total sales of mineral and spring water in Florida during 1916, as shown by the returns from the owners of springs and wells, amount to 202,970 gallons, valued at $15,676. This represents an increase over the preceding year when the sales amounted to 118,920 gallons, valued at $12,516.

The companies reporting the production of water for commercial purposes during 1916 include the following:

Cedar Springs, Jacksonville.
Chumuckla Mineral Springs and Hotel Company, Chumuckla Mineral Springs, Chumuckla, Florida.
Espiritu Santo Springs Company, Espiritu Santo Springs, Safety Harbor, Florida.
L. H. McKee, Quisiana Spring, Green Cove Springs, Florida.
Magnesia Spring Water Company, Magnesia Spring, Grove Park, Fla.
Purity Springs Water Company, Purity Spring, Tampa, Florida.
Tampa Kissingen Wells Company, Stomawa Mineral Well, Tampa, Florida.

SUMMARY STATEMENT OF MINERAL PRODUCTION IN FLORIDA DURING 1916.

Common or building brick, fire-proofing brick and tile	$ 226,362
Lime, including quick and hydrated	49,536
Limestone, including limestone for agriculture	479,837
Mineral waters	15,676
Phosphate rock	4,170,165
Sand and gravel	42,352
Sand-lime brick	90,794
Mineral products not separately listed	784,799
Total mineral production valued at	$5,859,821

ADDITIONAL STUDIES IN THE PLEISTOCENE AT VERO, FLORIDA.

THE FOSSILS PLANTS FROM VERO, FLORIDA, BY

EDWARD W. BERRY.

FOSSIL BIRDS FOUND AT VERO, FLORIDA, WITH DESCRIPTIONS OF NEW SPECIES, BY R. W. SHUFELDT.

VERTEBRATA MOSTLY FROM STRATUM NO. 3, AT VERO, FLORIDA; TOGETHER WITH DESCRIPTIONS OF NEW SPECIES,

BY OLIVER P. HAY.

REVIEW OF THE EVIDENCE ON WHICH THE HUMAN REMAINS FOUND AT VERO ARE REFERRED TO THE PLEISTOCENE,

BY E. H. SELLARDS.

ILLUSTRATIONS.

THE FOSSIL PLANTS FROM VERO, FLORIDA.

EDWARD W. BERRY.

The discovery of human remains associated with an extinct mammalian fauna at Vero has excited a great deal of local and general interest, and various theories regarding the age of these remains and the manner of their occurrence have already been advanced, as well as admirable accounts of the local geology by Sellards and others (1). It is therefore unnecessary for me to repeat any of these details in connection with my study of the fossil plants.

Plant remains in the form of laminae of impure peat or scattered fruits, chiefly acorns, are present from the bottom to the top of the deposits overlying the shell marl which forms the base of the section. The lower sands (designated No. 2 by Sellards) have yielded no leaves and but few acorns, but the upper bed (Sellards No. 3) contains many leaf layers alternating with sand laminae, and it is from the latter horizon that all of the plants enumerated in the following pages have been collected, except one species of acorn, which is common to both beds.

Recent and extinct mammalian and other bones occur in both layers, and human remains are also found in both beds. After a thorough study of the local sections and the paleontologic evidence, I am convinced that there is no hiatus between beds 2 and 3, and that there is no great difference in age from the bottom to the top of the section, although it records changing physical conditions and necessarily becomes more and more recent as the top of the section is approached. The lower sand marks the recession of the sea in

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(1) Sellards, E. H., Am. Jour. Sci. (IV), vol. 42, pp. 1-18, 1916.
Eighth Ann. Rept. Florida Geol. Surv., pp. 122-160, pls. 15-31, 1916.
Science, N. S. vol. 44, pp. 615-617, 1916.
Journ. Geol. vol. 25, pp. 4-24, tf. 1-4, 1917.
Chamberlin, R. T., Journ. Geol. vol. 25, pp. 25-39, tf. 1-9, 1917.
Vaughan, T. W., Idem., pp. 40-42.
Hrdlicka, A., Idem., pp. 43-51, tf. 1, 2.
Hay, O. P., Idem., pp. 52-55.
MacCurdy, G. G., Idem., pp. 56-62, tf. 1-6.

which the underlying shell marl was formed. The upper beds (No. 3) mark successive seasonal layers of valley filling in the narrow valley of a small stream. This stream was apparently always small, and the marvelous abundance of fossils at this one point seems to be due to a bar or sinkhole or similar cache formed near the junction of the two lateral branches which united near this point to form the main stream. The determinable plants are represented almost exclusively by fruits or seeds, as the leaves, with the exception of the coriaceous oaks, which are abundant, were too thoroughly decayed before they were buried to retain their identity.

The study of such remains is beset with many difficulties. The material has to be sorted without allowing it to dry. It then has to be impregnated with paraffin simultaneously with drying. Finally identification is hampered by the lack of recent material for comparison, and when identified the determination of the exact range of the still existing species on which so much hinges is a matter of great uncertainty in the present state of our knowledge of plant geography. I am under obligations to Mr. W. L. McAtee, of the Biological Survey, for determining five species of fruits for me, and I am indebted to Mr. R. M. Harper for data regarding the present distribution in Florida of some of the forms.

After giving an annotated list of the species identified, their bearing on the age and physical conditions at the time of deposition of the deposits will be discussed.

GYMNOSPERMAE

ORDER CONIFERALES.

FAMILY PINACEAE.

GENUS PINUS LINN.

PINUS TAEDA LINN. *THE LOBLOLLY PINE.*

The occurrence of this species in the Vero deposits is based on three seeds, and for that reason the identification may be questioned. The seeds are mature and are identical in form and texture with those of this species and are clearly not referable to *Pinus caribaea* or *Pinus clausa,* which grow around Vero at the present time.

The loblolly pine is found at the present time along the Atlantic coast from Cape May, New Jersey, southward to Cape Malabar on the east coast and Tampa Bay on the west coast of peninsular

Florida. It is present in Polk County in the Lake region of the central part of the peninsula, and probably extends with the southward extension of this region into DeSoto County. In the Mississippi embayment region it extends northward to Arkansas and southwestern Tennessee. Cones, scales and seeds have been recorded from the late Pleistocene of New Jersey (1) and Alabama (2).

PINUS CARIBAEA MORELET *SLASH PINE*

The occurrence of this species in the Vero deposits is based on a single characteristic cone scale. In the existing flora this pine is a West Indian and Central American species which extends northward over the southern half of the Florida peninsula. Farther north it has been frequently confused with *Pinus Elliottii,* a perfectly distinct species, which ranges northward to South Carolina. The former is common at Vero in the existing flora and has not previously been found fossil to my knowledge.

PINUS SP.

Fossil occurrence based on several immature seeds which are not specifically determinable. They suggest the abortive seeds in the distal part of the cones of *Pinus clausa,* but might equally well represent abortive seeds of some other species. *Pinus clausa,* the sand or spruce pine, is common along sandy shores and on old inland beach ridges in the vicinity of Vero at the present time.

GENUS TAXODIUM RICH.

TAXODIUM DISTICHUM (LINN.) RICH. *THE BALD CYPRESS.*

The bald cypress, which is one of the most abundant trees in the Pleistocene of our Southern States and is already well characterized in the late Pliocene of Alabama (1), is represented in the Vero deposits by a number of seeds and cone scales, but these remains are not abundant enough to suggest the presence of a cypress pond.

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(1) Berry, E. W., U. S. Geol. Surv. Prof. Paper 98L, p. 195, pl. 45, figs. 1-6, 1916.
(1) Berry, E. W., Am. Jour. Sci. (IV), vol. 29, p. 391, 1910.
(2) Berry, E. W., Torreya, vol. 10, p. 263, 1910.

The bald cypress is now found from southern Delaware to eastern Texas in the Coastal Plain and its Pleistocene range was somewhat more extensive. In Florida it is found nearly throughout the State in swamps and low stream valleys. At Vero it is not known in the immediate vicinity of the coast, but there are extensive swamps about 12 miles west of the town, which are, however, several miles beyond the drainage basin of Van Valkenburg's Creek. It has been recorded from Dade County by Harper.

ANGIOSPERMAE

MONOCOTYLEDONAE.

FAMILY CYPERACEAE.

GENUS CAREX LINN.

CAREX SP. *SEDGE.*

Two capitate clusters of the perigynia of some species of Carex were found fossil at Vero. It is not possible to identify them as to species, but the generic reference is positive. Various existing species of Carex are found at Vero and throughout Florida.

FAMILY ARACEAE.

GENUS PISTIA LINN.

PISTIA SPATHULATA MICHX. *WATER LETTUCE.*

A characteristic leaf of this species was found fossil at Vero. The water lettuce occurs as a free floating plant in still water or slow moving streams throughout the tropics. In the United States it occurs sporadically from Florida to Texas. It is recorded from the Lake region of the central peninsula and from Lake Okeechobee, but I did not see it in the Vero region.

FAMILY ARECACEAE.

GENUS SERENOA HOOKER F.

SERENOA SERRULATA (MICHX.) HOOKER. *SAW PALMETTO.*

The fossil remains at Vero comprise 3 leaf bases, fragments of the serrated petioles and several stones, all characteristic and readily determinable.

The Saw Palmetto is a shrubby gregarious species now found from South Carolina to Louisiana and common nearly throughout Florida, forming the prevailing scrub of the pine lands or flatwoods. It is exceedingly abundant around Vero on undrained sands, but has not heretofore been found fossil.

GENUS SABAL ADANSON.

SABAL PALMETTO (WALT.) R. & S. *CABBAGE PALMETTO.*

This species is represented in the Vero deposits by fragments of the clasping petiole bases and by stones. It was evidently as abundant a tree at the time the Vero deposits were formed as it is now in this region.

The cabbage palmetto ranges from the mouth of the Cape Fear River in North Carolina along the coast to the mouth of the Apalachicola River and reaches its maximum development in the Florida peninsula. As far as I know it has not heretofore been found fossil.

DICOTYLEDONAE.

ORDER MYRICALES.

FAMILY MYRICACEAE.

GENUS MYRICA LINN.

MYRICA CERIFERA LINN. *WAX MYRTLE.*

Nutlets and leaves represent this species in the Vero deposits. The wax myrtle ranges from Cape May, New Jersey, to Texas along the coast, as well as in the Antilles. It is very common as a small tree in sandy swamps near Vero.

FAMILY LEITNERIACEAE.

GENUS LEITNERIA CHAPMAN.

LEITNERIA FLORIDANA CHAPMAN (?) *CORK WOOD.*

This species is apparently represented in the Vero deposits by the characteristic persistent winter buds.

Corkwood is a shrub or small tree of muddy shores now found along the Gulf coast from west Florida to Texas. It is not found at the present time in peninsular Florida.

ORDER FAGALES.

FAMILY FAGACEAE.

GENUS QUERCUS LINN.

QUERCUS VIRGINIANA MILL. *LIVE OAK.*

This species is represented in the Vero deposits by characteristic elongated acorns and turbinate cupules. Some of the leaf fragments suggest the leaves of this species, but these latter are not certainly identified. Some of the cupules are suggestive of the closely allied *Quercus geminata Small.*

The live oak is one of the most abundant trees in the Pleistocene deposits of our southern states, and its ancestors are already well defined in the Pliocene of this region. It has been recorded from the early Pleistocene of Kentucky and Alabama and from the late Pleistocene of Alabama.

In the existing flora it ranges from Virginia to northeastern Mexico and does not forsake the region of the coast except in the Rio Grande valley. It occurs in hammocks nearly throughout Florida, and is not uncommon along the Indian River at Vero.

QUERCUS LAURIFOLIA MICHX. *WATER OAK.*

This species, represented by both leaves, acorns and cupules, is the most abundant fossil form at Vero. It is also the only plant represented from the bottom to the top of the section.

The water oak is found at the present time near the coast from the southeastern corner of Virginia to Louisiana in sandy swamps and stream valleys. It is present along the Florida coasts, except those south of the Everglades. Sargent gives its southern range as Mosquito Inlet on the east coast and Cape Romano on the west coast, and while it extends farther south it is not nearly as abundant around Vero as it is 100 miles farther north, nor as abundant now as it apparently was at the time of the formation of the Vero deposits.

QUERCUS BREVIFOLIA (LAM.) SARGENT. *BLUE JACK OAK.*

This species is represented in the Vero deposits by many characteristic leaves and by a few less certainly identified acorns and cupules.

Its habitat now is sandy pine lands from North Carolina to Texas. I found it common around Vero, although Sargent gives its southern limit on the east coast as Cape Malabar, which is about 50 miles north of Vero.

QUERCUS CHAPMANI SARGEANT (?)

This species is represented in the Vero deposits by a considerable number of immature acorns and cupules and is not certainly determined on that account, although the acorns are identical with the corrresponding immature acorns and cupules of this species. I regard the identification as reasonably well authenticated.

Quercus chapmani ranges from South Carolina to West Florida in sandy pine lands near the coast in the existing flora. It is comparatively rare except in West Florida from Apalachicola to Pensacola Bay, and is unknown within hundreds of miles of Vero. This type of oak was already in existence in the Miocene (1) and the Vero occurrence may represent a collateral descendant of this Miocene ancestry.

ORDER POLYGONALES.

FAMILY POLYGONACEAE.

GENUS POLYGONUM LINN.

POLYGONUM SP.

Achenes, identified for me by W. L. McAtee, represent this genus in the Vero deposits. They are not specifically determined. Polygonum contains over 200 existing species, mostly herbaceous and widely distributed. Many are swamp plants and a number occur in Florida.

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(1) Berry, E. W., U. S. Geol. Survey, Prof. Paper 98 F, p. 66, pl. 11, figs. 1, 2, 1916.

ORDER RANALES.

FAMILY MAGNOLIACEAE.

GENUS MAGNOLIA LINN.

MAGNOLIA VIRGINIANA LINN. *SWEET OR SWAMP BAY.*

This species is represented in the Vero deposits by a follicle. It ranges from Massachusetts to Texas in the existing flora and is found in swamps and wet hammocks throughout Florida. It has been recorded (1) from the Pliocene of New Jersey.

FAMILY ANONACEAE.

GENUS ANONA LINN.

ANONA GLABRA LINN. *POND APPLE.*

This species is represented in the Vero deposits by a single seed. The Pond Apple is essentially a tropical form and this is the only one of the numerous tropical species of Anona that reaches the United States. It occurs in ponds and swampy hammocks northward along the Florida coast as far as Cape Malabar.

FAMILY NYMPHAEACEAE.

GENUS BRASENIA SCHREB.

BRASENIA PURPUREA (MICHX.) CASPARY. *WATER SHIELD.*

A carpel of this species was found in the Vero deposits. The water shield is one of the most interesting survivals from the Pleistocene and its present geographical range is exceeded by few if any of the higher plants. It is an inhabitant of ponds and slow streams and in America it is found on both coasts and from Canada to Cuba and Central America. It is also present in Asia, Africa and Australia and was exceedingly common in Europe during the Pleistocene, occurring at this time also in North America.

There is no reason why it should not be present in suitable situations throughout Florida, but I do not know of any records in the Lake region or within some hundreds of miles of Vero.

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(1) Hollick, A., Bull. Torrey Bot. Club, vol. 19, p. 331, 1892.

ORDER SAPINDALES.

FAMILY ILICACEAE.

GENUS ILEX LINN.

ILEX GLABRA (LINN.) A. GRAY. *GALLBERRY.*

This record is based upon three drupes found in the Vero deposits. The Gallberry or Inkberry is at present found in sandy soil near the coast from Massachusetts to Florida, and I found it abundant along the drainage canal at Vero.

FAMILY ACERACEAE.

GENUS ACER LINN.

ACER RUBRUM LINN. *RED MAPLE.*

This species is represented by a characteristic samara in the Vero deposits. The red maple is an inhabitant of swamps and stream valleys ranging from Canada to Florida and Texas. Its range in Florida extends southward to about latitude 26 degrees, and it is still common around Vero. It has been recorded (1) from the late Pleistocene of Alabama.

ORDER RHAMNALES.

FAMILY RHAMNACEAE.

GENUS ZIZYPHUS LINN.

ZIZYPHUS SP.

A much reticulate stone, identified for me by W. L. McAtee, represents an extinct species, the characters of which it is hardly possible to adequately define from a single fruit.

The geologic history of Zizyphus is a most interesting one. As early as the Upper Cretaceous there were at least ten species in North America and the genus is a common Tertiary type both on

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(1) Berry, E. W., Am. Jour. Sci. (IV), vol. 29, p. 397, 1910.

this continent and Europe. The modern species are mostly Indo-Malayan and the only North American species, except for the naturalized *Zizyphus vulgaris,* is the Texas Buckthorn *Zizyphus obtusifolia* (Hooker) A. Gray, a western arid species, which is found from West Texas to Arizona.

What appears to be the same species as the Vero form was recorded some years ago from the late Pleistocene (Talbot formation) of New Jersey (1) and indicates the probable abundance of a new element in the Pleistocene flora of southeastern North America, one that has only recently become extinct.

FAMILY VITACEAE.

GENUS VITIS LINN.

VITIS CF ROTUNDIFOLIA MICHX. *MUSCADINE GRAPE.*

Large stout simple tendrils, together with fragments of stems, undoubtedly represent this species in the Vero deposits. The modern representatives inhabit sandy swamp borders and thickets from Maryland to Florida and Texas and are still common at Vero.

VITIS SP.

The Vero deposits have yielded 5 characteristic grape seeds which are not those of the preceding species, and which represent either *Vitis austrina Small* of the northern peninsula or *Vitis coriacea* Shuttlw of the West Indies and southern Florida.

ORDER THYMELEALES.

FAMILY LAURACEAE.

GENUS BENZOIN FABR.

BENZOIN CF MELISSAEFOLIUM (WALT.) NEES. *SPICE BUSH.*

This species is represented in the Vero deposits by drupes which are not certainly identified because of their immaturity. It is certain, however, that they represent this genus, which in the existing flora is not recorded nearer Vero than the West Florida region.

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(1) Berry, E. W., Torreya, vol. 10, p. 266, 1910.

ORDER RUBIALES.

FAMILY CAPRIFOLIACEAE.

GENUS VIBURNUM LINN.

VIBURNUM NUDUM LINN.

This species is represented in the Vero deposits by both drupes and stones. In the existing flora it is an inhabitant of swamps from Long Island to Florida and Louisiana. In peninsular Florida it is known from only the Lake region of DeSoto and Polk Counties and northward. Two southern varieties, *augustifolium* T. & G. and *serotinum* Ravenel, are sometimes distinguished by systematists, but I have no material of these for comparison.

Viburnum nudum has been recorded (1) from the late Pleistocene of North Carolina.

VIBURNUM CF DENTATUM LINN.

This record is based upon drupes and stones from the Vero deposits. It is close to this essentially more northern existing species, but may not be identical with it. *Viburnum dentatum* is an inhabitant of meadows and swamps and ranges from New Brunswick to the upland of Georgia. It does not occur in Florida at the present time.

ORDER VALERIANALES.

FAMILY AMBROSIACEAE.

GENUS XANTHIUM LINN.

XANTHIUM SP.

Two small fruits characteristically those of Xanthium and probably *Xanthium glabratum* (D. C.) Britton were found in the Vero deposits. Some years ago I collected a fruit of Xanthium from the late Pleistocene along the Chattahoochee River, the occurrence of which I did not publish as I was not positive that it had not been accidentally mixed with the Pleistocene material.

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(1) Berry, E. W., Torreya, vol. 14, p. 160, 1914.

SUMMARY.

The foregoing comprise more or less positively identified remains of 27 species of plants. Nineteen of these have not been previously found fossil, while the following eight have already been discovered in Pliocene or Pleistocene deposits:

Pinus taeda.
Taxodium distichum.
Quercus virginiana.
Magnolia virginiana.
Brasenia purpurea.
Acer rubrum.
Zizyphus sp.
Viburnum nudum.

The problem, in so far as it relates to the evidence of the plants, depends on the correct evaluation of the change which this plant assemblage shows when compared with the flora now growing at Vero.

Of the plants found fossil the following are still found at Vero, and I have included in this list as probably found in the present flora of Vero the 4 forms of Pinus, Carex, Polygonum and Xanthium which are not specifically identified. This list comprises:

Pinus caribaea.
Pinus sp.
Carex sp.
Serenoa serrulata.
Sabal palmetto.
Myrica cerifera.
Quercus virginiana.
Quercus laurifolia.
Quercus brevifolia.
Polygonum sp.
Magnolia virginiana.
Ilex glabra.
Acer rubrum.
Vitis cf rotundifolia.
Xanthium sp.

In addition to the foregoing 15 species still found at Vero the following two species are found growing within 10 or 12 miles of Vero:

Taxodium distichum.
Anona glabra.

Three species approach to within about 50 miles of Vero, being recorded from the southern extension of the Lake region flora of the central peninsula in DeSoto County. These are:

Pinus taeda
Pistia spathulata.
Viburnum nudum.

The following six species are not now found growing in peninsular Florida.

Leitneria floridana?	Vitis sp.
Quercus chapmani?	Benzoin cf melissaefolium.
Brasenia purpurea.	Viburnum cf dentatum.

Of these *Leitneria floridana* is a very local form not found nearer than the Apalachicola River, and the chief center of growth of *Quercus chapmani* is also in west Florida, while the true *Viburnum dentatum* does not occur nearer than the upland region of Georgia.

Finally, the Vero deposits have yielded a fruit probably identical with similar remains from the late Pleistocene of New Jersey representing an entirely extinct species of *Zizyphus,* a genus abundant in southeastern North America during the Tertiary, but not now represented except by a single species of the arid southwest (Texas to Arizona).

Two of the fossil species have been recorded from the Pliocene. These are *Taxodium distichum* and *Magnolia virginiana.* One, *Quercus virginiana,* is found in the early Pleistocene of both Kentucky and Alabama and the following occur in the late Pleistocene:

Pinus taeda.	Acer rubrum.
Taxodium distichum.	Zizyphus sp.
Quercus virginiana.	Viburnum nudum.
Brasenia purpurea.	

These latter, while they constitute but 26 per cent of the known fossil flora at Vero, are especially significant in connection with the fact that they all occur elsewhere in the physiographically youngest of the Pleistocene terrace deposits, namely, the Talbot of New Jersey and Maryland, the Chowan of North Carolina and the corresponding lowest terrace at several localities in Alabama, while the Vero deposits constitute the youngest physiographic terrace plain of the region and are referred to the Pensacola terrace by Matson (1).

In my judgment and in the ordinary acceptance of that term, this flora is unquestionably of late Pleistocene age.

Regarding its bearing on the interesting problem of the age of the human and associated mammalian and other remains at Vero, my study of the locality furnishes the following conclusions. The

(1) Matson, G. C., U. S. Geol. Surv., Water Supply Paper 319, pp. 31-35, 1913.

underlying shell marl, which forms a definite and undisputed datum plane, is late Pleistocene in age. Its species all exist in nearby waters at the present time, and many of them have been recorded from shell marls found from southern New Jersey to the Florida keys and forming a part of the lowest and latest well-defined terrace plain previously mentioned as having been named Talbot in Maryland, Chowan in North Carolina and Pensacola in Florida. It follows that the vertebrate remains which are so numerous at Vero cannot possibly be of middle or early Pleistocene age unless they are regarded as having been reworked from older deposits, and I cannot conceive that this was possible, nor do the vertebrate paleontologists who have examined the deposits consider that such was the case. In fact, I believe that if it had not been for the over estimate of the age of this vertebrate fauna, that Dr. Chamberlin would not have advanced his hypothesis of the reworking and mechanical mixing of these bones, nor that Dr. Hrdlicka would have insisted on the human burial theory to account for the presence of the human skeletal remains. While no human bones were collected during the time that I studied the deposits, I did collect a number of bone implements and fragments of pottery in association with the plant fossils that could not possibly have reached their resting place through the agency of human burial. Nothing is more reasonable than to suppose that the larger elements in the Middle Pleistocene fauna of more northern areas should have lingered for thousands of years in this more genial southern clime until the presence of man in considerable numbers and the changing climate, as is attested by the fossil plants, should have brought about the extinction of a large percentage of the fauna. The fauna itself confirms the rather limited data furnished by the fossil flora of this change in climate, since it indicates a more mesophytic habitat than exists today in the vicinity of Vero. Regarding the burial theory of Dr. Hrdlicka, it may be said that a part of the plant material came from immediately above one of the human skeletons, and I cannot conceive of the possibility of not being able to see evidence of artificial burial in material made up of alternate layers of sand and matted leaves and other vegetable debris. I therefore see no reason to doubt that relative modern men were contemporaneous with this partially extinct fauna of Middle Pleistocene aspect which survived in Florida to the late Pleistocene. With regard to the exact age of the Vero deposits there are it seems to me but two alternatives, and these apply equally and are in large part derived from a study of the physiography and the faunas and floras of the corresponding topographic forms in the other states of the Coastal plain. These alternatives are that they are about the same age as the Peorian interglacial deposits of the Mississippi Valley or are immediately post Wisconsin and correspond with what the Scandinavian geologists have named Litorina time.

FOSSIL BIRDS FOUND AT VERO, FLORIDA,

WITH DESCRIPTIONS OF NEW SPECIES.

(Plates I and II., Figs. 1-25.)

By R. W. SHUFELDT.

Important and interesting fossils of plants, certain invertebrates and vertebrates were obtained at Vero, Florida, in 1913. Vero is situated on the Atlantic coast, in the eastern-central part of the State. The excavations and exploration (still in progress) undertaken in that locality, which is referred to the Pleistocene, are now becoming generally known through various publications which have appeared on the subject. Chief among these is a paper by Dr. E. H. Sellards, the State Geologist of Florida, which appeared in the Eighth Annual Report of the Florida State Geological Survey (pp. 121-160, pls. 15-21), 1916.

During the early part of November, 1916, Doctor Sellards wrote me in regard to the lot of fossil bird bones which had been collected from Stratum No. 3 of the Vero excavations, and requested me to describe them for a report (Nov. 4, 1916). This material was received by me shortly afterwards, and I immediately undertook an examination of it. To do this as thoroughly as possible demanded the use of skeletons of a large number of species of existing birds representing the avifauna of the eastern parts of the United States. Such skeletons as appeared to be necessary were loaned me by the Division of Birds of the U. S. National Museum, a favor for which I am deeply indebted. My thanks are likewise extended to Dr. Charles W. Richmond, Assistant Curator of Birds, and to Mr. J. H. Riley, his assistant, for many favors in this connection, particularly for doing all in their power in the matter of facilitating my work through their promptness in getting the loaned skeletons into my hands.

In describing these fossil bones, they will be taken up in the order they occur on the annexed plates, with the unfigured specimens arrayed at the close of the list. All of the bird bones from Vero are included in this paper except the large *Jabiru weillsi* previously described by Dr. Sellards.

CATHARTES AURA. STRATUM 2.

(Plate I., Figs. 1, 2.)

One of the most conspicuous bones in this part of the collection is the imperfect specimen of a left *ulna* of *Cathartes aura;* it is in two pieces (Plate I., Fig. 2), the bits of the shaft joining them having been lost. So far as it goes, the specimen is practically perfect, barring a slight chipping of the extremeties. It agrees in all particulars with the ulna of the Turkey Buzzard as it occurs at the present day; even the distances between the papillæ for the ends of the secondary feathers of the wing are the same in number, and occupy identically the same positions on the shaft.

QUERQUEDULA FLORIDANA, sp. nov.

(Plate I., Fig. 4. Plate II., Fig. 25. Compare with Fig. 3.)
Pleistocene, Vero, Fla., Stratum 2.

There is present in the collection the right *humerus* of a small anserine bird, closely related to our Teals of the genus *Querquedula.* Comparisons have been made with several species of that genus; but it differs in one way and another from all of them, while it agrees in general character. It appears to be most nearly like the humerus as we find it in *Querquedula discors,* but differs from it in being somewhat shorter throughout; that is, the extremities of the bone are relatively larger and the shaft stouter. This humerus belonged to a species of *Querquedula* now extinct, and I propose for it the name of *Querquedula floridana,* the type bone being the humerus here described and figured. Extreme length, 6.6 cms.; extreme width of head (to apex of radial crest), 1.6 cms. Sigmoid curve of the shaft rather more pronounced than in *Q. discors.* Distally, the tubercles somewhat chipped—otherwise quite perfect.

ARDEA ? (sp. ?) Stratum 3.

(Plate I., Fig. 5.)

No. 6774. Represented by the distal two-thirds of a bird's left *tarso-metatarsus,* with the condyles considerably broken away, but the shaft perfect. This bone has been compared with the corresponding one in the skeletons of a great variety of waders of different families and genera. It belonged to some species of a heron, quite closely related to those of the genus *Ardea* of the same general size, and larger than such a form as the existing *Nycticorax n. naevius*. This specimen is somewhat too imperfect for reference, or to base a new species upon. It should be set aside until additional material is discovered that may throw more light on the question with respect to the species, living or extinct, to which it probably belonged or represents.

HERONS ? (sp. ?). Stratum 3.

(Plate I., Figs. 5, 6, 9-11.)

No. 7554. This is a rather large, elongate *vertebra* from the anterior end of the chain of the cervical vertebræ of the neck of some heron of medium size; it is more or less perfect anteriorly, but broken off posteriorly. Comparisons have been made with the corresponding bone in the skeleton of the neck in a large number of waders of all kinds, as heron, egrets, spoonbills, and their various allies. Of all these it comes nearest to *Herodias egretta*. The specimen is, however, in the absence of other bones from the same bird, too fragmentary to refer it with certainty to any existing species, or to base a new species upon.

In the same lot occur two other vertebræ (Figs. 9 and 10, Plate I.), and also a distal piece of a *tarso-metatarsus* (Fig. 11, Plate I.). All three of these are too small to have belonged to birds of the size which furnished the tibiotarsus shown in Figure 5, or the vertebra shown in Figue 6 of this plate. These two small vertebræ (Figs. 9 and 10) may have been from the same skeleton to which the piece of a *tarso-metatarsus,* shown in Figure 11, belonged; but there is no certainty about this. All three may quite possibly have belonged to some average-sized wader of the heron order; but it is impossible to be certain about this until additional material comes to light at Vero, of the same kind and character, and representing the same species.

TYTO PRATINCOLA (Barn Owl), Stratum 3.

Plate I., Figs. 7 and 8. (Fig. 7 fossil).

No. 6934. This is the distal moiety of a right *tibiotarsus* of an adult specimen of the Barn Owl (*Tyto pratincola*). It agrees, with surprising exactness, with the corresponding part of a tibiotarsus of this species of owl in a skeleton in the collection of bird skeletons in the Division of Birds, of the U. S. National Museum (No. 19,636), with which I have compared it.

LARUS ? (sp. ?), Stratum 3.

(Plate I., Fig. 12.)

No. 6773. In the lot at hand there are two fossil bones of birds bearing this number, one of which has already been described above (Fig. 5, Pl. I.), and the present one, which is the distal moiety of the right *tarso-metatarsus* of some water bird, and possibly, if not probably, of a gull (*Larus*), or some form related to the gulls. It is about the size of the corresponding bone in the skeleton of an adult *Larus atricilla;* but its shaft is much broader above, and more compressed in the antero-posterior direction. It should be set aside until some material be discovered in the same locality, which may throw light upon it.

ARDEA SELLARDSI, sp. nov., Stratum 3.

(Plate II., Fig. 15.)

No. 7551. This is the distal third of a right *tibiotarsus* of a heron, somewhat smaller than *Ardea herodias,* and apparently distinct from it. (3 +). It presents all the characters found in the same bone, or part of a bone, which we find in *A. herodias,* while at the same time its shaft is slightly stouter; the anterior tendinal groove narrower and more distinct; the anterior intercondylar valley narrower and deeper superiorly, and some minor differences. The condyles in the specimen are considerably abraded, and, moreover, broken off posteriorly.

This fossil is the type bone of a new species of extinct heron, for which I propose the name of *Ardea sellardsi,* naming it for Dr. Elias Howard Sellards, in recognition of the valuable work he is performing and has performed as State Geologist of the State of Florida.

ARDEA HERODIAS, Stratum 3.

(Plate II., Fig. 17.)

No. 6932. There are two pieces of fossil bird bones bearing this number in the collection; one of them is shown on Plate II., Fig. 17, and will be described below. The other is a piece of a long bone—that is, a portion of a humeral shaft of a rather large bird, and it is so fragmentary as to be valueless as a specimen for reference. The other (Plate II., Fig. 17) is the distal third of the left *tarso-metatarsus* of an adult *Ardea herodias* and probably differed in no marked respect from that species as we now meet with it in the existing avifauna of Florida. Possibly it may have been a subspecies of *Ardea herodias;* but there is no telling in regard to that from a fossil bone.

MYCTERIA AMERICANA (?) Pleistocene, Stratum 3.

(Plate II., Fig. 19.)

No. 7000. An imperfect distal third of a right *tarso-metatarsus* of a large wader, more or less imperfect, and trochleæ nearly all broken off. Upon comparing this imperfect fragment with the corresponding bone from a skeleton of *Mycteria americana* in the collections of the U. S. National Museum (No. 1507), it is found to agree very closely with it in nearly all the characters, and such differences as the fossil bone presents in this comparison may be entirely due to individual variation. In the fossil, the shaft is a trifle stouter and the tendinal groove somewhat wider, while, as a matter of fact, the differences are very slight. The probabilities are that No. 7000, here described, belongs to a specimen of *Mycteria americana.*

HUMERUS OF A FOSSIL BIRD (gen. et sp. ?), Pleistocene, Stratum 3.

(Plate II., Fig. 20.)

No. 7552. (24). Some of the characters of this fragment point to the possibility of its having belonged to some medium-sized anserine form. It had a length of about that of *Dendrocygnus autumnalis,* and it very possibly may have belonged to a bird of that genus—that is, a Tree Duck. It should be set aside until further material be brought to light from excavations at Vero later on.

LARUS VERO, sp. nov.

(Plate II., Fig. 21.)

Pleistocene, Stratum 3, Vero, Fla.

The type bone.

No. 6933. Left *carpo-metacarpus* of an extinct gull, of a larger species than *Larus atricilla,* or a larger bird among the terns than *Sterna maxima.* This bone runs very close with respect to characters among the gulls and terns. Still, everything else being equal, the *head* of the bone is proportionately larger in the terns, as compared with its shaft, than it is in the gulls. This can be appreciated by comparing Figures 21-23 of Plate II. Then the general morphology of the proximal extremity of the bone is somewhat different, which may also be appreciated by critically comparing the aforesaid figures. The specimen is imperfect, the shaft of medius metacarpal having been broken off and lost. Extreme length 5.75 centimeters.

For this new and now extinct Gull I propose the name of *Larus vero,* the specific name being for the locality where it was discovered.

SHAFT OF AN ULNA; BIRD.

(Not identified.)

No. 6793. Stratum 3. This bone belonged to some large bird of an unknown species. The extremities having been broken off and lost, it is too fragmentary for identification or reference. It should be set aside until further material comes to light during future excavations in the same locality.

Washington, July 20, 1917.

Number 6931.—Proximal two-thirds of a left tarsometatarsus, nearly perfect, of some wader (adult). This bone agrees very closely with the corresponding one, or part of one, belonging to a skeleton of an adult Egret (*Herodias egretta*) in the collections of the United States National Museum. The shaft in the fossil bone is but very slightly stouter, which may be due to individual variation or difference in sex. It is quite possible that the fossil bone belonged to the Egret just named, and certainly to a very closely allied species in the event that it did not. On the back of this specimen number 19 is found, in ink.

Number 6931,19—. For some reason this specimen is numbered exactly like the last, though it apparently has no relation to it, beyond, perhaps, having been discovered in the same place and at the same time. It consists of anterior moiety of the left scapula of an adult bird of some considerable size. Upon comparison it seems to very closely approach the corresponding bone, or that part of it, in the Turkey Vulture (*Cathartes aura septentrionalis*), and possibly may have belonged to that species.

Number 6773, 46. This is a right scapula, with the distal part broken off and lost. Like the two foregoing, it is thoroughly fossilized, and of a chocolate color, of a shade agreeing with the tarsometarsus described above. The individual was adult; the anterior extremity is somewhat abraded. It differs in not a few particulars from the last, though it came from a bird about the same size as a Turkey Buzzard. It is highly pneumatic, and a row of such foramina are to be seen in a deep transverse groove, seen upon its dorsal aspect, just within the anterior articular head of the bone. All three of these specimens should be held till more material is discovered, of a kind that will throw further light upon them, before final references are made.

EXPLANATION OF PLATES.

PLATE I.

(Both plates are reproduced from photographs of the actual specimens by Dr. R. W. Shufeldt. All the figures are natural size.)

Fig. 1. Dorsal aspect of the left *ulna* of *Cathartes aura*. No. 17872, Coll. U. S. National Museum.

Fig. 2. Dorsal aspect of the left *ulna* of *Cathartes aura* (fossil). From Stratum No. 3, Vero, Fla. (Fla. Geol. Surv., 1916). Pleistocene. Cat. No. 6783 (2 pieces). Imperfect.

Fig. 3. Anconal aspect of the right *humerus* of *Querquedula discors*. No. 17704, Coll. U. S. National Museum.

Fig. 4. Anconal aspect of the right *humerus* of *Querquedula floridana*, sp. nov. Shuf. From Stratum No. 2, Vero, Fla. (Fla. State Geol. Surv., 1916). Pleistocene. Very nearly perfect. Cat. No. 7550.

Fig. 5. (No. 6774). The distal two-thirds of the left tarso-metatarsus (imperfect) of some heron (*Ardea*), larger than *Nycticorax n. naevius*; anterior view. Not quite perfect enough for exact reference. Stratum No. 3, Vero, Fla. Fla. State Geol. Surv., 1916). Pleistocene.

Fig. 6. Dorsal aspect of a large, elongate vertebra (9) from the skeleton of the neck of some sort of a heron; imperfect. Leading section of the chain. Comes near *Herodia egretta*. From Stratum No. 3, Vero, Fla. (Fla. State Geol. Surv., 1916). Pleistocene.

Fig. 7. Distal half, anterior view, of the right *tibio-tarsus* of an adult specimen of *Tyto pratincola* (fossil). Vero, Florida. No. 6934. (Fla. State Geol. Surv., 1916). Compare with figure 8 of this plate.

Fig. 8. Right *tibio-tarsus* and *fibula* of a specimen of *Tyto pratincola;* anterior view. Nat. size. (Spec. 19636, Coll. U. S. Nat. Mus.) Compare with the fossil specimen shown in Fig. 7 of this plate.

Figs. 9 and 10. Vertebrae of some small or average-sized wader (bird). They are from the posterior region of the neck and nearly perfect. Fig. 9 is seen on ventral view, and Fig. 10 upon dorsal aspect. Vero, Florida, Pleistocene. (Fla. State Geol. Surv., 1916. Stratum No. 3.)

Fig. 11. From the same lot as the last; same date and Stratum. Distal extremity of a right *tarso-metatarsus* (bird). Not identified. Perfect as far as it goes. It probably belonged to some sort of an average-sized wader, perhaps after the heron order, or a near ally. Anterior surface.

Fig. 12. No. 6773 is the lower two-thirds of the right *tibio-tarsus* of some medium-sized water bird; nearly perfect as far as it goes. Anterior view. (Orig. Number 57 ?) Vero, Florida. Pleistocene. Stratum No. 3. (Fla. State Geol. Surv., 1916). It may possibly have belonged to a gull, somewhat larger than *Larus atricilla* and in the same genus. (Compare with No. 19592, Coll. U. S. Nat. Mus., *L. atricilla*.)

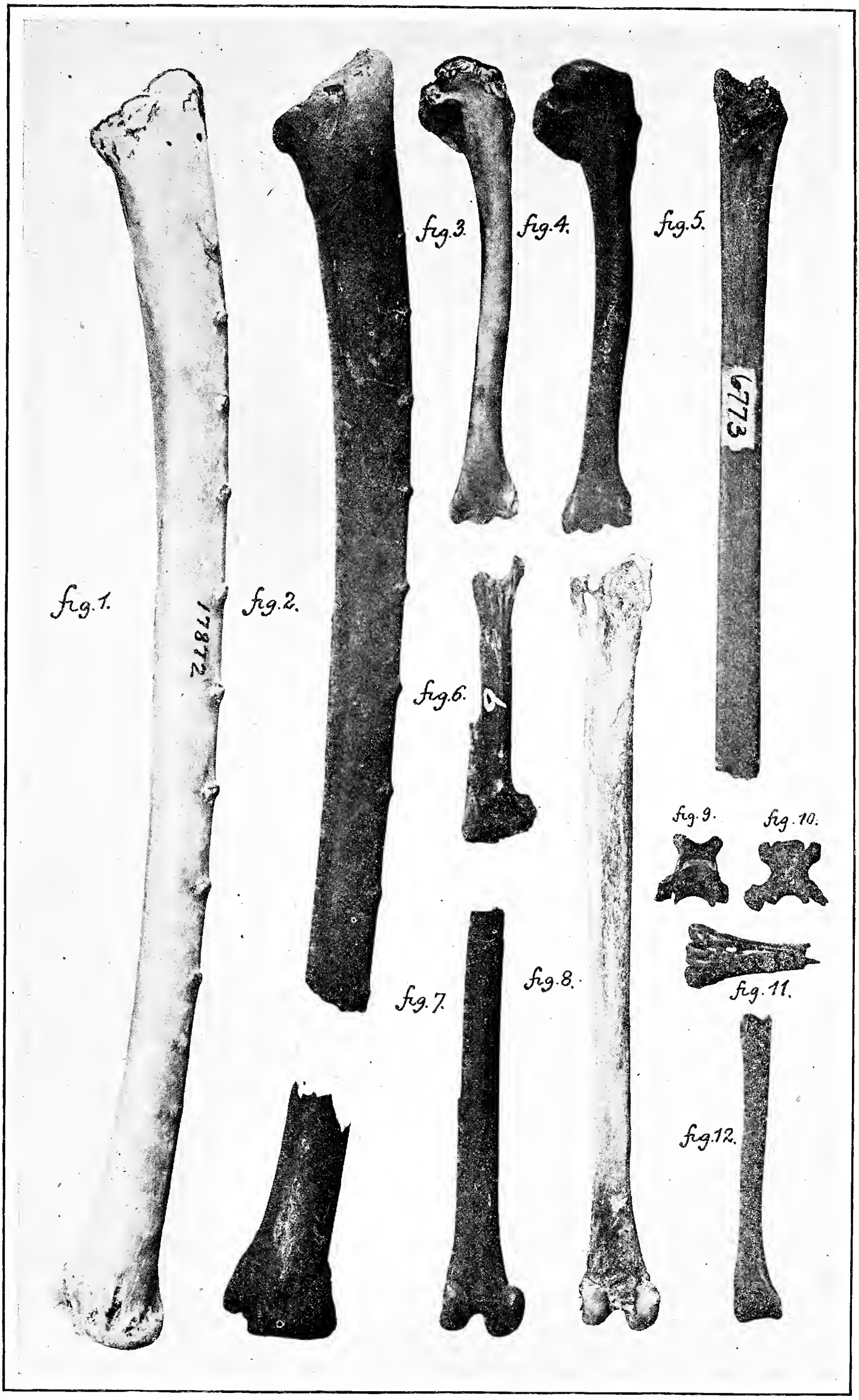


fig. 1.
17872
fig. 2.
fig. 3.
fig. 4.
fig. 5.
6773
fig. 6.
fig. 7.
fig. 8.
fig. 9.
fig. 10.
fig. 11.
fig. 12.

VERTEBRATA MOSTLY FROM STRATUM NO. 3, AT VERO, FLORIDA, TOGETHER WITH DESCRIPTIONS OF NEW SPECIES.

By OLIVER P. HAY.

ASSOCIATE OF THE CARNEGIE INSTITUTION OF WASHINGTON.

The writer has been permitted to study a collection of fossil vertebrates which Dr. E. H. Sellards, State Geologist of Florida, and his assistant, Mr. Herman Gunter, and others had made at different times in the Pleistocene deposits at Vero, Florida. The fossils noted below, some of which are described at length, were found in what has come to be known as No. 3, or as the "muck bed." In the following list those species whose names are preceded by † are extinct:

I. CATALOGUE OF SPECIES.

FISHES.

1. Aetobatis narinari. Spotted sting ray.
   A section of a tooth plate.

2. Lepisosteus platystomus. Short-nosed gar pike.
   A right dentary and one other bone.

3. Amiatus calvus (*Amia calva* of authors). Bowfin.
   The left articular and a left dentary with teeth.

4. Caranx hippos. Crevallé.
   An inflated bone belonging beneath the clavicle.

5. Caranx sp. indet.; not C. hippos.
   Inflated bones belonging in the median plane and supporting the fin-rays.

AMPHIBIANS.

6. Amphiuma means. Congo snake.
   Three vertebrae examined.

7. Siren lacertina. Siren.
   A single vertebra seen.

REPTILES.

8. Caretta caretta. The loggerhead turtle.
   A right squamosal bone.

9. Chelonia mydas. The green turtle.
A humerus of a young individual.

10. †Chelydra sculpta. Extinct snapping turtle.
Seven bones of one individual. Further described below.

11. †Trachemys? nuchocarinata. Extinct terrapin.
One nuchal bone.

12. †Pseudemys floridanus persimilis. Extinct subspecies of the Florida terrapin.
A pair of epiplastrals.

13. †Terrapene innoxia. Small extinct box-tortoise.
Many specimens, including a number of complete carapaces.

14. †Terrapene antipex. Large extinct box-tortoise.
Many specimens, single bones.

15. Gopherus polyphemus. The gopher tortoise.
Nuchal, epiplastral, and both xiphiplastrals; but probably of different individuals.

16. Drymarchon corais. (*Georgia couperi,* Baird and Girard's Cat. Rept. N. Amer., p. 92). Indigo snake.
Several vertebrae.

17. Farancia abacura. Red-bellied horn snake.
Articular bone.

18. Crotalus adamanteus. Diamond rattlesnake.
Vertebrae.

19. Alligator mississippiensis. Alligator.
Teeth, fragment of jaw, etc.

MAMMALS.

20. Didelphis virginiana. Opossum.
Many parts of the skeleton. Probably not distinguishable from the subspecies *pigra.*

21. †Dasypus, sp. indet. Fossil armadillo.
Represented by dermal scutes. Probably an undescribed species.

22. †Chlamytherium septentrionalis. Northern giant armadillo.
Besides dermal plates collected in No. 3 by Dr. Sellards, the writer secured two fine plates which show no signs whatever of transportation. They probably belonged to the same animal.

23. †Equus littoralis? Small extinct horse.
Represented by an incisor which, on account of its small size, appears to belong to this species. Dr. Sellards informs the writer that he has recently secured from No. 3 one good and complete incisor tooth of a horse. Its size indicates a horse larger than *E. littoralis* and hence belongs probably either to *E. complicatus* or to *E. leidyi.*

24. †Tapirus haysii? Extinct tapir.
A tooth, No. 6943.

25. †Tayassu lenis. Extinct peccary.
Various remains of one or more extinct peccaries have been found at Vero in both deposits, No. 2 and No. 3. Further remarks will be found below.

26. †Bison, sp. indet. Extinct bison.
From No. 3 the writer took a well preserved penultimate upper premolar of a bison. It had been considerably worn during the life of the animal. There is no reason to suppose that it belonged to the existing species.

27. Odocoileus osceola? Florida deer.
Various bones which seem to have belonged to a deer about as large as *Odocoileus virginianus* are referred provisionally to *O. osceola.* They belong possibly all to the next species.

28. †Odocoileus sellardsiæ, new species. Extinct Florida deer. This species is described below.

29. †Mammut americanum. American mastodon.
Fragments of bones which probably belong to this species are common in No. 3. In the collection studied, there is a large fragment of a tooth.

30. †Elephas columbi. Columbian elephant.
In the collection are four fragments of teeth.

31. Oryzomys palustris? Rice-field mouse.
A left ramus of the lower jaw, having the number 6773, is regarded as belonging most probably to this species.

32. Sigmodon hispidus. Cotton rat.
There are several jaws of a *Sigmodon* which does not appear to differ from the one here named.

33. Neotoma floridana. Florida wood rat.
A right ramus of the lower jaw shows no important differences when compared with jaws of the existing form in Florida. The teeth are missing.

34. Neofiber alleni. Allen's muskrat.
Several jaws and one nearly complete skull of this species are in the collection.

35. Sylvilagus palustris. Marsh rabbit.
The rabbit materials collected in No. 3 appear to belong to this species. The writer has a left mandibular ramus with teeth from this stratum.

36. Scalopus aquaticus australis. Southern mole.
This species is represented by a lower jaw.

37. Ursus floridanus. Florida bear.
There are present a lower right first molar and a lower right third molar which do not appear to differ from the corresponding teeth of the existing Florida bear. Possibly better materials might reveal differences.

38. Procyon lotor. Raccoon.
There is in the collection examined a right maxilla and some limb bones which appear to belong to this species.

39. Lutra canadensis. Otter.
Represented by a femur.

40. †Vulpes palmaria, new species. Extinct fox.
This fox is described below.

41. †Canis riviveronis, new species. Extinct coyote.
This new coyote is described below.

42. †Canis sp. indet. Extinct dog.
A small heavily built dog is represented in No. 3 by a humerus and a radius. Further remarks on it will be found below.

43. Lynx ruffus floridanus. Florida lynx.
Represented by a tibia and a lower jaw. Further described below.

II. DESCRIPTIONS OF CERTAIN SPECIES.

CHELYDRA SCULPTA HAY.

Plate 3. Fig. 1.

From the stratum designated by Sellards as No. 3, there have been sent to the writer seven bones of a *Chelydra,* which is to be referred to *C. sculpta* (8th Ann. Rep. Fla. Geol. Surv., p. 73). It is evident that all of these bones belonged to the same individual. The nearly complete nuchal and the right and left first costal plates are present and the latter fit the nuchal accurately. The second left costal joins accurately the costal in front. The fourth and the fifth right costals are present, and on the left is the fifth costal, with its proximal end missing.

All of the costals were in life connected with the peripheral bones, the jagged suture passing in most cases across the upper surface of the end of the rib. In a specimen of *C. serpentina,* whose warped carapace had been about 240 mm. long the first costal is sutured to the peripherals except over the rib. The others, except the seventh and eighth and a little of the hinder border of the second, are widely removed from the peripherals; and the ribs, whose ends of course are inserted into the peripherals, are for considerable distances left uncovered by the bone of the costal plate. In the fossil the costal plates hide the upper surfaces of the rib down to the edges of the peripherals.

The nuchal of the fossil differs in a conspicuous manner from that of the recent *C. serpentina*. In the latter there is on each side a slender process which runs along the inner border and inferior face of the anterior peripherals, reaching the hinder end of the second peripheral. In the fossil species this process is very short, as shown in figure 1 of plate 3. On the left side of the bone this process is broken off; on the right it is complete. The nuchal had an extreme width of 70 mm.; a length of 20 mm. in the midline. The nuchal scute had a length of 6 mm. and a width of 24 mm. The width of the first vertebral scute was 52 mm.; its length on the midline, 38 mm.

The first costal plate has an extreme width, fore and aft, of 34 mm.; a length of 64 mm., not including the distal end of the rib. The free proximal part of the rib has about the same size as in *C. serpentina,* but there is in the fossil a considerably larger angle between it and the proximal part of the costal plate. This difference in the direction taken by the free part of the rib is conspicuous in all of the costal plates.

TRACHEMYS? NUCHOCARINATA HAY.

This species was first recognized (8th Ann. Rep. Fla. Geol. Surv. p. 70, pl. VI., fig. 5) from a portion of a nuchal bone which had been found in Pleistocene deposits at Station 120, on the Inland Waterway canal, about 20 miles north of St. Augustine. A nuchal bone found in No. 3 at Vero evidently belongs to the same species.

Its catalog No. is 7011. It is complete and shows no signs of transportation. It is considerably smaller than the type, the length on the midline being only 29 mm., the greatest width 35 mm.; the width on the front border 14 mm. The first vertebral scute area is 23 mm. wide and is ornamented by the ridges produced by the growth of the horny scute. There is a prominent median keel.

Another nuchal No. 7573 was found in stratum No. 2. In size it is intermediate between the type specimen and the one described above. The bone is complete and without abrasion of any kind. The total length in the midline is 39 mm.; the total width, 42 mm.; the width of the front border, 22 mm.; the width of the first vertebral scute, in front, 39 mm. The nuchal scute area is not as narrow as it is in the type and not as wide above (5mm.) as it is on the underside of the bone (6 mm.). The area of the first vertebral scute is marked by strong lines of growth.

FARANCIA ABACURA (HOLBROOK).

In the collection made by Dr. Sellards in stratum No. 3, at Vero, is the articular bone of a snake which seems to have belonged to this species. The bone has a length of 41 mm., but a small piece is broken from the front end. It has been compared with an articular of a skull which belongs to Dr. R. W. Shufeldt, and which, as he reports, he took from a *Farancia* 6 feet and 3 inches long, found near New Orleans. This bone is 44 mm. long. Three other bones, considerably smaller, belonging to the National Museum, have been used for comparison.

In the New Orleans specimen the two plates which enclose the insertion of the masseter muscle are of equal height, 7 mm. In all the other bones, including the fossil, the outer plate is much lower. In the fossil the inner plate is 8 mm. high. While the fossil presents some peculiarities, they are probably due to individual variation. The snake which possessed this bone was probably about 6 feet long.

The lower jaw of *Abastor* is similar to that of *Farancia,* but the dentary extends backward only a short distance behind the front of the articular; while in *Farancia* the dentary, with teeth, is carried back more than half-way to the groove for the masseter muscle.

TAYASSU LENIS (LEIDY).

Plate 3. Figs. 2, 3.

While at Vero, November 1, 1916, the writer found in the stratum of sand, No. 2, 460 feet west of the railroad bridge, a finely preserved upper left hindermost molar of a small peccary. An examination of this seems to show that it belongs to *Tayassu lenis,* originally described and figured by Leidy (Holmes Post-pliocene Foss. S. Car., p. 108, pl. XVII, figs. 13, 14) as *Dicotyles fossilis.* In 1869 (Ext. Mamm. N. A. p. 389) Leidy named this *D. lenis.* It is now referred to the genus *Tayassu.*

The length of the crown of the molar (pl. 3, fig. 2) found at Vero is 14.8 mm.; the width in front is 10.2 mm. The tooth is remarkable for its simplicity of construction. Besides the four principal cones there is a heel consisting of two minute tubercles. No other tubercles appear anywhere. A faintly developed ridge descends from the summit of the metacone and meets a similar hardly perceptible ridge which descends from the summit of the protocone. There is no cingulum. A slight ridge descends from the paracone to the front of the base of the protocone.

Mr. I. M. Weills, of Vero, sent the writer a small collection of fossils which were found along the drainage canal at Vero. Among these was a remarkably small upper left canine (pl. 3, fig. 3) of a peccary. This also the writer refers to *T. lenis.* It was found near the top of No. 2. The front border is worn away from whetting against the lower canine. Its original height cannot be determined. Root and crown together now are 26 mm. high; the crown itself, 14 mm. The fore and aft diameter of the base of the crown is 7.2 mm.; the thickness, 5.2 mm. On the abraded surface the pulp cavity is exposed. A second upper left canine, from stratum No. 3, catalogue No. 6944, is much less worn on the front edge. The root and crown together measure 32 mm.; the crown above, 13 mm. The fore-and-aft diameter at the base of the crown is 7 mm. The thickness is 5 mm. These teeth are very small when compared with those of the existing pecaries.

On the page just cited of the Extinct Mammalia, Leidy referred to a remarkably small canine tooth of a peccary which Cope had originally described as *Cynorca proterva.* This canine had a fore-and-aft diameter of 9.4 mm. and a thickness of a little more than 6 mm. It thus resembled the canine found at Vero.

One of the two teeth of *Tayassu lenis* originally figured by Leidy was a lower molar, probably a second. It measured 7 by 5.75 lines; that is 14.6 mm. by 12 mm. In two existing peccaries measured the length of the second lower molar is almost exactly that of the uppermost hinder molar. In one of them the width of the second lower molar is somewhat less than that of the upper hindermost; in the other it is greater. It is seen from the above measurements that the length of the Vero tooth is almost the same as that of the second lower molar described by Leidy. The width of the Vero last molar is less than in Leidy's second molar. The lower hindermost molar which Leidy described had a length of about 17 mm.

Leidy mentions especially the simplicity of structure of the molars in his possession.

In No. 3 this species appears to be represented by the distal end of a tibia, No. 6737. This bone is much smaller than the corresponding bone of the existing peccary. The side-to-side diameter is only 14 mm. In the same stratum there has been found a peccary canine which appears to be entirely too large to have belonged to *T. lenis,* in case the small canine has been properly referred.

ODOCOILEUS SELLARDSIAE, NEW SPECIES.

Plate 3. Fig. 4.

Type specimen.—A fifth cervical vertebra, not water-worn, but lacking, through fractures, the right diapophysis and the borders of some of the other processes. No. 7923 of the Florida Geological Survey.

Type locality.—Vero, Florida.

Type formation.—Stratum No. 3 of the Pleistocene deposits at Vero.

Diagnosis.—Diapophysis entirely separated from the parapophysis of its side; its base short, on a level with, and wholly in front of, the hinder opening of the vertebraterial canal.

This species is named in honor of Mrs. Anna Mary Sellards, wife of the present State Geologist of Florida.

In the collection of the Florida Geological Survey is a fifth cervical vertebra (No. 7923), which was found in stratum No. 3, the "muck bed," at Vero. The exact locality (Station 19) was on the south side of the canal and extended from 460 to 470 feet west of the railroad bridge. This is where the second lot of human bones was found. On comparing this bone with the corresponding one of *Odocoileus virginianus, O. hemionus* (pl. 3, fig. 5) and *O. osceola,* it is seen to differ from all of them. In all of the species just named the diapophysis is more or less closely connected with the parapophysis, has a long base, and is situated below the vertebrarterial canal. In *O. sellardsiae* the diapophysis is separated from the parapophysis, has a short base, is on a level with the canal mentioned, and is in front of it. In short, it has the same position that this process has in the sixth vertebra. Otherwise the vertebra resembles the fifth in the other species. The length of the body of the vertebra, measured from the centers of the front and rear articulatory surfaces, is 42 mm. In a buck of *O. virginianus* at hand the corresponding length is 50 mm.

From the locality just mentioned there have been secured 50 deer bones representing at least three individuals. Among these bones are an axis; a first dorsal vertebra; two second dorsals, of which one fits closely the first dorsal present; a badly preserved, more posteriorly situated, dorsal; three lumbars, the third, fourth and fifth, which connect as well as in a recent skeleton; the complete sacrum; three innominate bones, two of which undoubtedly belong with the sacrum; and other bones, some of which will be mentioned later. It is necessary to compare these with corresponding bones of other deer. The centrum of the second dorsal lacks the hinder epiphysis; the corresponding one of *O. virginianus* retains it, but shows the suture. The two centra had almost exactly the same length. The rear of that of the Virginia deer, taken across the surfaces for the ribs, is 32 mm. wide; that of the fossil, 35 mm. The extreme width of the bones is almost exactly the same. The spine of the fossil vertebra is somewhat higher, but it is narrower from front to rear than the other. The surface for the tuberculum of the rib extends backward in the fossil farther than in the existing deer. The horizontal diameter of the spinal canal is considerably larger in the existing deer (18 mm.) than in the fossil (16 mm.). In a young *O. osceola* the diameter is 17 mm.

The hinder epiphysis of the fossil second vertebra is gone; but the length was that of the same vertebra of *O. virginianus* used for comparison. The width of the hinder end of the centrum of the fossil was apparently a little less than that of the existing deer. The extreme width across the transverse processes in the fossil is 44 mm.; in the existing deer, 56 mm. In the fossil the surface for the tuberculum of the rib extends backward considerably behind the notch for the exit of the spinal nerve; while in *O. virginianus* it stops well in front of the notch. In *O. osceola* the process reaches nearly to a perpendicular from the notch.

The three lumbars of the fossil, Nos. 7000, 7765, and 7766, have the length only slightly less than that of the same bones in *O. virginianus*. The width across the processes supporting the anterior zygapophysis of the third lumbars is 29 mm.; in *O. virginianus*, 31 mm. The distance across the postzygapophysis in the fossil is 23 mm.; in the other deer, 26 mm. The transverse processes of the fossil vertebrae are missing, but evidently they were not so broad as in the deer they were compared with. In the cases of the fourth and fifth lumbars only unimportant differences are seen on comparison with the corresponding bones of the Virginian deer. The processes are, however, all of slenderer build in the fossil. The transverse processes of the fifth are preserved, except the extremities. They are slenderer even than those of the sixth lumbar of *O. virginianus* and they are directed outward and but little forward.

On the two hinder dorsal vertebrae and on the lumbars of the deer found at Vero there is a structure which appears in none of the existing deer at hand, except the specimen which has here been used for comparison, No. 199510, of the U. S. National Museum. Usually the prezygapophysis bends inward like a hook and clasps the postzygapophysis of the vertebra in front. In the case of the fossil, a process on each side, mesiad of the hinder zygapophysial articulation, grows up and, bending outward, overlaps the hook mentioned, producing an articular surface on the end of the latter. The vertebrae are thus more firmly interlocked. On plate 3, figure 6, there is presented a view of the hinder end of the third lumbar. This arrangement is found well developed on the eleventh dorsal, No. 7591, found on the north side of the canal, 100 feet west of the railroad track, and on all of the lumbars; for the anterior zygapophyses of the first vertebra of the sacrum have each a smooth surface above. The extra process is weakly developed or missing in only rare cases. In the specimen of *O. virginianus* mentioned the same structure appears on the eleventh dorsal and continues on the lumbars, disappearing on the fourth. From the materials at hand it is judged that the arrangement described was more strongly developed than in the existing kinds of deer. It is, however, observed in some other artiodactyls and possibly has no great significance in the Florida fossil deer.

Among the 50 bones mentioned is a finely preserved sacrum which may well have belonged to the same individual deer as did the three lumbar vertebrae described above. The length of the bone in a straight line is 97 mm., while that of a buck of *O. virginianus* is 112 mm. The width across the front is 78 mm.; that in the buck mentioned, 94 mm. The sacrum of *O. virginianus* is thus relatively somewhat broader. Also the distance across the prezygapophysial articulation is relatively considerably greater, being 43 per cent. of the length of the sacrum, while in *O. sellardsiae* it is only

33 per cent. The length of the zygapophysial surfaces on the front of the sacrum is nearly twice as great as in the buck mentioned.

Found at the same spot is the practically complete left innominate bone which belonged with the sacrum. The one of the right side is present, but lacks the part behind the acetabulum. Both bones make accurate contact with the sacrum. The presence of all the bones of this pelvis is of interest because it indicates that they had not been washed in from some other place after a previous burial. In a small collection made for the writer by Mr. Isaac M. Weills there is a part of the first sacral vertebra, which is recorded as having been found 8 inches below the upper surface of stratum No. 2. The peculiar articulatory surface on the upper face of the prezygapophysis is somewhat more strongly developed than in the sacrum described above.

From No. 3 there are present an atlas (No. 7591), an axis (No. 7039), a sixth cervical (No. 7591), an eleventh dorsal (No. 7591), and the right ramus of a lower jaw (No. 7039) containing well-worn teeth. These were found near one another on the north side of the canal, 100 feet north of the railroad bridge. At least the atlas and the axis belonged to one individual. They point to a deer larger than *O. sellardsiae;* but common parts for comparison are wanting. The atlas, axis, and sixth cervical do not show any characters that separate them with certainty from *O. virginianus;* and they indicate a deer fully as large as this species. For the present they may be referred to *O. osceola.* The body of the eleventh dorsal is 3 mm. longer than that of the buck of the Virginian deer mentioned. The postzygapophyses have the same modification as has been described in the case of the lumbars which are referred to *O. sellardsiae.*

With difficulty Doctor Sellards secured, through Isaac M. Weills, most of the vertebrae and the pelvis of the existing Florida deer, *O. osceola,* for comparison with the fossil deer and with *O. virginianus.* *O. osceola* is certainly distinct from *O. sellardsiae.* Unfortunately the skeleton of *O. osceola* is that of a young female and one cannot be sure that the many differences found between it and such skeletons of *O. virginianus* as are at hand are not due to immaturity or to sex.

In the collection sent by Dr. Sellards are the proximal ends of two scapulae from No. 3. They have the catalogue numbers

7009 and 7764. They differ slightly in size, but neither has the neck of the bone as narrow as that of the specimen found by Sellards from stratum No. 2 (8th Ann. Rep. Fla. Geol. Surv. pl. XXVII, fig. 1).

Three complete humeri were found among the 50 bones mentioned, but they belonged to as many individuals. No constant differences appear on comparing them with humeri of *O. virginianus*. There are also the proximal end of another humerus from the station just mentioned and the distal ends of three from other stations.

From station 19 there come two radii, a right and a left, which must have belonged to the same rather young deer. The size is the same, each has lost the distal epiphysis, and curiously enough each has, on the inner face near the distal end, a hole about 10 mm. by 17 mm. How these holes have been made the writer does not know. One of these bones, the left, is here compared with the corresponding bone of *O. virginianus*.

MEASUREMENTS OF RADII IN MILLIMETERS.

	No. 6999	O. virginianus
Distance along inner border from surface for humerus to epiphysial suture	178	194
Total length on the inner (anterior) border (fossil estimated)	193	211
Greatest width at upper end	35	39
Greatest diameter at middle of length	19.5	25
Shortest diameter at middle of length	13	15
Greatest diameter at epiphysial suture	27	34

It will be observed that the fossil radius has relatively to the length a considerably slenderer shaft. No other differences are noted. The fragments of two or three ulnae present no peculiar features.

There have been found in No. 3 one complete right front cannon bone, No. 6764, and the distal halves of two others. The complete one is here compared with the same bone of *O. virginianus*.

MEASUREMENTS OF ANTERIOR CANNON BONES IN MILLIMETERS.

	No. 6764	O. virginianus
Total length	194	204
Width across upper end	26	30
Fore-and-aft diameter at midlength	16	17
Side-to-side diameter at midlength	15	18
Diameter across lower articulatory surface	27	31

It will be seen that the fossil bone is relatively slenderer than that of the existing deer. Possibly the fossil bone was that of a doe.

Another bone, No. 7766, is that of an adult, but it is much smaller than the bone just described. The fore-and-aft diameter at the middle of the length is 14 mm.; the side-to-side diameter, 13 mm.; the width across the lower articulation, 25 mm.

The bones of one pelvis have already been described. There is among the lot from station 19 a considerable part of the ischial portion of the right innominatum, which may belong with the one above described; but some bone is missing and contact is made impossible. From the same locality is another quite complete left innominatum.

The writer has seen only one complete femur of a deer from Vero, No. 5896; from stratum No. 3, north bank, east of the bridge. It appears to present no peculiar features; neither do the fragments of the other femora.

Several tibiae are represented by the distal end of the bones, but they show nothing distinctive. The same remark applies to the various bones present of the front and hinder feet.

There are present from No. 3 a beautifully preserved left hinder cannon bone, No. 6767, and the proximal end of one of the right side. Besides these, there has been sent one of the right side, No. 5195, whose stratum is not known and which lacks the epiphysis. As this and No. 6767 show some differences in proportions their measurements are here given, together with those of the same bone of *O. virginianus*.

MEASUREMENTS OF HINDER CANNON BONES IN MILLIMETERS.

	No. 6767	No. 5195	O. virginianus
Length to suture for epiphysis	212	225	210
Total length (5195 estimated)	230	244	231
Width of upper articulatory surface	25	22	26.5
Fore-and-aft diameter at middle of length	20.5	18	19
Side-to-side diameter at middle of length	16	15	16.8
Width at suture for epiphysis	29	27	30
Width of distal articulatory surfaces	29	27±	31

It will be observed that No. 5195 is a longer bone than either of the others, but all the transverse measurements are less. The fore-and-aft diameter at middle of the length in 5195 is but little more than 7 per cent. of the total length, while in the other bones it is about 9 per cent. Just what this means cannot now be determined. The measurements of the other two bones are not greatly different All of the fossil hinder cannon bones differ from those of *O. virginianus* in having the outer of the two ridges which bound the hinder groove more prominent than the inner one.

There are in the collection from station 19 a part of a right premaxilla containing the three premolars and a part of a left maxilla containing the three molars. Both have the numbers 6952. The molar teeth are somewhat more worn than the premolars, so that we must conclude that the two bones did not belong to the same individual. There is also a left ramus of a lower jaw, No. 7765, nearly complete and containing all of the teeth. To the molars of this jaw the molars of the fragment of maxilla fit accurately. Both must have belonged to one individual. A comparison of these with jaws and teeth of *Odocoileus virginianus* and of *O. osceola* yield to the observer no differences that seem to be constant. The following measurements of the teeth are furnished for future comparisons. The measurements of the teeth of a second complete left ramus, No. 6951, found at this same place, are included.

MEASUREMENTS OF TEETH IN MILLIMETERS.

	Upper Teeth	Lower Teeth	
	No. 6952	No. 7765	No. 6951
Length of line of premolars	36	34	30
Length of line of molars	44.5	48	51
Length of pm2	12	10	8
Width of pm2	11.2	5.3	5.2
Length of pm3	11.2	11.5	10
Width of pm3	12	7	6.8
Length of pm4	11	12	11.1
Width of pm4	13	8.2	7.6
Length of m1	13	12	14
Width of m1	13.5	10	9
Length of m2	15	14	15.5
Width of m2	16	10	10
Length of m3	15	20	21
Width of m3	16	10	10

Besides the differences shown in the measurements of the teeth of Nos. 7765 and 6951, the space between the rear of the symphysis and the front of the tooth row in the former is only 27 mm. long;

while in No. 6951 it is 38 mm. In the first, the bone is 9 mm. thick; in the latter, only 7 mm. As to the meaning of these differences nothing at present can be said.

A left ramus No. 7039, was found with the large cervicals 7039 and 7591. The tooth row has the same length as No. 6951. The distance of the symphysis is slightly greater than in 6951.

Among the deer bones collected in the "muck bed" at Vero are some which belonged to adult animals and are much smaller than the corresponding bones of other individuals. It is probable that these belonged to small animals, most likely does, but there is a possibility that they represent a distinct species.

VULPES PALMARIA, NEW SPECIES.

Vulpes pennsylvanicus? Sellards, E. H., 1916, Science, n. s. Vol. XLIV., p. 617; Jour. Geology, Vol. XXV., p. 17; 8th Ann. Rep. Fla. Geol. Surv., pp. 132, 152, 158, pl. XXX., fig. 4.

Type specimen.—A part of the right ramus of the lower jaw, containing the third and fourth premolars and a part of the socket for the canine. The first and second premolars had disappeared early in life. No. 6738 of the collection of the Florida Geological Survey.

Type locality.—Vero, Florida.

Type formation.—Stratum No. 3 of the Pleistocene deposit at Vero.

Diagnosis.—Talon of lower fourth premolar narrower than the body of the tooth. Third premolar without a cusp behind the principal one. Lower jaw thicker and heavier than in *Vulpes fulva.*

The writer has carefully compared the type jaw of this fox with that of various specimens of the red fox (*V. fulva*) and has concluded that it does not belong, as Sellards thought it possibly did, to this existing species, but to one hitherto undescribed. In the following table various measurements are presented, taken from the jaw found at Vero; and the corresponding ones of a red fox from Clarke county, Virginia, and of *V. macroura* from Montana.

MEASUREMENTS OF LOWER JAWS AND TEETH IN MILLIMETERS.

	V. palmaria Type	V. fulva No. 810	V. macroura No. 67384
Length from rear pm_4 to rear canine	40.0	38.0	42.0
Height of jaw at rear of pm_4	18.0	13.5	14.0
Thickness of jaw at rear of pm_4	7.2	6.0	7.0
Height of jaw at front of pm_3	14.0	11.4	13.0
Thickness of jaw at front of pm_3	7.0	6.0	6.0
Length of pm_3	9.1	9.0	10.0
Width of pm_3	3.5	3.2	3.4
Length of pm_4	10.4	9.6	10.0
Width of pm_4	4.3	4.1	4.0
Side-to-side diameter of socket of canine	6.5	5.1	----

The skulls numbered 810 and 67384 are in the U. S. National Museum.

That the fossil jaw belonged to a fox and not to a coyote is shown from the following considerations: 1. On the inner side of the talon of pm_4 there is in the coyotes a well-developed basin which involves the hinder border of the principal cusp. In the red fox this is much less strongly developed. In the fossil it is little developed; so little that the talon, instead of being as wide as or wider than the base of the principal cusp, is narrower. The corresponding part of pm_3 resembles that of the fox much more than that of the coyote. 2. In the coyote there is almost always a well-developed cusp behind the main one in the third premolar. In the fox this is sometimes distinct; but is usually small and more often wholly wanting. In the fossil it is altogether wanting.

A comparison of the measurements given shows clearly that the lower jaw of *V. palmaria* was much heavier than that of *V. fulva*. In the former the height at the rear of the fourth premolar is 45 per cent. of the distance from the rear of the canine to the rear of pm_4; while in the specimen of *V. fulva* it is only 34 per cent. In thickness the percentages are respectively 18 and 15.8. In the fossil the length of the third premolar is relatively slightly less than in *V. fulva,* the percentages being respectively 22.7 and 23. On the other hand the fourth premolar of the fossil is slightly longer, the percentages being 26 and 25.2.

From a cave at Port Kennedy, Pennsylvania, Cope (Jour. Acad. Nat. Sci., Phila., Vol. II, 1899, p. 228, pl. XVIII, figs. 4, 4a) described a fox which he called *Vulpes latidentatus.* This was based on a first upper molar. This molar differed from that of the red fox in its proportions, the transverse diameter of the two being the same, but the anteroposterior diameter of the fossil tooth exceeding that of the red fox. Inasmuch as an upper tooth only of the Port Kennedy animal is known and lower teeth only of the one from Florida, it is not practicable to make a close comparison between them.

CANIS RIVIVERONIS, NEW SPECIES.

Canis latrans? Sellards, E. H., 1916, Science n. s., Vol. XLIV., p. 17; Jour. Geology, Vol. XXV., p. 617; 8th Ann. Rep. Fla. Geol. Surv., pp. 157, 158, pl. XXVIII., fig. 2; text-fig. 15.

Type specimen.—A part of a right maxilla, No. 7036 of the collection of the Florida Geological Survey, containing the fourth premolar and the sockets of the third premolar and of both molars.

Type locality.—Vero, Florida.

Type formation.—Stratum No. 3 of the Pleistocene deposit at Vero, Florida.

Diagnosis.—Third upper premolar in a line with the fourth. The fourth relatively short; its anterior inner cusp prominent. Molars broad.

This maxilla certainly represents a coyote, but not *C. latrans*. Nor is it that of an Indian dog or one of the larger wolves. The prominence of the anterior inner cusp of the carnassial tooth puts the animal with the coyotes and removes it from the domestic dogs and large wolves. In the specimen from Florida, as in the coyotes, the third premolar is in a line with the fourth; while in the dogs and in *Canis occidentalis,* in nearly every case, the third premolar makes an angle with the fourth. This is owing to the fact that in the domestic dogs and the large wolves the width of the jaws decreases rapidly to the front of pm^4 and then begins to narrow less rapidly. In the coyotes the change is made in front of pm^3.

This fossil differs from the near relatives of *C. latrans* in having the anterior lobe of the carnassial relatively shorter. The measurement is made from the front of the tooth to the bottom of the notch behind the main cusp. In the fossil this forms 61 per cent. of the length of the tooth. In four specimens of the existing coyotes this was 63.1; 62.8; 63.1; 64 per cent. However in the specimen of *C. latrans* of the following table, No. 38462 of the

U. S. National Museum, the ratio of the length of the anterior lobe to the length of the tooth is slightly less than the fossil. In three specimens of *C. occidentalis* the percentages were 70.9; 66.6; 64.5. In four Indian dogs they were 63.8; 62.5; 62.1; 65.6.

In this fossil the transverse extent of the sockets for both the first and the second molars is greater relatively to the first measurement in the succeeding table than in nearly every specimen of coyote, wolf, and domestic dog. Here again the fossil approaches *C. latrans* No. 38462 more closely than it does any of the others, being in the fossil 39.5 to 100; in *C. latrans,* 37.7 to 100. The teeth themselves must have been somewhat broader than in the existing species examined. On the other hand, the inner root of pm^4 is narrower fore-and-aft than in any of the recent skulls examined.

The following measurements are presented:

MEASUREMENTS OF TEETH OF COYOTES.

	7036 Fossil	216723 Wyoming	155597 Arizona	59896 Arizona	38462 Minnesota
Distance from front of socket for pm^3 to rear of socket for m^1	40.0	44.5	42.0	37.0	45.0
Length of pm^4	18.0	21.5	20.0	18.0	21.5
Width of pm^4 at front	9.0	9.4	10.0	8.2	10.0
Width across main cusp	7.8	7.5	7.2	5.8	8.6
Fore-and-aft distance across outer sockets of m^1	10.0	12.0	11.0	9.6	13.0
Fore-and-aft diameter of inner socket of m^1	5.0	7.5	7.0	7.0	7.0
Distance from inner to outer side of socket of m^1	15.8	16.0	13.5	12.5	17.0
From front to rear of sockets for pm^3	11.0	12.0	11.2	10.0	12.0

In general the carnassial of the Florida specimen is shorter in relation to the length of the two hinder premolars and the two molars and at the same time thicker than in the other skulls examined; but in the Arizona coyote, No. 155597, the width in front is relatively the same, being one-half of the length of the tooth.

The carnassial of the fossil has been compared with that of two domestic dogs Nos. 216646 and 216651 of the National Museum.

MEASUREMENTS OF CARNASSIALS OF *C. RIVIVERONIS* AND OF TWO DOMESTIC DOGS.

	7036	216646	216651
Length of pm^4	18.0	16.6	17.0
Width in front	9.0	8.5	9.0
Width at middle	6.2	6.4	6.1
Percentage of width at middle to length of tooth	34.4	38.5	39.9
Width across rear lobe	6.1	6.2	6.0

In the collection made in No. 3, at Vero, is a part of a humerus which has the catalogue number 6798. The total length of the fragment is 62 mm. Above, it begins on the deltoid ridge. It is referred provisionally to *Canis riviveronis.*

MEASUREMENTS OF HUMERI IN MILLIMETERS.

	Fossil 6798 F. G. S.	Coyote 1326 U. S. N. M.	Red Fox 7550 U. S. N. M.
Fore-and-aft diameter at lower end of flattened part of deltoid ridge	14.2	15	10.1
Width at level above named	9	9.5	7
Fore-and-aft diameter at lower end of fragment and at corresponding place in the other species	10.4	11.2	7.8
Side-to-side diameter at place indicated above	9	10	7

It will be seen that the fragment of fossil humerus resembles in size more that of the coyote than it does that of the red fox (*Vulpes fulva*). The fragment is more compressed at the lower part of the shaft than is that of the fox and less than that of the coyote. This bone seems to belong to a coyote, probably *Canis riviveronis.*

In the collection is the shaft of a left femur, No. 6796, from No. 3. The head and the greater trochanter are broken off; also the condyles.

It is here compared with the same bone of the red fox No. 7550 U. S. National Museum, and with that of a coyote No. 1326 of the same museum.

MEASUREMENTS OF FEMORA IN MILLIMETERS.

	Fossil 6796	Red Fox 7550	Coyote 1326
Length of shaft	117.0	96.0	120.0
Total length of femora (6796 estimated)	161.0	132.0	166.0
Greatest diameter just below lesser trochanter	12.0	13.0	17.0
Least diameter just below lesser trochanter	8.0	9.0	12.0
Greatest diameter at middle of shaft	10.5	9.0	12.2
Least diameter at middle of shaft	8.2	7.2	10.0
Side-to-side diameter at lower epiphysial suture	12.0	12.0	15.0
Fore-and-aft diameter at lower epiphysial suture	11.0	11.0	13.5

The fossil femur was larger than that of the red fox; also straighter and more flattened anteroposteriorly. The same differences in form are seen on comparison with the femur of the coyote. In the fossil femur the outer border is not so sharp as in the red fox, while the inner border of the lower half is flatter. The shaft is more compressed than in either the red fox or the coyote. The bone is referred provisionally to *Canis riviveronis.*

Doctor Sellards has written that the fragment of humerus was found in No. 3, 475 feet west of the railroad bridge. The femur was found the same day 5 feet nearer the bridge in the same deposit. The jaw forming the type of *C. riviveronis* was found on the north bank 450 feet from the bridge.

CANIS, SPECIES UNDETERMINED.

From stratum No. 3, at Vero, Sellards (8th Ann. Rep. Fla. Geol. Surv., p. 157, pl. XXVIII., figs. 7, 8) described and figured a humerus and a radius of a dog; and these he referred with doubt to *Canis latrans.* Both bones were found 450 feet west of the railroad bridge. One might therefore suppose that they had belonged to the same individual dog; but the radius seems to be too short for this. Herewith is presented a table in which corresponding measurements of the humeri of the fossil dog, of a domestic dog, of a coyote, and of a red fox, are given.

MEASUREMENTS OF HUMERI OF CANIDAE.

	Fossil 6735	Dog 21989	Coyote 1326	Red Fox 21158
Total length	132	134	153	117
Length from head to distal end of outer condyle	129	130	151	115
From front of bone to rear of head	34	36	34	23.5
Fore-and-aft diameter at middle of total length	14.8	15	12	8
Side-to-side diameter at mid-length	10.5	13	10	7
Greatest distance across epicondyles	26.5	31	28	18
Width lower articular surface	18.5	19.2	19	11

The bone numbered 21989 is that of a domestic dog whose skull had a vertex length of 170 mm. and a width of 115 mm. across the zygomatic arches. No. 1326 is a bone of a coyote found in Nebraska. The fox is from Brownville, Maine.

It will be seen that the fossil humerus resembles that of the dog more closely than that of either the coyote or the fox; but the anteroposterior distance through the head is a little less in the fossil than in the dog and the shaft is more compressed, the side-to-side diameter being 8 per cent. of the total length; while in the dog this diameter is 10 per cent. of the length. The distal end of the bone is also narrower than in the dog. The inner epicondyle of the fossil is less developed and is flatter than in the dog.

A reference to the table shows that the humerus in question cannot have belonged to an animal at all like the red fox; nor to the fox *Vulpes palmaria,* which was about the size of *V. fulva;* nor to *Canis riviveronis,* which we may suppose from its jaw and teeth to have had the size of a coyote. It seems evident that there is in No. 3 a small heavy-set dog which is not known from skull remains. The naming of it may be deferred until better material has been secured.

The radius just mentioned is here compared with the same bone of the domestic dog and that of the coyote.

MEASUREMENTS OF RADII OF CANIDAE.

	Fossil. 6736	Dog U. S. N. Mus. 21989	Coyote. 1326
Total length of bone	113	137	155
Greatest width near upper end	14.3	15	16.1
Thickness at right angles to above	9.1	11	11.1
Greater diameter at middle of length	11	12	12.5
Diameter at right angles to above	6	7.5	7
Greater diameter at distal end	19	20	22
Diameter at right angles to above	10	11.5	12

The fossil radius belonged to a canine animal whose foreleg was probably nearly three-fourths as long as that of the coyote and a little more than four-fifths the length of the leg of the domestic dog, No. 21989.

The radius of the domestic dog 21989 is 3 mm. longer than its humerus; whereas, the radius No. 6736 is 20 mm. shorter than the humerus No. 6735. The radius must have belonged to an individual about one-seventh smaller than that to which the humerus belonged. It is the bone of a mature animal.

The foreleg of this dog probably was slightly more than 15 inches long, not including the scapula.

LYNX RUFFUS FLORIDANUS (RAFINESQUE).

Lynx sp. Sellards, E. H., 1916, Jour. Geology Vol. XXV., p. 17; 8th Ann. Rep. Fla. Geol. Surv., pp. 152, 158, pl. XXVIII., fig. 3.

A left mandibular ramus, No. 6739, from bed No. 3, Vero, appears to represent this subspecies. The angle and the articular process are missing. The canine and the third and fourth premolars and the first molar are present. The jaw and teeth are here compared with those of *Lynx ruffus floridanus*, No. 173028 of the United States National Museum, from Florida.

MEASUREMENTS OF LOWER JAW AND TEETH IN MILLIMETERS.

	Fossil Jaw 6739	173028
Length from rear of m_1 to front of symphysis	45.5	47.0
Height of jaw at front of pm_4	14.0	16.0
Height of jaw at rear of m_1	17.0	17.0
Thickness of jaw at front of pm_4	7.5	7.5
Thickness of jaw at rear of m_1	7.5	8.0
Length of symphysis in front	23.5	22.5
Length of tooth row pm_3—m_1	29.0	30.0
Length of pm_3	8.0	7.6
Thickness of pm_3	4.5	4.2
Length of pm_4	10.1	10.8
Thickness of pm_4	5.0	5.1
Length of m_1	12.0	12.2
Thickness of m_1	5.1	5.3
Fore-and-aft diameter of canine at base	7.5	8.0
Side-to-side diameter of canine at base	7.0	6.0

On comparing the jaw with a series of skulls from Florida it is found that the fossil shows apparently no essential specific differences. The carnassial of No. 6739 has the notch deeper than any of the existing specimens, but a few approach it closely.

A right tibia seems not to differ essentially from that of the living form. When compared with No. 173028, United States National Museum, from Florida, differences appear; but these are probably only of individual importance.

From Port Kennedy cave Cope (Jour. Acad. Nat. Sci. Phila., Vol. II., 1899, p. 250) described *Lynx calcaratus,* which was so closely related to *L. ruffus* that originally he referred it to this species.

III. GENERAL CONCLUSIONS.

Of the 43 species which have been enumerated in this paper it will be seen that 17 are regarded as being extinct. This amounts to 40 per cent. If the fishes, amphibians, and reptiles are considered apart from the others, they present only 26 per cent. of extinct species. These low forms are more likely to persist than are the more highly organized mammals. Nevertheless, a large proportion of the cold-blooded animals are represented in the collection by very meagre remains; and it is possible that with more abundant materials species distinct from those now living might be recognized. Of mammals there are 24 species, of which 12, just one-half, are regarded as no longer living. It is especially the mammals which figure in Pleistocene faunal lists; and they are more properly the ones to be used in making comparison with discoveries made elsewhere.

On page 26 of volume XXIII of the Iowa Geological Survey, the writer has presented a list of the species of mammals which have been found in the Aftonian interglacial deposits. These are 21 in number, of which 19 are extinct, close to 90 per cent. It must be noted, however, that most of the Aftonian deposits consist of coarse materials and that the small species, mostly rodents, have not been collected. The discovery of these would quite certainly reduce the percentage.

In the Iowa Report on the page noted above there is a list, taken from Matthew, of mammals which had been found at Grayson, near Hay Springs, Nebraska. These are supposed to be of the same geological age as those from the Aftonian. They are 21 in number, of which 15 appear to be extinct, about 71 per cent.

The cave at Port Kennedy, Pennsylvania, has furnished 47 identified mammals, of which 80 per cent. are extinct. The deposits of this cave belong certainly to the early Pleistocene. As the conditions there were favorable for the preservation of all kinds of land animals, it would seem that the normal percentage of extinct mammals for the early Pleistocene is about 80. What is found in any particular locality will depend, however, on special conditions. In No. 2 at Vero, there appears to be 70 per cent. of extinct mammals.

In the Conard fissure, in Arkansas, Barnum Brown found about 50 identifiable species of mammals, of which about 47 per cent. are extinct. The list is to be found on pages 31 and 32 of the Iowa volume cited above. Inasmuch as great numbers of the smaller animals, especially insectivores and rodents, had accumulated there, and few of the large animals which it is certain were living then in that region, as elephants, mastodons, ground sloths, and bisons, it is not improbable that the percentage of extinct species is too low. On account of the presence of some species there which appear to be of a boreal type, the writer has supposed that the animal lived during one of the glacial stages, probably the Illinoisian.

On account of the comparatively low percentage (50) of the extinct mammals belonging to No. 3 at Vero, the writer has been inclined to the opinion that the stratum belongs to the middle Pleistocene; while No. 2 is thought to belong to the early part of the epoch. However, the geologists who have studied the deposits, both those who argue for the late age of beds and those who believe them to be older, think that there was no great interval between them.

As regards the origin of the vertebrate remains which are found in the muck bed at Vero, the writer believes that the animals left their remains where they are now found, and that they were not washed into that stratum from some other place of previous burial. In too many cases are two or more bones of one individual of an extinct species found closely associated to have been transported even a few hundred yards. The bones of the animals do not present the abrasions and the polishing which transportation would produce. Again, had the bones of both No. 2 and No. 3 been washed in from some common source and at no great interval of time apart, there appears to be no good reason why the percentage of extinct forms in the two should not be practically the same.

The two deposits found at Vero, and at present known as No. 2 and No. 3, and the remains of fossil animals found in them, are of especial interest, because in both of these strata have been found bones of human beings. In stratum No. 3, in addition to skeletal remains, implements made by man are numerous.

We are, therefore, confronted by questions as to the antiquity of those human remains. As has already been indicated, the writer believes that the deposits in question are not only of Pleistocene age but of early or middle Pleistocene. He is also convinced, after having examined the locality and collected fossils from it, that the human remains are as old as the deposits in which they are found. The arguments in favor of the last proposition have already been presented by Doctor Sellards.

The writer will here briefly present some evidences which go to show that men possessing a culture much like that of modern Indians existed in America at least as far back as the Sangamon interglacial stage, about the middle of the Pleistocene, and possibly still earlier.

a. In 1846, Dr. M. W. Dickeson exhibited before the Academy of Natural Sciences of Philadelphia a part of a human pelvis which had been found in a blue clay below the loess, and two feet below bones of megalonyx and other extinct animals. Chemical analysis of the human bone has shown that it is more highly fossilized than the animal bones.

b. In 1891 Prof. F. M. Witter, of Muscatine, Iowa, reported that two flint arrow points had been discovered in the loess at Muscatine, at depths of 12 and 25 feet.

c. In the same communication Professor Witter stated that he had himself found flint chips in a gravel bed on Mad Creek, near Muscatine, at a depth of 10 feet from the surface.The gravel bed was overlain by loess and near-by in the gravel had been found a tooth of an elephant.

d. In 1900 Dr. J. A. Udden published a statement which had been made to him about the finding of a stone ax at Council Bluffs, Iowa, in loess at a depth of 35 feet.

e. In 1903, Dr. C. A. Peterson, of St. Louis, announced that a stone ax had been found near St. Louis at the bottom of the loess, at a depth of 14 feet.

f. In 1902 Dr. S. W. Williston reported that Messrs. Overton and Martin had found, in Kansas, a flint arrow head underneath the shoulder blade of a fossil bison, at a depth of 20 feet from the surface. The animal belonged to the species *Bison occidentalis.* Its remains have been frequently found, but never in deposits overlying the Wisconsin drift.

In all probability man had his origin in southern Asia. From this region, and not from Europe, were peopled the other continents and the islands of the seas. A people as advanced as many American Indians may have reached America long before the Cro-Magnons had been able to dispossess the fierce Heidelbergers and the Neanderthalers who had preoccupied Europe.

DESCRIPTION OF PLATE

PLATE 3.

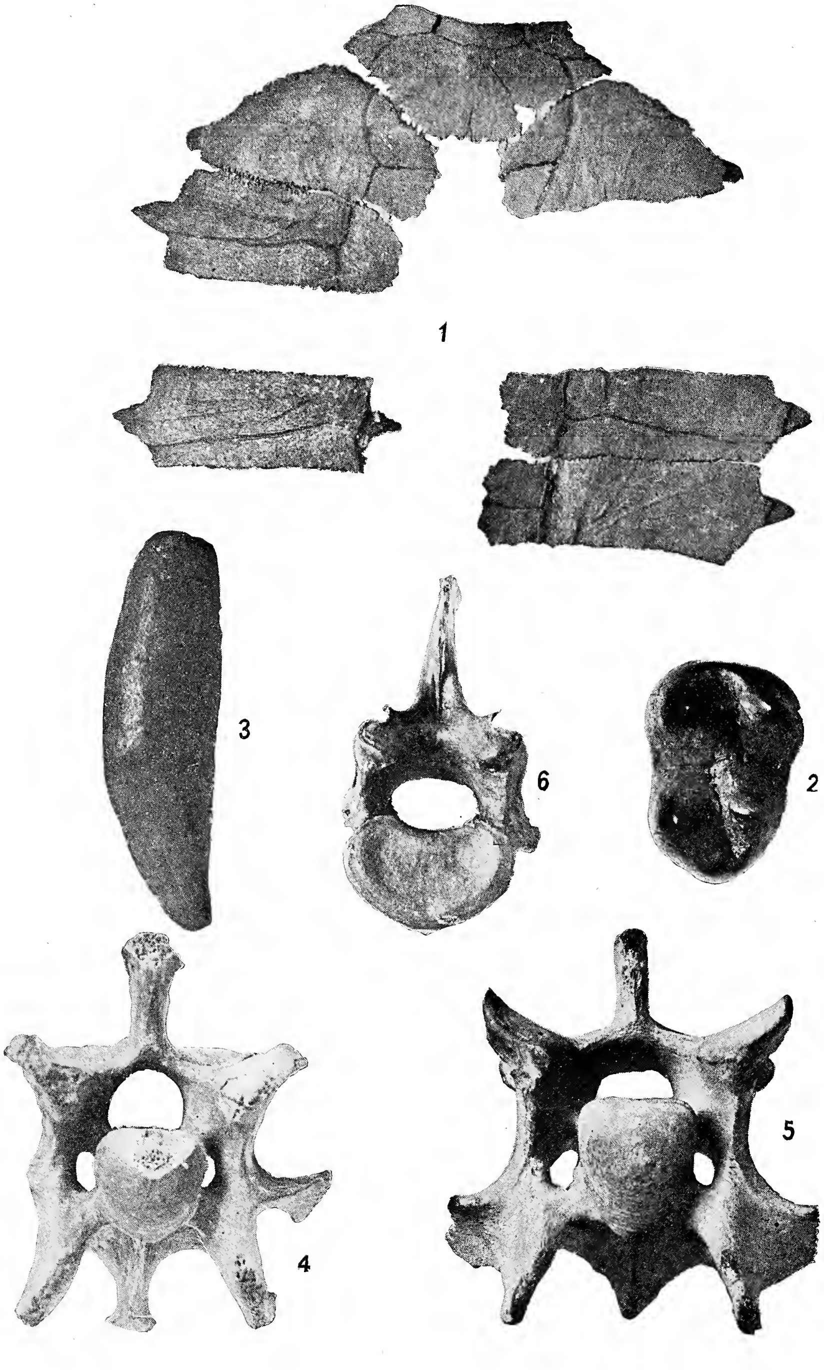
Fig. 1. Chelydra sculpta Hay. View from above, ×½.
Seven bones of the carapace of one individual found together.

Figs. 2, 3. Tayassu lenis Leidy. × 2.
2. Upper left hindermost molar. View of grinding surface.
3. Upper left canine, showing the outer face.

Fig. 4. Odocoileus sellardsiae Hay. × 4-5.
Fifth cervical vertebra, showing the front end. × 4-5.

Fig. 5. Odocoileus hemionus Rafinesque.
Fifth cervical vertebra, presenting the front end.

Fig. 6. Odocoileus sellardsiae. Third lumbar vertebra.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REVIEW OF THE EVIDENCE ON WHICH THE HUMAN REMAINS FOUND AT VERO, FLORIDA, ARE REFERRED TO THE PLEISTOCENE.

E. H. SELLARDS.

An account of the discovery of human and other fossils found at Vero was given in the preceding annual report of this Survey. Since that time important additional investigations have been made at the locality. In the latter part of October, 1916, a conference was held at Vero, at which time the following geologists and anthropologists were present: Dr. O. P. Hay, Research Associate of the Carnegie Institution, Washington; Dr. G. G. MacCurdy, Anthropologist, Yale University, New Haven, Connecticut; Dr. A. Hrdlicka, Anthropologist, U. S. National Museum, Washington; Dr. T. W. Vaughan, Geologist, U. S. Geological Survey, Washington; Dr. R. T. Chamberlin, Geologist, University of Chicago, Chicago, Illinois. In March, 1917, Professor E. W. Berry, of Johns Hopkins University, Baltimore, Maryland, visited the locality. At this time also Dr. Chamberlin returned to Florida to supplement his former observations. Supplementary collections were made by the State Survey at this locality in October, November and December, 1916, and in March, 1917.

As a result of these investigations, together with the studies of others who have kindly identified fossils, the locality at Vero has received detailed study and very full discussion. The papers which have been published, in addition to those of the present volume, relating to these deposits include the following, listed in the order in which they were issued:

On the Discovery of Fossil Human Remains in Florida in Association with Extinct Vertebrates, by E. H. Sellards, Amer. Jour. Sci., vol. 42, pp. 1-18, July, 1916.

Human Remains from the Pleistocene of Florida, by E. H. Sellards, Science, N. S. Vol. 44, pp. 615-617, October 27, 1916.

Human Remains and Associated Fossils from the Pleistocene of Florida, by E. H. Sellards, Eighth Annual Report, Florida Geological Survey, pp. 121-160, pls. 15-31; figs. 1-15, October, 1916.

On the Association of Human Remains and Extinct Vertebrates at Vero, Florida, by E. H. Sellards, Journal of Geology, vol. 25, pp. 4-24, January-February, 1917.

Interpretation of the Formations Containing Human Bones at Vero, Florida, by Rollin T. Chamberlin, Journal of Geology, vol. 25, pp. 25-39, January-February, 1917.

On Reported Pleistocene Human Remains at Vero, Florida, by Thomas Wayland Vaughan, Journal of Geology, vol. 25, pp. 40-42, January-February, 1917.

Preliminary Report on Finds of Supposedly Ancient Human Remains at Vero, Florida, by Alex Hrdlicka, Journal of Geology, vol. 25, pp. 43-51, January-February, 1917.

The Quaternary Deposits at Vero, Florida, and the Vertebrate Remains Contained Therein, by Oliver P. Hay, Journal of Geology, vol. 25, pp. 52-55, January-February, 1917.

Archaeological Evidences of Man's Antiquity at Vero, Florida, by George Grant MacCurdy, Journal of Geology, vol. 25, pp. 56-62, January-February, 1917.

Further Notes on Human Remains from Vero, Florida, by E. H. Sellards, Amer. Anthropologist, n. s. pp. 239-251, vol. 19, No. 2, April-June, 1917.

The Problems of Man's Antiquity at Vero, Fla., by George Grant MacCurdy, Amer. Anthropologist, n. s. pp. 252-261, vol. 19, No. 2, April-June, 1917.

On the Finding of Supposed Pleistocene Human Remains at Vero, Florida, by Oliver P. Hay, Journal Washington Academy of Sciences, Vol. 7, pp. 258-260, June 4, 1917.

To the conclusion that the human remains and artifacts at Vero are of Pleistocene age, some objections have been offered. On the other hand, the detailed studies that have been made both of the vertebrate and plant fossils, and also of the section, have very materially strengthened that conclusion. The objections as well as the new evidence will be reviewed in this paper.

Objections to this conclusion have been offered by Drs. Hrdlicka, MacCurdy and Chamberlin. Dr. Hrdlicka, alone of those who have seen the deposits, offers the interpretation that the human remains represent merely recent, or relatively recent, inclusions in the deposit by human burials. Dr. MacCurdy, on the other hand, regards the human remains and artifacts as normal inclusions within this deposit, but is not convinced that the deposits are of the Pleistocene period. Dr. Chamberlin based his objection to the Pleistocene age of the deposits on the assumption that the extinct vertebrates had washed into these beds from an older formation nearby and hence were secondary.

These several objections, it may be noted, are not related the one to the other. If the human bones and artifacts represent recent burials by human agency as claimed by Hrdlicka, there is no occasion to maintain either that the Pleistocene fossils have washed into recent beds as suggested by Chamberlin, or that the deposits themselves are of relatively recent age as maintained by MacCurdy.

The objections that have been offered to the Pleistocene age of the human remains have been considered by the writer in a paper published in a recent issue of the American Anthropologist (N. S. vol. 19, pp. 239-251, No. 2, 1917). The evidence that the human bones reached the place where found by natural agencies and not by human burial is there presented in some detail, and for convenience of reference is reprinted here. The evidence that the vertebrate fossils in the stream bed are primary and not secondary was also given in the paper to which reference has been made. The evidence that the deposits themselves, both strata No. 2 and 3, are of the Pleistocene period is more fully presented than heretofore in the present volume.

The following extract is from the American Anthropologist with some minor alterations which, however, do not affect the substance of the article.

The question as to whether or not the human bones represent burials may perhaps be best discussed by considering the bones of the individual found in the south bank of the canal west of the lateral inlet. Of the bones of this individual, the right ulna, a part of the humerus, a part of a scapula, one incisor, and parts of the skull had fallen from the bank. Of these bones the ulna, the humerus and a piece of the frontal are bleached from exposure to the sun. The other bones mentioned were found in cavings which had recently fallen from the bank, and do not show bleaching. All of the other bones that have been obtained at this locality were found in place in the bank. The bones which apparently may safely be attributed to this individual include, in addition to those mentioned, the left ulna, the shaft of the right femur (in two pieces), the proximal part of the left radius, the ascending ramus of the right lower jaw, two metatarsals and numerous fragments of the skull and some pieces of ribs. Bones found a little farther to the east which may or may not pertain to this individual include, a right astragalus, a right external cuneiform, a piece from the right pubes, and a part of the left ilium, two phalanges and a section from a limb bone, as well as some other bone fragments. These last named bones are from stratum No. 2 of the section, while all the others listed were on the contact line of Nos. 2 and 3.

All of the bones are more or less broken and incomplete. The first bone found in place was the proximal part of the left ulna. An additional part of the shaft of this bone was subsequently found a few inches farther back in the bank. The second bone found in place was the proximal part of the shaft of the left femur. Two and a half months later, after the excavating had been carried farther back into the bank, an additional part of the shaft of this femur was obtained, the two pieces of bone being separated in the bank by a distance of eight feet. This bone, the two pieces having been put together, is illustrated in figure 3 of plate 19 of the Eighth Annual Report of the Florida Geological Survey. The third bone found in place was the proximal part of the left radius. A photograph showing these three bones in place in the bank was reproduced in the American Journal of Science, July, 1916, and in the Eighth Annual Report of the Florida Geological Survey, plate 17, figure 1, and is included herewith. The two bones, left ulna and left radius, it may be noted, are separated by a space of five feet. The part of the radius preserved has a length of 145 mm., and hence the distance between the bones, as well as the thickness of the section, may be readily computed from the photograph. Vertically above the radius, as may be seen in the photograph, is twelve or fourteen inches of light colored, coarse, clean sand, with which is intimately mixed a quantity of broken marine shells, this part of the deposit representing material washed from the underlying stratum (No. 1 of the section). This is followed by about ten or twelve inches of vegetable material and sand, including, as may be seen in the photograph, pieces of driftwood. Above this layer is seen a lens of coarse, clean sand, including some pieces of broken marine shells, all of which has been thrown in by the stream. This sand lens, as seen in the photograph, has a thickness of about six inches. Above this sand lens to the soil line is found fourteen or fifteen inches of material consisting chiefly of muck, including some sand, the depth of this bone beneath the surface being about forty-two inches. In passing to the right the deposit of sand immediately above the radius "pinches out" so that the piece of femur which lies approximately four feet farther west is immediately beneath the muck, as is also the ulna.

In the writer's description of this locality the depth is given as four feet, which is not in excess of the thickness of the deposit overlying some of the bones. All of the bones lie at the contact line of this deposit and the next older bed, and the varying depth of the bones beneath the surface is due to the fact that the top surface of the next older deposit is irregular. The essential point involved, however, is not as to the depth at which the bones lie, but the fact that the deposits above the bones consist of alternating layers or strata which have not been disturbed. A sample was retained showing the sand in which the radius was imbedded, and also a sample of the sand including the broken shell vertically above the radius. This clean-washed, coarse sand, together with the shell fragments, contrasting decidedly with the overlying accumulation of driftwood and muck, affords positive evidence of stream-washed material, and conclusive proof that the deposit has not been dug into or otherwise disturbed.

The illustrations which accompany this paper include: A ground plan of the human bones found in place in the canal bank west of the lateral inlet, a photograph showing the ulna, femur and radius, all of which bones are broken and incomplete, in place in the bank (omitted from this reprint); a closer view showing the succession of strata directly above the radius; a detailed view of the radius in place, including the sand and shell deposit immediately above it; and a view (taken in the laboratory) showing the sand and broken marine shell, slightly enlarged, from immediately above the radius. These illustrations afford a record that is, it would seem, conclusive as to the conditions under which these bones were found. From the photographs it may be seen that flat objects, such as shells and shell fragments, lie prevailingly in a single plane of deposition, and that the deposits are cross-bedded, both of which features are characteristic of deposition by water. A study of the photographs and more especially of the section itself shows conclusively that these bones were washed to the place where found by the waters of this stream and that they became entombed at the same time and in the same way as the sand, shell fragments, pieces of wood and other materials of this deposit. These bones are, therefore, unquestionably fossils of this formation and were not subsequently introduced into the deposit by human agency or in any other way.

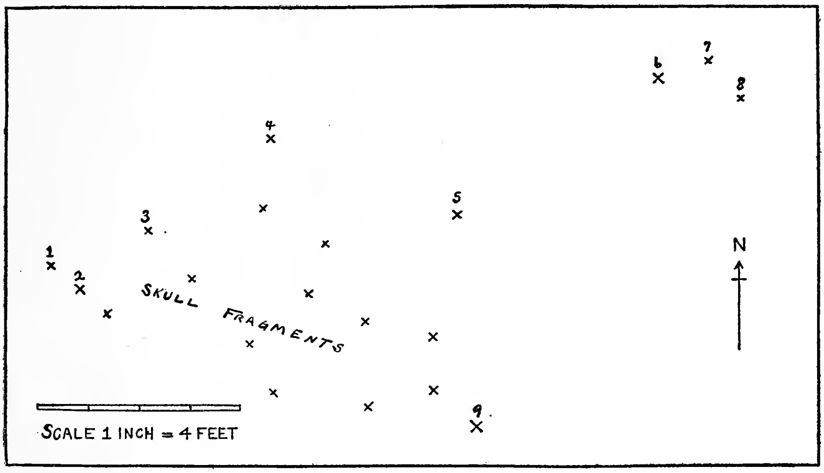

Fig. 1:—Ground plan showing the location of human bones found in the canal bank at Vero in April and in June, 1916. Index to bones: 1, left ulna; 2, a part of the shaft of the same bone; 3, left femur; 9, a part of the shaft of the same bone; 4, radius; 5, metatarsal; 6, astragalus.; 7, external cuneiform; 8, part of ilium. Courtesy of University of Chicago Press.

After the photographs were taken excavating at this locality was continued and human bones were collected over the area indicated in the accompanying sketch. The manner of occurrence of the human skull is instructive. Scarcely one-half of the skull was obtained, and the pieces that were secured were distributed over an area of not less than seven by three feet. The broken skull fragments fit together securely. Most of the skull pieces were found in the sand containing the broken pieces of marine shells, and it is evident that they were washed to their present resting place in the same way and at the same time as the radius and the other bones. The absence of bones and parts of bones is as instructive as the condition of the bones themselves. Of the jaws, for instance, there has been obtained only the right ascending ramus. This piece of bone is well preserved and the break shows a sharp fracture. There is no reason, therefore, to doubt but that the part of the jaw that is missing, if included within this formation at all, is also well mineralized. The same is true of the radius of the left femur and of the skull bones, as well as of the skeleton as a whole. From the time of the location of these bones in April to the conference in October, the bank at this place was worked only by hand trowels and the material after being worked by the trowels was passed through screens, much of it being double screened through coarse and fine mesh. At no time were laborers allowed to work the bank with shovels or other implements. If the remainder of the jaw had been preserved within the area covered by this sketch, or in fact within a somewhat greater area, it would certainly have been recovered. The same is true of the missing and imperfect bones of the skeleton. These bones and parts of bones were either not washed into this formation, and for that reason failed of preservation, or if preserved in this deposit were lying some place outside of the area covered by this sketch.

It is evident that the bones of this skeleton had become thoroughly dried before they were moved and broken, this fact being indicated by the sharp fracture of the bones. Dr. Hrdlicka has referred to the breaks in the bones as being "fresh," and suggests that the breaks may have occurred for the most part as the bones were uncovered and fell from the bank.* It is, however, certain that the breaks in these bones that were in place in the bank, such as the left ulna, the left radius, the right femur, and the left femur, and the bones of the skull occurred at the time the bones were washed to the place where they were found. Some of the bones may have been carried much farther by the stream at this time, while others possibly never found their way into this stream bed, thus accounting for the imperfection of the skeleton.

To assume that these bones represent a burial affords no adequate explanation of the separation of the radius and the ulna; of the displacement of the two parts of the right femur; nor of the broken and scattered condition of the skull as well as the scattering of the skeleton. On the other hand, recognition of the fact that the bones were washed by the stream to their present resting place affords an explanation of every phenomenon that is presented including: The broken condition of the bones; the separation of the radius and ulna a distance of five feet; the separation of the two pieces of the right femur a distance of eight feet; the position of the radius beneath fourteen inches of coarse sand and broken marine shells, the scattering of the parts of the skull; the presence of driftwood in the deposit and the uninterrupted bedding above the bones, as well as the imperfect representation of the skeleton as a whole.

In all of its features this deposit maintains the characteristics of a stream fill, and we may plainly read the history of the accumulation of material at this immediate spot. The stream had cut into the marine shell marl (stratum No. 1 of the section), making a rather sharp trench in that formation. As the result of flood waters there was thrown into this trench an accumulation of coarse sand and broken marine shells which filled the bottom of the trench to a maximum depth of fourteen inches. Of the human bones the radius as seen in the photograph was left lying practically at the bottom of the little trench, while a piece of the femur and the ulna as well as parts of the skull were thrown well upon the side. Quiet conditions followed, interrupted occasionally by mild flood waters. One of these floods threw in the lens of coarse sand, including broken marine shells, which is seen in the photograph about twenty inches above the ulna. Under these alternating conditions of quiet waters and flood waters there was accumulated the successive layers of muck and sand, with occasional inclusions of driftwood forming the stratified deposit which permanently sealed the bones and preserved them until the present time.

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*Journal of Geology, Vol. xxv., p. 45, 1917.

The manner of occurrence of the pottery and bone implements must likewise be considered. Pottery is distributed throughout the deposit that has been designated as stratum No. 3, being more abundant, however, near the base. One hundred or more pieces of broken pottery have been taken from this formation. Bone implements are likewise general in their distribution, although the greater number have been taken near the base of stratum No. 3. The large arrowhead illustrated in the Eighth Annual Report of the Florida Geological Survey (fig. 1, pl. 21) was found lying in a layer of light colored, coarse sand at the base of stratum No. 3. The great abundance of pottery, bone implements and flints near the base of this deposit is accounted for in the writer's interpretation by the fact that the stream current was stronger when these first deposits were laid down than subsequently,and hence more material from the surrounding land surface was washed in than at a later time when the waters became more quiet. The muck which predominates in the upper part of the deposit belongs to the period of quiet and more or less ponded waters.

The muck of this section is followed strategically by fresh-water marl, for while the marl is not everywhere present, the relative age is indicated by the fact that laterally the muck passes under and ultimately grades into the marl (Journ. Geol. *loc. cit.*, fig. 3, p. 10). The marl itself, although containing a few fresh-water shells and other fossils, represents chiefly calcareous material accumulated by chemical or bio-chemical processes. Its presence, therefore, is significant as to the probable age of the section. Hrdlicka (*loc. cit.* p. 49) refers to the fact that this fresh-water marl when first uncovered is often soft and hardens on exposure. This, however, is true of marls in general. The Ocala limestone of early Tertiary age is frequently soft when first uncovered and invariably hardens upon exposure; the same is true of many other limestones. He notes also the fact that shells piled up by the aborigines are sometimes found to have become cemented. It is to be borne in mind, however, that the cementing of shells artificially piled up is a materially different matter to the accumulation of a stratum of marl by natural processes.

The evidence that the vertebrate fossils in the stream bed are primary and not secondary is very positive. The following discussion in regard to the origin of these fossils is reprinted from the article by the writer in the American Anthropogist to which reference has been made.

* * * Dr. Chamberlin postulates that these fossils have been washed from the older Pleistocene deposits which lie immediately back of the beach through which the north and south forks of the stream cut, and refers to this formation as the "deposit which originally housed the old mammalian bones."

If the mammalian bones which are found in such abundance were washed from deposits further to the west, naturally we may expect to recover other and better fossils from the original or parent formation. Fortunately the opportunity for examining the formation in question for fossils is exceptionally good. The main canal after cutting across the beach ridge continues inland a distance of twelve miles. Moreover, the lateral which enters from the south continues for some miles in a general southwesterly direction. Paralleling the main canal and on the north side of it there is also a third canal which reaches inland about one-eighth of a mile. The banks of these three canals which contain large masses of the particular deposit which Chamberlin regards as the source of the bones, have been carefully searched by the writer and others and no vertebrate fossils have been obtained. *It appears, therefore, that the formation from which Dr. Chamberlin would derive the bones is almost if not entirely non-fossiliferous.* In view of this fact is it to be believed that the abundance of bones found in the stream bed have washed from this formation?*

In this connection the condition of the fossils themselves may be called into evidence. Both Drs. Hrdlicka and Chamberlin have referred to the relative completeness of the human skeletons, but there is obviously no point in this reference that will support the theories advanced by either of them. All of the human bones have been submitted by the writer to Dr. Hrdlicka who states that he recognizes the presence of five individuals. One of these is represented by a single molar tooth; another by a single toe bone, while of another nothing appears to be known other than an incisor tooth. Obviously these three individuals could not have been represented by more fragmentary material. Of the two remaining individuals but an imperfect representation of the skeleton of each has been obtained, including twenty-six bones of the one and of the other scarcely so many.

Of the extinct wolf, *Canis ayersi,* thirty or more bones of a single individual have been found at one place, while near by was obtained the skull and femur probably of the same individual. The skeleton of this extinct animal is more fully represented, therefore, than is that of any one of the human skeletons. The extinct armadillo-like genus, *Chlamytherium,* is represented by a lower jaw, a bone from the skull and many dermal plates, all found at one place and probably all belonging to a single individual. The extinct stork, *Jabiru weillsi,* is represented by a humerus, part of a corocoid, part of two ulnas and two metacarpals, all found at one place and probably from one individual. Extinct turtles are represented by all or by parts of the carapace so fragile as not to withstand secondary deposition. The mastodon is represented by a part of the skull and tusk as well as a lower jaw and by teeth. The elephant is represented by whole teeth and by parts of the skeleton. The tapir is represented by a practically complete skull. There is in fact, as the writer has heretofore stated, no essential difference either in the completeness of the skeleton or in the manner of preservation between the human bones and those of the associated animals.

There remains the objection advanced by MacCurdy that the deposits containing the human remains are comparatively recent and are not to be referred to the Pleistocene period. This conclusion as presented by MacCurdy applies particularly to stratum No. 3, in which human remains were abundant. The human remains and

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*Since the above was written the deposits in question have been re-examined by Dr. Chamberlin, the writer and others and further shown to be non-fossiliferous.

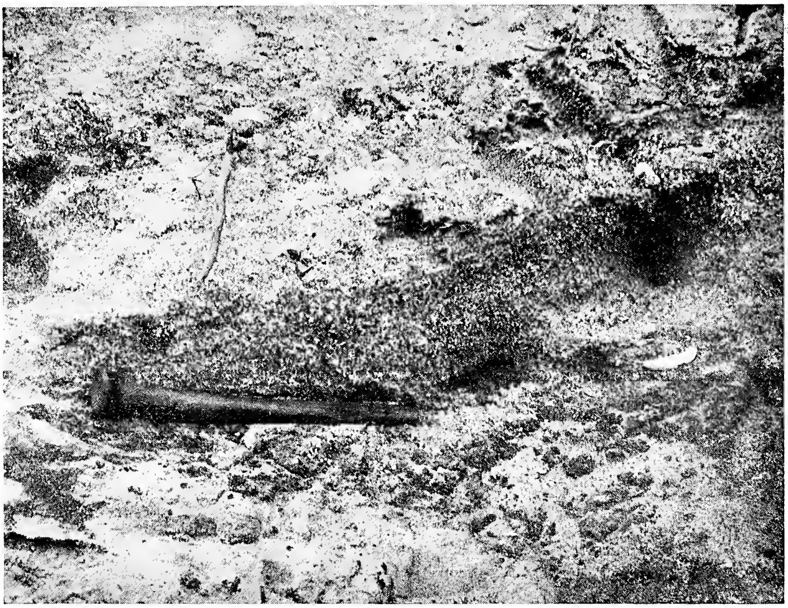


Fig. 1. Human radius in place in the canal bank. Approximately one-third natural size.

Fig. 2. Succession of strata above the radius. The radius is near No. 2.

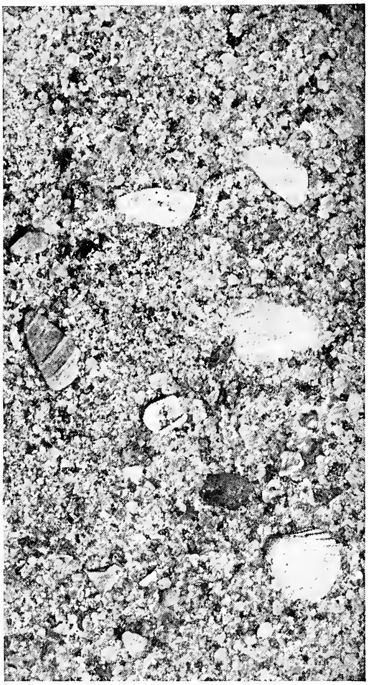


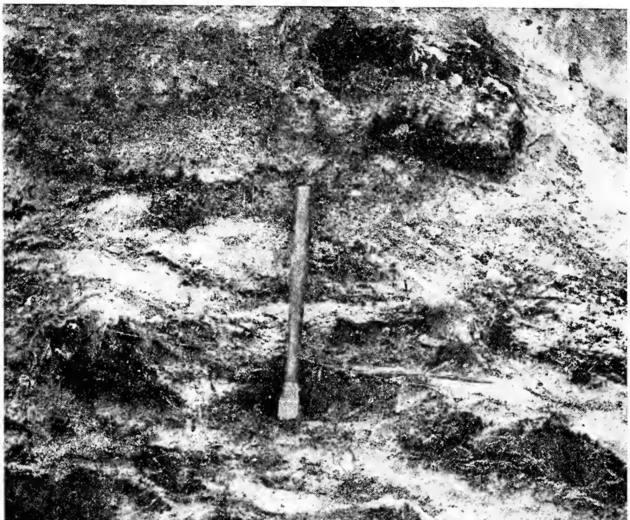
Fig. 3. Photograph, slightly enlarged, of sand and shell from above the radius.

EXPLANATION OF PLATE 5.

Fig. 1. Photograph of bone implement in place in the canal bank.

Fig. 2. Closer view of same implement.

The implement is seen in the two photographs at the right of the hammer. Actual length of bone implement 157 mm.



artifacts which have been obtained from stratum No. 2, MacCurdy is disposed to account for as accidental inclusions.

Additional evidence for referring the deposits containing the human materials to the Pleistocene has been derived from the detailed study which has been made of the vertebrate and plant fossils. Careful studies have now been made of the mammals, birds, turtles and plants. In each group is found extinct species, as well as other species, which at the present time do not extend their range into Florida. However, inasmuch as the papers relating to these fossils are available through the Survey reports, it will not be necessary to review them here, except possibly to note the relative proportion of extinct species in each group, particularly as applied to the upper part of the deposits.

Of the mammals of stratum No. 3, as identified by Dr. Hay, almost one-half are extinct. Of six birds specifically identifiable from this stratum, two, or 33 per cent, according to Dr. Shufeldt, represent new and presumably extinct species. The turtles of stratum No. 3, according to Dr. Hay's determination, include eight species of which four, or 50 per cent, are unknown in the recent fauna. In addition one of the remaining four forms is believed to be sub-specifically distinct from the modern. The plants from stratum No. 3 as determined by Professor Berry include twenty-seven species, of which one is extinct. If we consider the geographic range, however, the plants make a much more favorable showing. Of the twenty-seven species, five, according to Berry, or approximately 20 per cent, do not at present extend their range into Florida.

The insects of this deposit have not yet been determined. A mite, obtained by Mr. Berry while collecting fossil plants, has been determined by Mr. Nathan Banks as belonging to the genus *Oribella,* and as possibly representing a new species, although not all of the types of the described species have yet been compared.

The evidence derived from a study of the animals and plants is thus consistent and supports the reference of the deposits, including stratum No. 3, where the human remains and artifacts are so numerous, to the Pleistocene period.

The invertebrate fauna of the deposit is fairly well known. A list of the land and fresh-water mollusks associated with the vertebrates was given in the Eighth Annual Report of this Survey. This group was found to include twenty-eight species, all of which are represented in the existing fauna. The invertebrates of the marine shell marl which lies at the base of this section have since been determined for the Survey through the courtesy of the National Museum. Two lots of fossils have been collected from this part of the section, of which the following is a combined list. The corals have been identified by Dr. T. W. Vaughan, the mollusks by Mr. W. C. Mansfield, and the bryozoa by Dr. R. S. Bassler. An × following the name of a species indicates its presence in the recent fauna.

MARINE INVERTEBRATES FROM VERO, FLORIDA

GASTROPODA

Terebra cinerea Gmel. ×
Terebra concava Say ×
Terebra dislocata Say ×
Olivella mutica Say ×
Olivella jaspidea ? Gmelin
Oliva literata Lam. ×
Marginella, near apicina Mke. ?
Marginella sp. (immature).
Fasciolaria distans Lam. ×
Busycon carica Linn. ×
Busycon perversum Linn. ×
Melongena corona Gmelin. ×
Columbella (Anachis) avara Say ×
Nassa acuta Say ×
Urosalpinx ? (yo.)
Eupleura caudata Say ×
Murex fulvescens Say ×
Epitonium lineata Say ×
Epitonium sp.
Purpura haemostoma var. floridana Conrad. ×
Cerithium floridanum Morch ×
Cerithium, near muscarum Say
Cerithium sp.
Modulus floridanus Conrad ×
Turritella (worn)
Littorina irrorata Say ×
Crepidula, fornicata Say ×
Crepidula, plana Say ×
Neverita duplicata Say ×
Sigaretus perspectivus Say ×
Vermicularia nigricana Dall ×
Petaloconchus irregularis Orb. ×
Fissurella alternata Say ×

PELECYPODA

Nucula proxima Say ×
Glycymeris americana Defrance ×
Glycymeris pectinata Gemel. ×
Scapharca (Scapharca) transversa Say ×
Scapharca (Cunearca) incongrus Say ×
Scapharca (Argina) campechiensis Dillwyn ×
Arca (Noetia) limula Conrad, intermediate form between *A limula* and *A ponderosa* Say
Arca cf. umbonata Lam.
Barbatia (Acar) reticulata Gmel. ×
Pecten gibbus, var. dislocatus Say ×
Plicatula romosa Lam ×
Anomia simplex Orbigny ×
Crassinella lunulata (?) Conrad ?
Crassinella sp.
Cardita (Carditamera) floridana Conrad ×
Venericardia tridentata Say, var, averaging about 20 radiating ribs. ?
Venericardia perplana Conr. ×
Phacoides (Parvilucina) multilineatus T & H. ×
Phacoides, near nasuta Conr. (n. sp.?)
Phacoides (yo)
Phacoides floridanus Conrad ×
Divaricella quadrisulcata Orb. ×
Cardium (Trachycardium) muricatum Linn. ×
Cardium (Cerastoderma) robustum) Solander ×
Cardium (Trachycardium) isocardia Conr. ×
Cardium (Laevicardium) serratum Linn. ×
Cardium (Laevicardium) mortoni Conrad ×
Dosinia distans ×
Dosinia (yo)
Chione (Lirophora) latilirata Conrad ×
Chione cancellata Linnaeus ×
Chione interpurpurea Conr. ×
Chione (Timoclea) grus Holmes ×
Chione sp.
Anomalocardia cuneimeris Conr. ×
Venus (yo.)
Venus mortoni Conrad ×
Venus campechiensis Gmelin var. ×
Tellina lintea Conrad ×
Transennella caloosana Dall—reported not later than the Pleistocene.
Strigilla flexuosa Say ×
Strigilla sp.
Semele proficua Pulteney ×
Semele bellastriata (?) Conr.
Donax variabilis Say ×

Donax tumida Phil. ×
Mulinia lateralis Say ×
Mulinia lateralis (long variety)
Mulinia lateralis var. corbuloides Desh. ×
Mactra (yo.)
Spisula solidissima var. senulis Say ×
Rangia cf. cyrenoides Desmoulins
Corbula cuneata (?) Say ?

CORALS

Oculina robusta Pourtales ×
Solenastraea hyade (Dana) ×

BRYOZOA

Cupularia denticulata Lamarck.

By referring to the list it is seen that sixty-one species of mollusks are recognized as identical with living forms. One species, *Transennella caloosana* Dall, has not been reported from deposits later than the Pleistocene. One other species, an *Arca,* is regarded as intermediate between the extinct *A. limula* and the recent *A. ponderosa.* One specimen is referred doubtfully to *Corbula cuneata,* a species not known in the recent fauna. The collection contains, in addition, several species, the identification of which is doubtful. Among these is a shell near to *Phacoides nasuta,* which may possibly represent a new species. In this connection it may be noted that Shimek has presented evidence showing that the land and fresh-water molluscan fauna from as early in the Pleistocene as the Aftonian inter-glacial stage has remained essentially unchanged to the present day, while the vertebrate fauna of the same stage has become largely extinct.* Likewise at this locality in Florida a vertebrate fauna containing many extinct species is associated with a land and fresh-water molluscan fauna containing so far as known only recent species. This vertebrate fauna also is more recent than the marine molluscan fauna of the underlying beds which, with few exceptions, includes species identical with the living forms. It is evident, therefore, that the presence of existing species of mollusks in the formation cannot be taken as proof that the deposits are recent, especially in view of the presence of extinct species of vertebrates and plants.

*Evidence that the Fossiliferous Gravel and Sand Beds of Iowa and Nebraska are Aftonian, by B. Shimek. Bull. Geol. Soc. of Amer. Vol. 21, pp. 119-140, 1910.

In the section as exposed in the canal bank there are distinct uninterrupted lines of stratification, beneath which human materials are found. One of these is a stratum of fresh-water marl which is best seen on the south bank of the canal. Beneath this marl have been found both human bones and bone implements. The photograph included in plate 5 of this report shows a bone implement in the south bank of the canal 32 feet west of the lateral inlet, lying beneath this marl at a depth of 4 feet from the surface. This implement was collected in March, 1917, and is No. 7786 of the Florida Survey collection. The marl at this place is about 1 foot thick, and may be traced laterally continuously along the canal bank to the locality where it reaches the maximum of about 18 inches in thickness. Human bones have been found beneath this marl, as reported in papers previously published, at a place where it has a thickness of about 18 inches and is so well indurated as to form a hard rock. In this rock itself was found the tooth of a fox differing from the modern fox of Florida (Fla. Geol. Surv., 8th Ann. Rep. p. 132, 1916). In general it is observed that the bone implements, flints, pottery and human bones all lie below the stringers and layers containing fossil plants and animals, the association being such as to establish the fact that they are contemporaneous.

CONCLUSIONS.

The human remains and artifacts are contemporaneous with extinct species of mammals, birds, reptiles, and at least one extinct species of plants, as well as with other animal and plant species that do not at the present time extend their range into Florida. The age of the deposits containing these fossils according to the accepted interpretation of faunas and floras is Pleistocene.

ADDENDUM.

Correction:—In the Eighth Annual Report of this Survey and in some other publications, an implement found in the deposits at Vero and illustrated by figure 6 of plate 23 (8th An. Rpt.) is referred to as a wood implement. Upon further examination, however, this implement is found to be of bone, and no wood implements are known from the deposit.

ERRATA.

P. 78, 26th line, for Say, read Sby.
40th line, for nigricana, read nigricans.

P. 79, 3d line, for Gemel, read Gmelin.
5th line, for incongrus, read incongrua.
12th line, for romosa, read ramosa.
20th line, for nasuta, read nassula.
29th line, for distans, read discus.
33d line, for interpurpurea, read intapurpurea.

P. 80, 6th line, for senulis, read similis.
10th line, for Solenastraea hyade, read Solenastrea hyades.
12th line, for Cupularia denticulata Lamarck, read **Cupularia denticulata** Lamarck ×.

GEOLOGY BETWEEN THE OCKLOCKNEE AND AUCILLA RIVERS IN FLORIDA.

BY E. H. SELLARDS.

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TEXT-FIGURES.

MAPS.

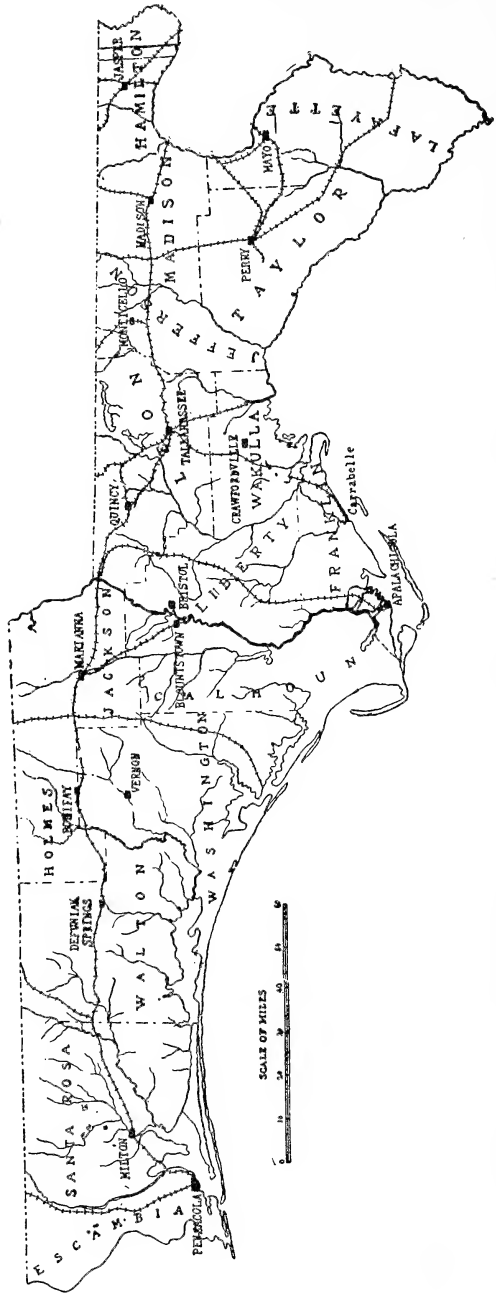

Fig. 2.—Sketch map of Florida west of the Suwannee River. The area described in the present report is that between the Ocklocknee and Aucilla rivers, including Leon, Jefferson and Wakulla counties.

GEOLOGY BETWEEN THE OCKLOCKNEE AND AUCILLA RIVERS IN FLORIDA.

E. H. SELLARDS.

INTRODUCTION.

LOCATION AND AREA

The area to which this report relates lies between the Ocklocknee and Aucilla rivers, and extends from the Florida-Georgia state line to the Gulf of Mexico (map, fig. 2). Three counties are included, namely, Leon, Jefferson and Wakulla. The area of Leon County is approximately 730 square miles or 467,200 acres, that of Jefferson 593 square miles or 379,520 acres, and that of Wakulla, 601 square miles or 389,640 acres, making a total area of 1,924 square miles or 1,231,360 acres. Leon County was established December 29, 1824, and Jefferson County January 20, 1827, under the territorial governorship of William P. Duval. The County of Wakulla was established March 11, 1843, under the second territorial governorship of Richard K. Call. The three counties are thus among the oldest counties of the State, having been established while Florida was still a Territory.

The history of the settlement and subsequent development of Leon County dates from about the time of the purchase of Florida from Spain in 1821. The area known as Florida at one time extended as far west as the Mississippi River and included approximately the southern half of what are now the states of Alabama and Mississippi. That portion from the Atlantic Ocean west to the Apalachicola River was known as East Florida, while that from the Apalachicola to the Mississippi River was known as West Florida. St. Augustine and Pensacola were the respective seats of government.

General Andrew Jackson was appointed Military Governor of the Floridas upon the purchase from Spain and served as such until 1822. During this year Jackson resigned and President Monroe appointed William P. Duval as first Territorial Governor. It was in June, 1822, that the first meeting of the Legislative Council, consisting of thirteen men who assisted the Governor, was held at Pensacola. The following year in May the council met at St. Augustine and it was at this time decided, since East and West Florida were now under one government, to appoint a commission to select a site for the permanent capital. Two commissioners were appointed, one from St. Augustine and one from Pensacola.

The territory designated to be examined for the permanent location of the new capital lay between the Chipola and the Suwannee rivers. Accordingly in October, 1823, the two commissioners met at St. Marks, a most central point and a very important port at that time. The selection of Tallahassee, yet practically a wilderness and just vacated by the Indians, was soon made. It was necessary, however, for the commissioners to visit the chiefs of the two bands of Seminole Indians, who were camped near what is now known as Lake Lafayette and obtain, if possible, their consent and agreement to these plans. Entire approval, it seems, was withheld until the following year, when Governor Duval visited them and obtained their confidence and acquiescence. Accordingly in 1824 the city of Tallahassee was surveyed and the first house was built that year. A log cabin erected on the southeast corner of the present capitol grounds served as the Capitol Building, and it was here that the first meeting of the Legislative Council in Tallahassee was held.*

Jefferson County, named for Thomas Jefferson, the third President of the United States, was organized soon after the establishment of Leon County, of which it was formerly a part. Monticello, named for the Virginia home of President Jefferson, became the county seat, and was surveyed in 1828.† The new county was early settled by people from the more northerly southern states many coming from Virginia and South Carolina. That this county, too, had earlier been inhabited by the Indians is seen from the present day names such as Aucilla, Miccosukee, Wacissa and Waukeenah.

Agriculture was the main pursuit of the first settlers in both of the counties, and its development increased steadily with the increase of population. The rolling uplands of the northern portion of these counties were early under cultivation. Cotton was the main product and this was extensively grown by slave labor. St. Marks and Newport were the principal points of shipment for the

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*A History of Florida, by Caroline Mays Brevard.

†Soil Survey of Jefferson County, Florida, p. 7, U. S. Department of Agriculture, Advance Sheet, Field Operations of the Bureau of Soils, 1908.

agricultural products of this area, and these remained important ports until the building of railroads, which diverted travel by overland routes.

The favorable location of Wakulla county, bordering as it does on the Gulf of Mexico, permitted its early settlement by seafaring people. As early as 1718 the Spaniards built a fort at Port Leon, two miles south of St. Marks, giving to it the name of San Marcos de Apalache. Remains of the old fort may still be seen. During the settlement of the area under discussion St. Marks held a very important position, that of port of shipment and of entry for a large territory. The country lying to the north produced cotton and other staple products, and St. Marks together with Newport received the bulk of this for shipment. Public roads were built and improved in order to make the transportation into these ports less difficult. The volume of business carried on between the ports in this county and the counties lying northward, however, merited and induced quicker and more satisfactory transportation. Accordingly in the year 1836 General R. K. Call, then Governor of Florida, built the first railroad in the State, from Tallahassee to St. Marks, which is said to be the third oldest railroad in the United States.

At the present time the industries of this county include farming, stock raising, lumbering and turpentining, as well as fishing.

CLIMATE

Records on temperature and rainfall are available at the Tallahassee Station from the United States Weather Bureau. This station probably may be accepted as fairly representative of the area covered by this report. The average for rainfall and temperature at Tallahassee are based on records from 1891 to 1903.*

The annual mean temperature at Tallahassee, in Leon County, is 67 degrees Fahrenheit. The mean for the four seasons of the year is as follows: Winter, 53; Spring, 67; Summer, 80; Fall, 68. The absolute maximum summer heat recorded at this station is 97 F. The minimum winter temperature recorded is -2° F.

The annual mean rainfall at Tallahassee is 58.2 inches. This is distributed throughout the year as follows: January, 3.5 inches; February, 4.8 inches; March, 5.9 inches; April, 2.7 inches; May,

*Climatology of the United States, by Alfred Judson Henry, Bull. Q, U. S. Dept. Agriculture.

3.6 inches; June, 6.8 inches; July, 8 inches; August, 7.1 inches; September, 5.1 inches; October, 3.7 inches; November, 2.9 inches; December, 4.1 inches.

VEGETATION

The rolling uplands of the northern part of this area, although largely cleared at the present time, supported originally a mixed timber growth, including short-leaf pine and many hard-wood deciduous trees, such as red-oak, hickory, dog-wood, magnolia and live-oak. The chief timber growth of the level lands, particularly in the southern part of the area, is long-leaf pine. In the flat-woods the undergrowth associated with this pine is chiefly saw-palmetto, while in the well drained land the palmetto is wanting. The limestone belt of Wakulla County includes a considerable area of hammock land supporting a mixed largely deciduous timber growth.

When studied in detail the vegetation of this area may be divided into several more or less well-marked vegetation types, and in his report on the vegetation of Northern Florida, published in the sixth annual report of this Survey, Dr. R. M. Harper has indicated eight vegetation types within this area. The plants characterizing each type are there listed.

ELEVATIONS

The only precise levels available in this area are bench marks established by the U. S. Coast and Geodetic Survey and by the U. S. Geological Survey. These are placed at intervals across the area from east to west following the line of the Seaboard Air Line Railway, and from Tallahassee northwest following the Georgia, Florida and Alabama Railway. In addition to these precise levels, lines of levels have been made recently along some of the public roads, either by the State, through the Department of Roads, or by the County, through the County Engineers. The profiles and levels of railroads have also been available in determining elevations. Where no other levels were available the anaeroid barometer has been used to some extent, especially a number of readings checked by barograph made during the summer of 1917 by Dr. Oliver B. Hopkins. The levels on the public roads in Leon County were made in part during 1916 by, or under the direction of Mr. J. W. Jones, then County Engineer, and in part during 1916 and 1917 by, or under the direction of Mr. B. E. Reed, County Engineer. Those on the road which leads east from Tallahassee have been for the most part checked by the State Department of Roads. The levels on the public roads of Jefferson County were made during 1917 by Mr. J. W. Jones, County Engineer. The levels thus obtained have afforded material assistance in the study of the topography and geology, and the writer wishes to express his appreciation for the assistance thus received from these various sources, which has very much facilitated the preparation of this report. The line of levels from Lake Jackson to Orchard Pond and from Lloyd to the sinks near Lake Miccosukee, as well as some other levels, to determine important points, were made by the writer for this report. Mr. H. Gunter has assisted not only in making these levels, but also in the general field work as well as in making the maps and compiling data for the report.

The following list includes a description of the bench marks that have been established upon precise levels, within this area. The location of these benches is also approximately indicated on the map which accompanies this report. The other elevations shown on the map, although not precise levels, are sufficiently exact to serve a useful purpose in topographic and geologic studies. Aside from locating bench marks the plan has been followed of entering on the map, so far as practicable, maximum and minimum elevations, thus indicating the hills and the valleys crossed by the lines of levels.

DESCRIPTION OF BENCH MARKS.

Greenville (in Madison County). In the south face of the brick building opposite the Seaboard Air Line Railway station*. Elevation --------99.376 feet

About two and one-half miles west of Greenville, near mile post 126; 26 feet north of the Seaboard Air Line Railway tracks†. Elevation--------93.015 feet

About 4½ miles west of Greenville, in fence corner at road crossing; 586 feet east of mile post 128; 26 feet north of Seaboard Air Line Railway tracks†. Elevation --91.424 feet

About one-half mile east of Aucilla, at the first telegraph pole east of a cut; 26 feet south of the Seaboard Air Line Railway tracks†. Elevation--95.374 feet

Aucilla, 244 feet west of the Seaboard Air Line Railway station, just outside the fence corner west of the first road west of the station††. Elevation 82.592 feet

About three miles west of Aucilla, at mile post 134, 26 feet north of Seaboard Air Line Railway tracks†. Elevation -------------------------84.478 feet

About five miles west of Aucilla, at mile post 136, 26 feet north of Seaboard Air Line Railway tracks†. Elevation --------------------------------88.589 feet

Drifton, about opposite end of Seaboard Air Line Railway station, near telegraph pole, 26 feet south of tracks††. Elevation ---------------- 129.744 feet

Braswell, 130 feet northeast of the Seaboard Air Line Railway station, near telegraph pole, about 160 feet north of the main track†. Elevation 189.540 feet

About six miles west of Drifton, about 650 feet east of mile post 144, near road crossing, 26 feet south of Seaboard Air Line Railway track†. Elevation 148.687 feet

Lloyd, about 492 feet east of S. A. L. Ry. station; 82 feet west of road crossing; 26 feet south of S. A. L. Ry. tracks††. Elevation -------- 80.325 feet

Lloyd, opposite the Seaboard Air Line Railway station; 33 feet south of the main track††. Elevation -- 82.605 feet

About three miles west of Lloyd, at mile post 150, about 26 feet north of S. A. L. Ry. track†. Elevation ------------------------------------ 70.889 feet

Chaires, about 246 feet west of S. A. L. Ry. station; 50 feet south of the main track†. Elevation -- 58.215 feet

Lake Lafayette, about seven miles east of Tallahassee, at mile post 158; 26 feet north of the S. A. L. Ry. tracks†. Elevation --------------- 49.009 feet

About 3½ miles east of Tallahassee, about a half mile east of mile post 162; 13 feet east of a road crossing; 26 feet north of the S. A. L. Ry. tracks†. Elevation -- 89.386 feet

Tallahassee, in the southwest footing of the S. A. L. Ry. water tank near the passenger station; bench mark is the top of an iron anchor bolt marked by a cross. Elevation --- 80,269 feet

Tallahassee, in the southeast corner of the Supreme Court Building*. Elevation --- 188.110 feet

Tallahassee, in the northeast corner of the State Capitol Building*. Elevation -- 214.931 feet

Tallahassee, in the southeast corner of the brick building used by the State Savings Bank*. Elevation ------------------------------------- 216.040 feet

About four miles west of Tallahassee, near private road crossing, about ½ mile west of mile post 169; 26 feet north of S. A. L. Ry. track†. Elevation --- 65.968 feet

About 7½ miles west of Tallahassee, near a private road crossing, about 1-3 mile west of mile post 172; 26 feet south of S. A. L. Ry. track†. Elevation -- 135.836 feet

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*This type of bench mark is the red metal disk designed by the Coast and Geodetic Survey, lettered "U. S. Coast and Geodetic Survey, B. M. $250 fine or imprisonment for disturbing this mark." The disk is 3 inches in diameter, with a 3-inch tenon upon the back for setting it, and is set in cement flush with a horizontal or vertical surface. In the latter case a horizontal mark cut on it, or the horizontal mark of a cross, is the bench mark.

†A standard disk like that described above set in the top of a stone or cement post about 4 feet long and with a rectangular top 4 to 8 inches on a side, projecting about 6 inches above ground.

††A 3-inch aluminum or bronze cap riveted upon a 3-inch iron pipe, set in the ground, 5 to 6 inches being exposed above the ground. A cross cut in the center of the top is the bench mark. (U. S. Geological Survey bench mark).

About 3½ miles northwest from the Georgia, Florida and Alabama Railway station in Tallahassee, about 1344 feet northwest of mile post 53; 98 feet west of a private road crossing; 30 feet north of G. F. & A. Ry. tracks. Concrete post. Elevation ---89.353 feet

About seven miles northwest of Tallahassee, just east of a railroad cut, 26 feet north of G. F. & A. Ry. tracks. Concrete post. Elevation------104.147 feet

About 10½ miles northwest of Tallahassee, about 1-3 mile northwest of mile post 60, 26 feet north of G. F. & A. Ry. tracks, at west end of railway cut. Concrete post. Elevation --113.950 feet

About 3.7 miles southeast of Havana, at mile post 63; 33 feet north of G. F. & A. Ry. tracks. Concrete post. Elevation-----------------143.871 feet

Havana (in Gadsden County) about 328 feet west of the G. F. & A. Ry. station; 6 feet from north fence of a tobacco field; 49 feet south of the G. F. & A. Ry. main track. Concrete post. Elevation-------------------247.050 feet

Midway (in Gadsden County) about 164 feet west of the S. A. L. Ry. station; 26 feet south of the main track. Elevation------------------196.758 feet

With regard to elevations the area falls into two very pronounced divisions, a northern upland section and a southern area of lesser elevation. The northern division, which includes the greater part of Leon and rather more than one-half of Jefferson counties, lies within the belt of red sandy clay hills of northern Florida. Lakes are very numerous and vary in size from small to large. The hills rise above the lake basins by gradual slopes, usually from 50 to 100 feet. The southern belt is more uniform and the land surface rises gradually in passing inland from the coast.

Elevations are indicated on the map of this area and on the profile across the state from north to south, which accompanies the map. From the state line to Tallahassee the profile follows the public road known as the Dixie Highway, while from Tallahassee to the Gulf it follows the St. Marks branch of the Seaboard Air Line Railway. The highest land is that which extends with some interruptions from Tallahassee north about ten miles. This upland probably represents essentially the original plateau level, having been but little reduced by erosion. The hill on which the State Capitol stands at Tallahassee is about 216 feet above sea level, while the maximum plateau level farther north is about 238 feet above sea level. Near the northern line of the State the general land level is somewhat lowered. This is true not only on the line of this profile, but generally throughout this area. Within this belt near the north line of the State are found the two large basins, Iamonia and Miccosukee. (Map and profile inserted following p. 100.)

TOPOGRAPHY.

The topographic forms of this area, the hills, valleys and lake basins seem on casual inspection to be irregularly placed and entirely lacking in system. That this is not true, however, becomes apparent upon close study of the region. Primarily the topographic forms, the hills and valleys, were determined by normal or usual surface streams, and to this extent fall into drainage systems with the usual highland divides and remnants between basins. In addition, the land surface has been materially affected by underground solution in the limestone and subsidence of the overlying materials. This process of underground solution tends to interrupt the drainage systems through the formation of isolated basins. Such basins may be formed in established drainage systems. In such cases the drainage may be in part, at least, reversed, the water finding its escape into underlying limestones.

The topography in this area is so directly dependent upon the geologic structure that an account of the topographic types may be deferred to follow a description of geology.

GEOLOGY.

The geologic formations found at the surface within this area are chiefly of Oligocene and Miocene age, although more recent deposits overlie these in places near the coast. The materials of these formations include limestone, clays, sands, sandy-clay and shell marl. The limestones are chiefly those of the Chattahoochee formation (Oligocene), while the clays and sandy-clays are for the most part included within the Alum Bluff formation (Miocene). Most of the shell marls of this area, as well as some of the sands above them, represent the Choctawhatchee formation (Miocene).

The following table presents a summary of the formations of this area, all of which are of Cenozoic age:

Pleistocene. No marine fossiliferous Pleistocene known within the area.
Pliocene. No marine fossiliferous Pliocene recognized.
Upper Miocene. Choctawhatchee formation; shell marls and sand.
Lower Miocene. Alum Bluff formation; calcareous sands and clays.
Oligocene. Chattahoochee formation; limestones and calcareous clays.
Eocene. Not exposed at the surface, although reached in well drilling.

EOCENE.

Although not exposed at the surface, the Eocene deposits are reached by deep wells. This has been shown by the samples from the well of the Bonheur Development Company. This well, which is located in Wakulla County, 16 miles south of Tallahassee, has reached, at the time of publication of this report, a depth of 2000 feet. The well, which is the deepest in West Florida, is of much interest, as it shows the presence of a great thickness of calcareous formations underlying this part of the State. The samples of drillings from the well have been collected and preserved by Mr. B. M. Cates, who also presented a set of the drillings to the State Geological Survey. With the exception of the Oligocene limestones near the surface, this well passes through Eocene deposits, chiefly limestones, and apparently is still in Eocene deposits at the depth of 2,000 feet. The well is being drilled as a test well for oil.

OLIGOCENE.

CHATTAHOOCHEE FORMATION.

The type locality of the Chattahoochee formation is at the Chattahoochee Landing on the Apalachicola River in Gadsden County. The thickness of the rock exposed in the cut for the public road at this landing is as much as 65 feet, and the full thickness of the formation is evidently considerably greater. The rock of this formation as exposed at this place consists of rather impure limestone, the impurity being chiefly clay. The deposits are stratified, ledges of rock of medium hardness alternating with softer, more clayey or marly layers. The inclusion of clay in the rock is about in the proper proportion to form a natural cement, the rock nearby at River Junction having been used in a limited way for that purpose.

The limestones of the Chattahoochee formation found in Leon, Jefferson and Wakulla counties, although representing an eastward extension of this formation, are for the most part harder and more nearly pure than are those at Chattahoochee Landing. In Wakulla County this rock has been used as a material for concrete and for road building purposes. The following analysis of a sample of this rock from the Griscom plantation near Lake Iamonia has been made by the State Chemist. The sample is from a well and was taken at a depth of 60 feet from the surface.

Fig. 3.—Geologic sketch map. 1. Alum Bluff formation (Miocene), with occasional exposures of the Chattahoochee formation. 2. Chattahoochee formation (Oligocene). 3. Undifferentiated, including the Alum Bluff and Choctawhatchee formations (Miocene), and possibly some later deposits in the south-western part of the area. Scale of map: One inch equals 11 miles.

ANALYSIS OF LIMESTONE ROCK FROM LAKE IAMONIA.

Moisture	.33%
Insoluble matter	4.67%
Calcium oxide 53.20% equivalent to calcium carbonate	95.00%

This limestone underlies the whole area of these three counties. It has, however, a slow dip to the south which carries it beneath the surface in the southwestern part of Leon County and in the western part of Wakulla County, although in the eastern part of Wakulla County, it remains at the surface to the Gulf of Mexico.

The Ocklocknee River, which forms the western boundary of Leon and Wakulla counties, flows on this formation from the State line to somewhat below the crossing of the Seaboard Air Line Railroad, a distance in a direct line of approximately 20 miles. At the crossing of the Seaboard Air Line Railroad the Ocklocknee River turns in a direction west of southwest. Had the river continued south from the station Ocklocknee, it would have remained on or practically on the limestone to the Gulf. Its southwestward course, however, carries it onto formations of later age. In other words, the Chattahoochee limestone dips beneath the bed of the river, the dip of the rock to the south being greater than the gradient, or fall of the stream, when deflected as it is to the southwest.

The St. Marks River and its tributaries form an indefinite drainage system crossing the area in a general north-south direction. This stream flows practically on the limestone throughout its whole course to the Gulf, and is in part a surface stream and in part subterranean. The history of the development of this drainage system will be described subsequently. Between the Ocklocknee River on the west and the Aucilla River on the east there are practically no surface streams, as the limestone is sufficiently near the surface to receive the drainage. A partial exception is afforded by the Wakulla River, which emerges from its subterranean course to form the great Wakulla Spring. The Sopchoppy River, another exception to the general rule of absence of streams, is in the southwestern part of the area where the limestone has dipped beneath the surface. The Aucilla River flows near the top surface of this limestone from the State line to the Gulf.

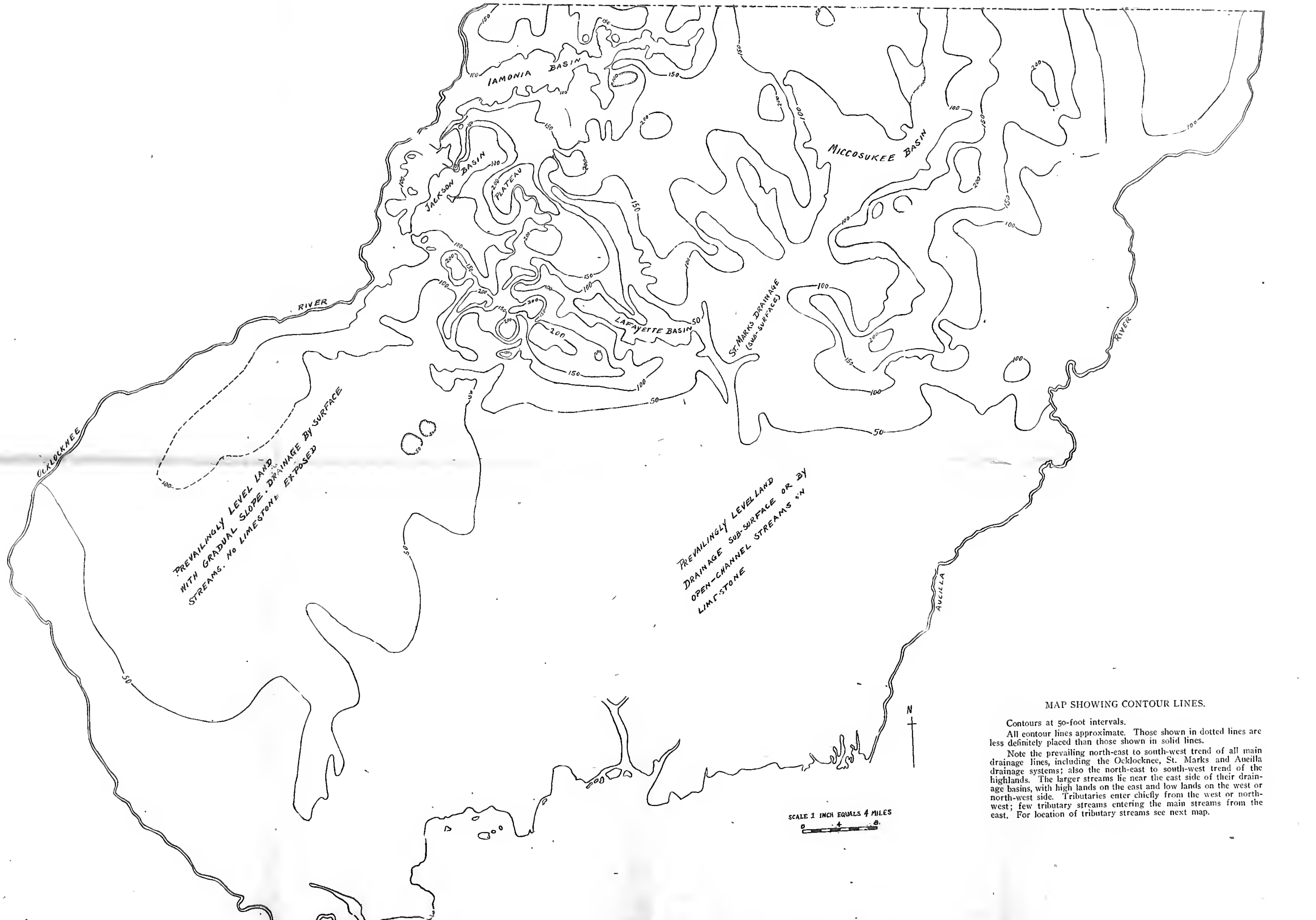
Throughout practically the whole of Leon County, and a part of Jefferson and Wakulla Counties, the Chattahoochee limestone lies buried beneath the Alum Bluff sands and clays, and it is only through the removal of these overlying materials by erosion that the rock of this formation has at places become exposed at the surface. In the eastern part of Wakulla County, and the southern part of Jefferson County, there is a large area over which this formation lies at or very near to the surface. The following localities in Leon County may be recorded at which this formation may be seen at the surface. The large area in Wakulla and Jefferson Counties over which it is found at the surface is indicated on the map. (Fig. 3).

SURFACE EXPOSURES OF THE CHATTAHOOCHEE LIMESTONE.

In addition to these surface exposures the limestone rock is reached occasionally by dug wells and usually by drilled wells. A well dug on the Griscom plantation on the south side of Lake Iamonia (Sec. 32, T. 3 N., R. 1 E.) reached the limestone at a depth of 60 feet or less. In the southern part of Leon County the surface elevation drops off to a much lower level, and in this area the limestone is comparatively near the surface. Approaching the Wakulla County line in the eastern half of the county, limestone rock lies at the surface, where it has been quarried for road purposes.

An exposure of limestone rock, which probably represents the Chattahoochee formation, is found on the Meridian Road near the Georgia-Florida line, the rock, which is found in a depression in a field at the side of the road, is hard and compact. A few miles further east a similar limestone was seen in a sink known locally as the "Cascades."

The basins of the large lakes of Leon County, including Iamonia, Jackson, Miccosukee and Lafayette, all of which are solution basins, are reduced to or below the level of the limestone. The writer was fortunate in having an opportunity in the fall of 1909 of examining these basins at an exceptionally low stage of water. The basins are drained by sinkholes, which are in fact openings into the limestone. The principal sink of Lake Iamonia is found adjoining the bluff at the north side. Limestone rock is exposed near the bottom of this sink. A similar limestone was observed at the bottom of a sink in Lake Jackson. In Lake Lafayette basin the limestone rock is seen at the sink near the northwest corner of the lake. The principal sink of Lake Miccosukee is at the west side of the lake near the north end. The limestone at this sink is a compact, chalky white



MAP SHOWING CONTOUR LINES.

Contours at 50-foot intervals.

All contour lines approximate. Those shown in dotted lines are less definitely placed than those shown in solid lines.

Note the prevailing north-east to south-west trend of all main drainage lines, including the Ocklocknee, St. Marks and Aucilla drainage systems; also the north-east to south-west trend of the highlands. The larger streams lie near the east side of their drainage basins, with high lands on the east and low lands on the west or north-west side. Tributaries enter chiefly from the west or north-west; few tributary streams entering the main streams from the east. For location of tributary streams see next map.

FLORIDA STATE GEOLOGICAL SURVEY
E. H. SELLARDS, State Geologist

MAP OF
LEON, JEFFERSON, AND WAKULLA COUNTIES
1917
INCLUDING A PROFILE FROM THE STATE LINE
TO THE GULF COAST

Base map from State Department of Roads.

Elevations from U. S. Coast and Geodetic Survey; U. S. Geological Survey; County Engineer of Leon County; County Engineer of Jefferson County; Seaboard Air Line Railway; Georgia, Florida and Alabama Railway; Atlantic Coast Line Railway; and original levels. Bench marks based on precise levels are given to the fraction of a foot. Other levels are given in whole numbers to the nearest foot.

rock. The overflow from Lake Miccosukee passes to the south and enters the limestone through a sink a few miles south of the lake where the limestone is again exposed in Jefferson County. On the Ocklocknee River this limestone is exposed a short distance above the crossing of the Seaboard Air Line Railway.

In Wakulla County this limestone lies at or near the surface throughout practically all the eastern half of the county. The western boundary of the limestone rock in this country, leaving the Gulf Coast near Shell Point, passes north probably a little east of Medart and west of Crawfordville, entering Leon County near or a little east of Hilliardville. Although underlying the west half of the county, the limestone lies below the surface. The limestone rock in this area is for the most part hard and compact and is often found as boulders at the surface.

Throughout the southern part of Jefferson County, the limestone lies at or very near the surface, while flinty and indurated phases of the rock which resist erosion frequently lie on the surface, and in places have accumulated forming masses of surface rock. In the northern part of Jefferson County the conditions are similar to those of northern Leon County. The limestone is covered by later formations, and is exposed only in depressions and sinks, although it is frequently reached in well drilling.

Although limited in extent, these exposures in Leon County and in the northern part of Jefferson County, together with the larger surface exposures in Wakulla County and in the southern part of Jefferson County are sufficient to show that the Chattahoochee limestone underlies the whole area at no great depth.

STRUCTURE.

As an aid in the study of structure it becomes important to record, so far as possible, the elevation of exposures of the successive formations. Such data, however, must be regarded as approximate. First of all a part of the formation may have been removed, either by solution or by mechanical erosion, so that what appears to be the top may in reality be somewhat or considerably below the top. Moreover, the lack of a detailed topographic map, or other adequate series of exact levels adds to the difficulty of studies in the structure of the formations.

Of the formations exposed within the area covered by this report, the most serviceable in the study of structure, perhaps, is the Chattahoochee limestone. North of Lake Iamonia this rock has been found to lie in the Thompson well, Sec. 23, R. 1 E., T. 3 N. as high as 138 feet above sea level. In a well on the Hutchinson place, about two miles further east, the top of the rock was reached at an elevation of 112 feet, while a few miles further east, in a well at Stringer's store, north of Lake Miccosukee, the rock was found at an elevation of 119 feet above sea. Passing to the south the rock is found at lower elevations. On the south shore of Lake Iamonia it has been reached at elevations of 98 and 90 feet, respectively, and on the north bank of Lake Jackson at 92 feet above sea. At the crossing of the Seaboard Air Line Railway, on the Ocklocknee River, the rock lies at an elevation of 66 feet above sea. South of Lake Lafayette the rock is found at about 54 feet above sea level. At Lloyds it is reached in wells at about 57 feet above sea, while on Burnt Mill creek, somewhat south of Lloyds, it is exposed in a sink at an elevation of 41 feet above sea. Passing farther south it drops as already noted gradually to sea level. In determining direction and rate of dip, however, it is necessary to use the data with care. Owing to disintegration beneath the surface, wells may pass much below the level of this rock without encountering it. On the small map, figure 4, the top surface of the rock is indicated at a number of localities, the elevations having been determined by lines of levels from known bases. While the top surface of the limestone is extremely irregular, owing to disintegration, there is evidence of a slow dip to the south. The greatest elevation above sea observed for this rock is 138 feet in the well north of Lake Iamonia, and at this place is about 40 miles north of the Gulf, where the rock lies as sea level, there is indicated an average dip to the south of about three and one-half feet per mile. In the Aldrich well near Tallahassee the rock lies as high at least as 89 feet above sea, and possibly somewhat higher. On the Ocklocknee River, due west, the rock lies at about 66 feet above sea, while to the east at Lloyds, as already noted, it lies at about 57 feet above sea. These elevations must be used with care, although the exposure on the Ocklocknee River apparently is near the top surface of the formation, since the rock disappears below water level a few miles farther down stream, and is succeeded by the Alum Bluff formation. These records may indicate a slight dip to the southwest, as well as a general dip to the south.

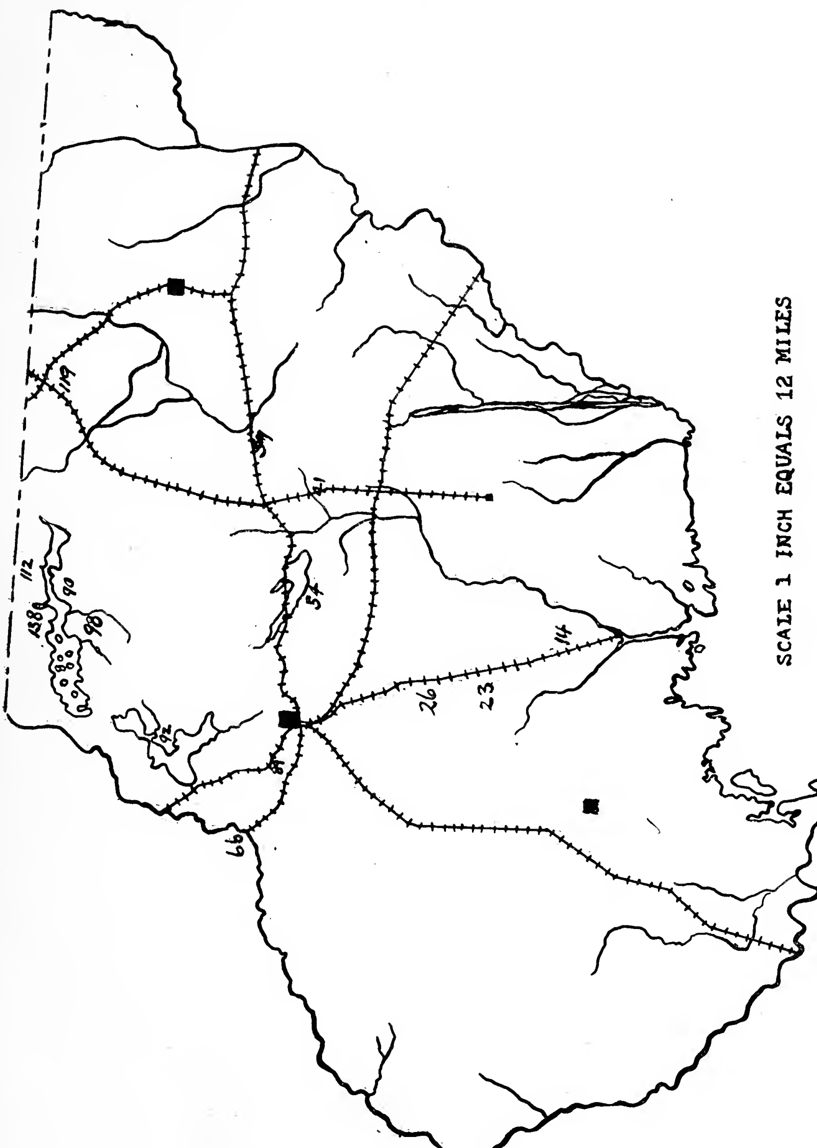


Fig. 4.—Map showing elevation above sea level of top surface of the Chattahoochee Limestone.

MIOCENE.

THE ALUM BLUFF FORMATION.

The Alum Bluff formation which lies next above the Chattahoochee, includes clays, fuller's earth, calcareous and phosphatic sands, and sandy clays. Formerly the red sandy clays at the surface of this area were supposed to be separable from the Alum Bluff and to belong to the Lafayette formation. It does not seem, however, that there is any definite or well defined break within this deposit. The difficulty in determining the age of the surface materials is due to the fact that they contain no fossils, or if fossils were present they have disappeared, probably by solution. The red sands lying near the surface in this area represent in fact a zone of partial decay. If there is a persistent dividing line, such as could be used in defining a formation, between the superficial materials and the known fossiliferous Alum Bluff deposits beneath, it has not been detected, and the whole deposits may for the present be referred to the Alum Bluff formation.

As thus defined the Alum Bluff formation in this area attains a thickness of from 100 to 150 feet. These deposits underlie and chiefly make up the red hills of Leon County. Near the southern margin of Leon County and over most of the eastern half of Wakulla County this formation has largely disappeared through disintegration, the limestone of the next older formation, as already noted, lying near the surface. In the southwestern part of Leon and the western part of Wakulla counties, this formation, although present, dips below the surface and is concealed by the later formations.

TYPICAL EXPOSURES OF THE ALUM BLUFF FORMATION.

Perhaps the best single exposure in Leon County at the present time of beds referred to the Alum Bluff formation is found on the Bainbridge road four miles northwest of Tallahassee. The section which is seen in the cut of the public road affords an exposure of about 38 feet and is as follows:

Finely laminated clayey sands, passing at the top into the soil	8 feet
Cross-bedded clayey sands often with white partings	25 feet
Greenish clay which upon weathering breaks into small pieces	3 feet
Yellow sands at the base of the exposure	2 feet

The materials seen in this exposure are characteristic of those of the northern part of Leon and Jefferson counties. Cross-bedding in the sands is frequently observed. White partings between the layers of sand is common to the area. A band or stratum of greenish clay such as that seen in this section is of very general occurrence. The laminated appearance sometimes seen in these deposits is shown in the photograph of plate 6, which represents a cut in the public road a mile north of Thomas City, in Jefferson County.

On the Ocklocknee River occasional exposures of this formation may be seen from the crossing of the Seaboard Air Line Railway for about 15 miles down stream. One of the good exposures is that found at Jackson Bluff. This formation is shown also on many of the small streams tributary to the Ocklocknee River. The mill site on Freeman Creek at the crossing of the Jackson Bluff road rests on the greenish sands of this formation. The fuller's earth horizon has been detected on a small stream entering the Ocklocknee River on property belonging to the Allen estate. This is probably near the north side of section 36, R. 3 W., T. 1 S.

Other exposures of deposits which are tentatively referred to this formation are seen in all road cuts in north Leon and Jefferson counties, although usually much altered in the shallow cuts by disintegration. Upon being affected by the processes of decay the materials of this formation undergo well marked and characteristic changes. The clay-producing minerals partly disintegrate; the small constituent of iron becomes oxidized and stains the formation red. Another early effect of decay is the obliteration of the stratification lines giving the formation the massive appearance seen in all shallow cuts. In an early stage of decay the material becomes mottled and blotched, being iron-stained in streaks and patches where surface waters have permeated. Where more completely decayed and more thoroughly permeated by surface waters, the material becomes uniformly red, and is usually more or less loamy in character, and thus passes into soil.

STRUCTURE.

The Alum Bluff formation, so far as is known, is conformable with the Chattahoochee formation and may therefore be expected to have the same structure. As in the case of the Chattahoochee limestone, the formation probably has a slow dip to the south. This is indicated by the fact that on the Ocklocknee River the formation

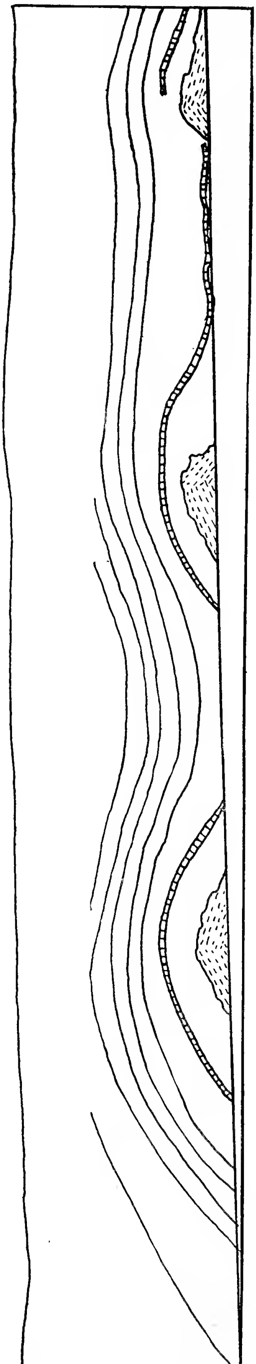


Fig. 5.—Sketch taken from a cut in the public road, 5½ miles east of Tallahassee, illustrating minor structural features in the Alum Bluff formation produced by slumping, settling and sink hole formation due to the solution of the underlying limestone. Scale, vertical and horizontal, 1 inch equals 14.2 feet.

passes below water level, thus indicating a dip in excess of the gradient of the stream. Within the formation itself bedding lines can be followed to some extent, and when not disturbed either by disintegration or by slumping the lines are found to be approximately horizontal with probably a slight south dip, scarcely perceptible in any one exposure and recognizable only when a given stratum is compared in successive exposures.

One of the most easily recognizable divisions of the formation is a stratum of blue clay, which, although having a thickness of only about three feet, is very persistent over this area. This clay is seen in the following exposures in which the actual level of the clay has been determined:

Bainbridge road, 4 miles north-west of Tallahassee	170 ft.
Meridian road, 5½ miles north of Tallahassee	170 ft.
Meridian road, 4 miles north of Tallahassee	164 ft.
Thomasville road, 4 miles north-east of Tallahassee	161 ft.
Thomasville road, 7 miles north-east of Tallahassee	159 ft.
St. Augustine road, near east city limits of Tallahassee	153 ft.
Bellair road, about 1 mile south of Tallahassee	151 ft.
St. Augustine road, 7½ miles east of Tallahassee	147 ft.

In recording the level of this clay it is necessary to make sure that the deposits are in place and that the elevation has not been lowered either by subsidence due to underground solution, or by creep or slump down the slope of the hill. The clay stratum is a line of weakness in the deposit, and creeping and slumping frequently take place along this plane. Thus at the locality referred to on the Meridian road 5½ miles north of Tallahassee, this clay stratum, although having a thickness probably of only about three feet, is seen in the exposure for a distance along the slope of the hill of 380 feet, and through an apparent vertical interval of 22 feet. At many other localities, also, the clay has an apparent thickness on the slope of the hill which is obviously greater than its actual thickness. Similarly the overlying sands following the slope of the hill seem to have a far greater thickness than they actually have in vertical section. On a hill where the formations are known to be affected by slumping, only those strata which are undisturbed can be used in determining the thickness of the section or the level at which the stratum lies.

On Little River in Gadsden County, west of Midway, a shell marl phase of the Alum Bluff formation is exposed at the public road crossing at an elevation of about 70 or 80 feet above sea level. On the Sopchoppy River, about 30 miles south, essentially the same phase of the formation is exposed practically at tide water level. The dip of the Alum Bluff formation to the south is thus seen to be 2½ or 3 feet per mile.

APPARENT STRUCTURE WITHIN THE ALUM BLUFF FORMATION.

Within the Alum Bluff formation in railroad and public road cuts is frequently observed what at first appears to be minor structural features, including very small, although pronounced, anticlines and synclines, as well as faults and other distortions of the strata. These structural features are perhaps best seen at the present time in Leon County on the St. Augustine road, five and one-half miles east of Tallahassee, although similar structures may be seen at many other localities. (See Fig. 5, p. 106.)

Striking as these structures are, it is probable that they are merely incidental to the disintegration of the formation. Solution in the underlying limestone in this area has resulted in the subsidence of overlying materials. On a small scale this is seen associated with the formation of sinks, and on a larger scale in the formation of solution basins, such as those of the many large and small lakes of this area. This disintegration by solution will be more fully described in connection with the topographic history of the region.

It is to be observed that these apparent structural features are found only in localities where the general land surface has been lowered through erosion, including underground solution accompanied by the formation of sinks and basins. In all cuts made into this formation, where it has not obviously been disturbed by sink formations or by slumping and settling, the bedding planes are horizontal or nearly so.

THE CHOCTAWHATCHEE FORMATION

The Choctawhatchee formation, which is of upper Miocene age, includes marine shell marls and marine sands. The type locality of this formation is at Alum Bluff on the Apalachicola River. In the section at this bluff 31 feet are referred to this formation, while overlying deposits more than 100 feet thick, consisting of coarse sands, may also belong in whole or in part to the same formation. In Leon and Wakulla counties the deposits appear to be thin, although there is little opportunity to measure the formation as a whole. The area in Leon and Wakulla counties known to be covered by this formation, as indicated on the map, is limited and is confined to the belt of country near the Ocklocknee River. The formation is not known to extend into Jefferson County.

Inasmuch as the marine phase of this formation extends into the southwestern part of this area, it may be suggested that possibly the uppermost sands and clays of the northern part of the area represent the shoreward margin of the same formation. This is, perhaps, a possibility, although in the absence of any definite proof it seems unsafe to assume a complete Miocene submergence of the whole area.

TYPICAL EXPOSURES

Perhaps the best single exposure of the Choctawhatchee formation within this area is that seen at Jackson Bluff, where six or seven feet of shell marl represent the marine fossiliferous phase of the formation. This marl is also seen at a number of other places farther down stream, as well as in many of the small streams entering the Ocklocknee River. The presence of this marl has been noted on Duggar Creek in Section 9, T. 1 S., R. 2 W.; also near Hugh Black's sawmill on Mill Creek.* The shell marl passes below the bed of the stream before reaching the Gulf Coast.

PLIOCENE.

No marine Pliocene deposits have been recognized within this area. On New River, however, in Franklin County, the writer found a limestone bed containing fossils which have been identified by Dr. T. W. Vaughan as probably representing the Miocene or the Pliocene.† If the Pliocene is present at this locality in Franklin County it is very probable that deposits of this period extend into the southwestern part of Wakulla county. The red sandy clays of Leon and Jefferson counties were, as already stated, formerly placed in the Lafayette formation, and at that time were

*Fla. Geol. Surv. Rept., Second Ann. Rept., p. 121, 1909.
†Personal letter of Dec. 16, 1915.

assumed to be probably of Pliocene age. In view of the lack of definite information as to these superficial deposits, it is difficult to assert that they may not be a part of a Pliocene formation. However, such an assumption seems unwarranted, inasmuch as there is no clear evidence to show that they are not a part of the Alum Bluff formation which is known to extend over this area.

PLEISTOCENE.

The fossil remains of the land animals of the Pleistocene period have been found at several localities within this area. From Wakulla Springs has been taken numerous proboscidian bones. A number of bones of the mastodon or the elephant taken from this spring many years ago are said to have been lost by shipwreck while being transported to Washington. No fossiliferous marine Pleistocene beds have been detected, although such may be expected near the coast, especially in the southwestern part of this area, where the dip carries the older formations below the surface.

The harbors of the Gulf Coast of Florida represent with little doubt flooded stream valleys* and indicate a slight submergence from a higher elevation which occurred probably during the Pleistocene period. The Wakulla River was probably at one time a tributary to the St. Marks River, although at the present time the two streams unite at tide water. The Sopchoppy River was likewise probably formerly a tributary to the Ocklocknee River, although at present it flows into Ocklocknee Bay, which is the flooded mouth of the Ocklocknee River.

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*The Geological History of Harbors. By N. S. Shaler, U. S. Geol. Survey, 13th Ann. Rpt., pt. 2, 1893.

MINERAL RESOURCES.

LIMESTONE.

The limestones of this area have been used for road building and for various miscellaneous purposes. These limestones, all of which are of the Chattahoochee formation, are found chiefly in the southeastern part of Leon, the eastern part of Wakulla and the southern part of Jefferson counties. The formation, however, comes to the surface at places in the northern part of Leon and Jefferson counties. Much of the rock used in Wakulla County is in the form of hard boulders lying on the surface. Although much of this rock is found at the surface in the southern part of Jefferson County, it is not being utilized at present, owing to a lack of transportation.

At Burns, in Wakulla County, the limestone rock of this formation has been produced for many years by B. M. and W. C. Cates. The rock is either picked up over the surface of the ground, or is obtained by shallow quarries. It is sold in bulk, or is broken for concrete material. In recent years also the rock has been ground and sold for agricultural purposes. At the present time this rock is being quarried in Wakulla County by G. W. Rhodes, and is used in building roads.

BRICK-CLAYS.

No brick is being manufactured within this area at the present time, although it is probable that some of the clays are suitable for making common building brick. Two brick-making plants, the Ocklocknee Brick Company and the Tallahassee Pressed Brick Company, are each located just across Leon County line in Gadsden County. Many years ago building brick was made from the red sandy clays near Tallahassee.

A sample of clay from the property of W. M. Carraway, near Wacissa in Jefferson County, has been tested in the United States Clay Testing Laboratory at Pittsburg, Pa. The report on this sample taken from Press Bulletin No. 7 of the Florida Geological Survey, is as follows:

Sample No. 21. Jefferson County. Medium plastic with fair working properties; water of plasticity, 32.6%; no drying difficulties; linear drying shrinkage, 9.77%; linear burning shrinkage, at 990 degrees C., 0.22%; at 1110 C., 1.09%; at 1230 C., 0.55%; at 1320 C., 0.49%; buff burning; per cent porosity, at 990 degrees C., 35.6% ; at 1020 C., 34.0% ; at 1050 C., 33.2% ; at 1080 C., 33.4% ; at 1110 C., 33.8% ; at 1140 C., 33.6% ; at 1170 C., 33.6% ; at 1200 C., 33.7% ; at 1230 C., 32.8% ; at 1260 C., 34.4% ; at 1290 C., 33.7% ; at 1320 C., 33.5%. A sandy buff burning clay which retains an open porous structure at temperatures up to 1320 degrees C. (2408 degrees F.). May have some use in the manufacture of soft porous common building brick.

FULLER'S EARTH.

The fuller's earth deposits which are mined in Gadsden County extend into the southwestern part of Leon County and the western part of Wakulla County. The known exposures of fuller's earth are found chiefly near the Ocklocknee River in the southwestern part of Leon County. That they have not been worked is due probably chiefly to the lack of suitable transportation.

PHOSPHATE.

No workable phosphate beds are known in this area. The Alum Bluff formation, however, carries some phosphate rock, although probably not in commercial quantities. Gray calcareous phosphatic sandstone, chiefly as nodules or interrupted layers, are of frequent occurrence throughout this area. Occasional samples of this rock, derived probably from near the base of the Alum Bluff formation, have been found to contain as much as from 50 to 70 per cent of calcium phosphate. As a rule, however, the sand rock is much lower in phosphate. Hard rock phosphate has been reported also from near Wacissa in Jefferson County.

ROAD MATERIALS.

The principal road building materials of this area are sandy clays and limestones. The clays are very generally distributed over the northern part of Leon and Jefferson counties. The limestone, as has already been stated, is found chiefly south of the clay belt in the southern part of Jefferson and in the eastern part of Wakulla counties. At the present time both of these materials are being extensively used, the sand clays for the roads in the northern part and the limestone rock for the roads in the southern part of the area.

WATER SUPPLY.

The water supply in this area is obtained from springs and wells. The wells from which the city water supply at Tallahassee is taken are from 400 to 717 feet deep and terminate in the Eocene limestones. The wells at Monticello are reported to be from 400 to 800 feet deep. Wells supplying water to private estates in Leon and Jefferson counties are for the most part from 200 to 350 feet deep. Shallow dug or driven wells are used in many localities and obtain water either from the sands or clays or from the limestones.

SPRINGS.

The principal springs of this area are the large limestone springs of the belt bordering the coast. The area farther north receives the heavy rainfall which largely disappears into the overlying formations and reappears through the large springs near sea level. Aside from the limestone springs of the coastal belt there are numerous soft water springs in the upland section. These smaller springs receive their supply of water from the sands and clays lying above the limestones.

WAKULLA SPRING.

Wakulla Spring is the largest of the springs of this area and is second in amount of flow only to Silver and Blue Springs in Marion County, while in the size of the basin and the depth of the water it probably exceeds all other springs of Florida. The spring is the immediate source of Wakulla River, which flows into the Gulf at St. Marks. In February and March, 1917, many of the large springs of the State were measured by the State Geological Survey in co-operation with the U. S. Geological Survey. The flow of Wakulla Spring at that time (Feb. 12), measured at the bridge three miles below the spring, was found to be 122,000 gallons per minute. The width of the basin of this spring is about 400 feet, while the depth of the water in the basin is probably about or somewhat less than 80 feet. As with many of the limestone springs, the water is remarkably clear, and objects may be clearly seen at the bottom of the basin.

WACISSA SPRINGS.

Wacissa Springs in Jefferson County include a group of springs the combined flow of which make up the Wacissa River, which flows into the Aucilla River near the Gulf. These springs emerge near or somewhat above tide water level and are not well confined to a definite channel, and hence the flow is difficult to measure. The combined flow of the springs, however, is great and the stream is navigable to its source.

NEWPORT SPRINGS.

The Newport Springs are located in the eastern part of Wakulla County, on the west bank of the St. Marks River and near the village of Newport. The springs here have long been known, and years ago this was a most attractive and popular watering place. During recent years the former popularity of this resort has been revived and a great many improvements have been made. The improvements consist of a good wall or curbing around the spring, a bathhouse and a number of well arranged cottages. The basin of the spring is from four to five feet deep and from 15 to 20 feet in diameter. The water has a decided sulphur odor and has been bottled for sale. The following analysis of this water made in the office of the State Chemist, A. M. Henry, analyst.

Constituents.	Parts per Million.
Chlorine (Cl)	18.
Carbonate radicle (CO_3)	0.
Bicarbonate radicle (HCO_3)	216.
Loss on Ignition	70.
Total dissolved solids	342.

PANACEA SPRINGS.

Panacea Mineral Springs are located at Panacea, on the Gulf coast in southern Wakulla County. The springs consist of a group of several springs within a comparatively small area. The water from the several springs is said to be different, no two of the springs furnishing water of the same mineral content. The water is bottled for sale. The springs are a health resort, and hotel accommodations are provided for guests. The following analyses of the waters from springs Number 1 and Number 2 were made by Dr. V. Coblentz, New York City, November 28, 1898:

SPRING NUMBER 1.

Constituents.	Grains per U. S. Gallon.	Parts per Million.
Sodium Chloride	135.976	2331.160
Magnesium Chloride	15.080	258.532

Calcium Chloride	3.213	55.083
Sodium Sulphate	8.407	144.128
Magnesium Sulphate	4.441	76.136
Calcium Sulphate	3.213	55.083
Calcium Carbonate	20.475	351.021
Ferrous Carbonate	0.882	15.120
Magnesium Carbonate	1.051	18.018
Silicic Acid (SiO_2)	0.893	15.309
Alumina	Traces	Traces
Organic Matter (Loss on Ignition)	3.210	55.031
Total	198.118	33.96.415

SPRING NUMBER 2.

Sodium Chloride	23.664	405.693
Magnesium Chloride	15	258.532
Calcium Chloride	0.870	14.915
Potassium Chloride	1.452	24.892
Sodium Sulphate	2.307	39.550
Magnesium Sulphate	3.770	64.632
Calcium Sulphate	0.382	6.548
Iron Carbonate	0.672	11.520
Calcium Carbonate	6.656	114.109
Alumina	0.197	3.377
Silica	0.348	5.966
Total	58.398	1001.169

In addition to the springs that have been mentioned, there are numerous smaller springs entering the creeks and rivers which flow into the Gulf. Some of these springs enter the Gulf below tide water and are known only by the "boil" of water through the salt water. Others form an important source of supply to the creeks and rivers. Among these are springs entering and making up Spring Creek, near Shell Point, in Wakulla County, and those entering the St. Marks River.

GEOLOGIC HISTORY.

The geologic history of this region has been indicated in connection with the description of the formations, and may be very briefly summarized. During Eocene and Oligocene time marine conditions prevailed over this part of the Coastal Plain, which were favorable to the accumulation of a great thickness of marine limestones. Early in the Miocene there was a gradual change by which much land material was washed into the ocean, thus resulting in the accumulation, in shallow waters, of the sand, sandstone and clays which make up the Alum Bluff formation. This interval, the early Miocene, is also a time of the extensive accumulation of phosphate in the Florida formations. The phosphate, at this time, however, was disseminated through the formations and was, perhaps, in no case sufficiently concentrated to form workable deposits, the concentration into the, at present known, workable beds having taken place subsequently.*

During the latter part of the Miocene marine shell marls (the Choctawhatchee formation) accumulated in the southwestern part of this area, indicating an incursion of the sea at that time. While minor extensions of the sea over the coastal belt of this area may have occurred during the Pliocene and Pleistocene, it would seem that much of the higher lands have been above sea level since the Miocene, and have thus been subjected through this long period of time, to the slow but constantly operating agencies of erosion and disintegration.

TOPOGRAPHIC AND PHYSIOGRAPHIC DEVELOPMENT.

The area to which this report relates presents unique problems in the development of land forms, and affords a chapter of unusual interest in topographic and physiographic development. The underlying deposits are very largely marine, and we may safely assume were deposited continuously over a large extent of the ocean bottom. When the land was first lifted above sea level, some surface

*Origin of the Hard Rock Phosphate Deposits of Florida, Fifth Annual Rept., Fla. Geol. Surv. pp 23-80, 1913; Pebble Phosphates of Florida, Seventh Ann. Rept., Fla. Geol. Surv. pp. 25-116, 1915.

irregularities no doubt existed, but certainly no such pronounced basins and hills as those which are found at the present time. The striking features in the topography we must assume have developed since the area became dry land, and subjected to the modifying influences of eroding agencies in contrast to depositional agencies, which chiefly influence submerged areas. The topography, as it is seen in this region to-day, including the hills, valleys and many lake basins, which add so much to the beauty of the landscape, has resulted, we may believe, from natural agencies acting through a long period of time and still operating. The topographic and physiographic development is, therefore, a part of the geologic history and includes chiefly the history of the region after it became dry land.

The topographic forms which result from erosion and disintegration of the land surface vary in character in keeping with the variations in the intensity of action of the different eroding agencies, and also in accordance with variations in the formations which are subjected to these influences. It thus follows that eroding agencies are by no means of the same intensity the world over. A warm, moist climate, accompanied by dense vegetable growth, affords unusually favorable opportunity for those disintegrating processes that are promoted by the presence of organic acids and carbon dioxide gas. An analagous variation in intensity of action characterizes many of the other agencies of disintegration according to the varying conditions under which they operate. Moreover, successive formations are by no means uniform in composition or in resistance to agencies of decay. To understand the resulting land forms it becomes necessary, therefore, to take into consideration both the character of the formations and the conditions under which the disintegrating agencies have operated. While the land forms usually result from a combined action of many agencies, yet the predominating influence of a single agency, or a group of agencies, may often be recognized.

The preceding pages contain a description of the formations underlying this area, and also a brief account of climate and vegetation. Calcareous formations are present either at the surface or underlying other deposits. Over a considerable part of the area these rocks are occasionally exposed, and it is only in the southwestern part of the area that they are so deeply buried as not to affect the topography. The rainfall is heavy; much of the drainage is subterranean; the native vegetation is for the most part dense; the processes of decay are rapid, and organic acids are present in the surface water. All of these conditions are favorable to disintegration by solution. The large amount of water which enters the earth in the northern part of this area finds its exit through large springs along the coast, thus establishing a definite system of underground circulation.

That underground solution under these conditions is effective as a disintegrating agency is shown not only by the topographic forms that have resulted, but also by the character of the water itself. Upon entering the earth the rain water is practically free of solids in solution, but upon reappearing from the limestone, it carries a heavy load of solids in solution. Under the conditions which prevail in this area solution in the limestone is rapid and the land forms in the northern and the eastern part of the area owe their form chiefly to this agency modified by surface wash and other minor agencies.

LAKE BASINS AND LAKES.

Among the most pronounced of the topographic features of this area are the numerous large and small basins, many of which are now occupied by lakes. These basins, the largest of which are Iamonia, Jackson, Miccosukee and Lafayette, have resulted from solution in the underlying limestone, accompanied by partial removal of the overlying sands and clays. Each basin has an individual history which may be followed to some extent. The lakes and lake basins are largely confined to the northern part of the area in Leon and Jefferson counties.

The origin of these lake basins is a part of the history of the development of the topography of the region. In this development both mechanical erosion and solution have had a part. A first step in the process of erosion is the development of stream channels and valleys, largely through mechanical erosion. In addition to mechanical erosion, solution by underground water is effective, especially in regions underlaid by limestones.

That the amount of limestone carried away in solution in underground water is great may be determined by the analysis of the water of some of the large springs coming from the limestone. From an analysis of water of several springs it has been estimated that the limestone springs of Florida carry on an average about 219 parts solids in solution per million parts water.* Wakulla Spring alone flows approximately a million pounds of water per minute (122,000 gallons). Hence probably as much as 200 pounds of solids in solution reaches the ocean through this one spring per minute. It is impossible to estimate the total flow of all springs from this area or to estimate the total escape of solids in solution through all springs, but it may be seen that the amount now passing to the ocean in this way is very considerable for each day in the year. When it is remembered that this process is not only going on now but has continued for a very long period of time, the total amount of solids so removed may be in a measure at least appreciated as quite sufficient to account for the solution basins that have been formed. Of the minerals thus removed calcium carbonate or limestone greatly predominates, exceeding the combined amount of all other minerals.

A first effect of solution in the limestone is to develop cavities through the rock along the line of ready flow of underground water. These cavities gradually enlarge until the overlying material is no longer able to support its own weight and caves, thus forming a sink.

The formation of a sink is a first step in the development of the many basins large and small occupied by these lakes. A sink usually retains connection with the underlying limestone for some time after its formation, and water entering the sink escapes into the limestone. Under these circumstances more or less of the material lying immediately around the sink is carried by surface wash through the sink. Moreover, the large amount of water entering through the sink results in rapid solution in the limestone of that immediate vicinity. The result is frequently the formation of other sinks in proximity to the first. As the sinks become clogged or partly filled, new sinks form by this process, continually enlarging the basin.

The large basins of this type are usually shallow water lakes which at times become entirely dry. It may be readily understood, also, that a basin that at one stage of development is a shallow water lake may subsequently become permanently dry, the lake having become drained by natural agencies. The smaller lakes, on the other hand, are usually relatively deep water lakes.

*Fla. Geol. Survey, Bull. No. 1, p. 47, 1908.

LARGE BASINS WITH SHALLOW-WATER LAKES

IAMONIA BASIN.

Iamonia basin lies near the north line of Leon County. The basin is irregular in outline, but has an average width of from one to one and one-half miles. The total length of the lake is from twelve to thirteen miles. At its west end the basin connects with the swamp of the Ocklocknee River. During flood seasons the river overflows into the lake. Similarly a high stage in the lake results in an overflow into the river. Small tributary streams enter the lake from both the north and the south side, as well as from the east end. The tributaries are small flat-bottomed streams which are dry, except during the rainy season. The lake fluctuates according to the rainfall. The lake basin when full covers an area of about 6,500 acres. Except at the west end, where it joins the Ocklocknee River, the basin is largely surrounded by the red clay hills characteristic of this part of the State. These hills rise to an elevation of from 50 to 100 feet above the level of the lake.

The sink through which the water escapes from this lake is found on the north border. Limestone rock, probably of Upper Oligocene age, is exposed near the bottom of the sink, the water escaping through or under these rocks. Above the limestone partly decayed sandy clays occur. These contain few fossils, although oyster shells were found in abundance at one locality. The total depth of the sink below the general level of the lake is not less than 50 feet. The sink is formed, as is usual in this type of lake, facing an abrupt bluff 30 feet or more in height. A considerable number of sinks are found around the border of the lake, especially in the vicinity of the one large sink which receives the drainage of the lake. The formation of these sinks is doubtless due to the fact that the water entering the drainage sink spreads laterally in the underlying limestone and dissolves the rock rapidly. The result is the formation by subsidence of numerous sinks adjacent to the drainage sink. The presence of these sinks also indicates the manner of enlargement of the lake basin, and indicates in each case the direction of most rapid enlargement at the present time. At other times the enlargement by solution and subsidence may have been most active in some other locality or direction or part of the lake basin.

This lake only occasionally goes entirely dry, and as a result a covering of muck or peat occurs over the greater part of the bottom of the lake. This deposit of muck reaches a considerable thickness in such natural depressions as occur over the lake bottom. Beneath the muck is usually found a deposit of light colored sand and beneath this is the red sandy clay.

Iamonia basin represents apparently a stream valley lowered by solution and enlarged laterally by subsidence through the formation of sinks. Originally a small stream tributary to the Ocklocknee River flowed through this section. In this part of the country soluble limestones occur at no great distance from the surface, and in the course of the natural processes of erosion the stream approached sufficiently near this limestone to permit of the formation of sinks and the escape of the water of the stream through the sinks. The enlargement of the valley to its present size has proceeded through the formation and partial filling of successive sinks. As each sink forms, it carries down to or below the lake level, a certain small area of land. Moreover, the water passing through the bottom of the sink carries with it more or less detrital material so that the surrounding area is somewhat lowered by wash through the sink. In the course of time other sinks form, while the older sinks become clogged and usually partly fill up. The direction of active enlargement of each lake can be determined from the location of the recent sinks. As previously remarked, this rapid enlargement is usually around the sink which is at present actively receiving the drainage. The basin of this lake is 85 or 90 feet above sea level.

JACKSON BASIN

Jackson Basin lies near the western border of Leon County, within one and a half or two miles of the Ocklocknee River. This lake is irregular in shape, and has a total area of about 4,500 acres. The boundaries of the basin are sharply marked by the surrounding highlands, which rise 75 to 100 feet above the level of the lake. Several sinks are found in the southern half of the lake. The largest of these, known locally as the "lime sink," is well out in the basin and in the angle between the north and east arms. An opening in the bottom of this sink in May, 1907, permitted the water to run out, leaving the sink dry, and also draining the lake or such part of it as was connected with the sinks. An indefinitely defined broad depression or slough extends to the southeast from the lime sink.

Several water holes representing old sinks are found along the line of this depression. A new sink was formed along the bottom of the depression about one mile southeast of the lime sink in June, 1907. A compact limestone showed in the bottom of this sink at a depth of about 25 feet from the surface. At the time this sink was formed the lake was low, a part of the water having been carried off through the opening which had been formed in the lime sink a month earlier. All the water that could reach the new sink was carried off in the course of two or three days, leaving the lake dry except for occasional water holes.

The surface soil in the basin is quite generally a gray sand darkened by the admixture of organic matter. In the lower parts of the lake, quite generally covered by water, more or less muck or peat is found, formed from the accumulation of aquatic vegetation. Sand lighter in color and lacking the organic matter occurs at a depth of from 1½ or 2 to 3 or 4 feet. Beneath this sand is the usual red sandy clay.

The basin of this lake lies probably between 75 and 80 feet above sea level. The lake may have had an outlet to the Ocklocknee River passing just east of Lake Jackson station, although at the present time the lake basin is about 25 feet below the lowest point in this divide.

LAFAYETTE BASIN

Lafayette Basin lies in the eastern part of Leon County, between Tallahassee and Chaires. The basin begins three and one-half miles east of Tallahassee, and extends to within one mile of Chaires, having a total length of about five and one-half miles and a width of one-half to one mile. An arm of the lake extends north from near the east end of the lake. The bottom of the basin is nearly level, with the exception of occasional slight depressions. The tributaries to the lake are flat-bottomed streams with relatively broad valleys and no well defined channel. The soil in the stream valleys is a sandy loam, and the streams are ordinarily dry, carrying water only during the rainy season.

A drainage sink in this basin is found near the west end of the lake, along the northern border. The sink when measured in September, 1909, was found to have a total depth of 75 feet. The sink has been formed, as is usual in this type of lake basin, near a prominent bluff. A second sink is formed beyond the lake border, thus indicating the enlargement of the lake basin in that direction by subsidence, due to underground solution. This new sink is one hundred yards or more in circumference, and when formed carried

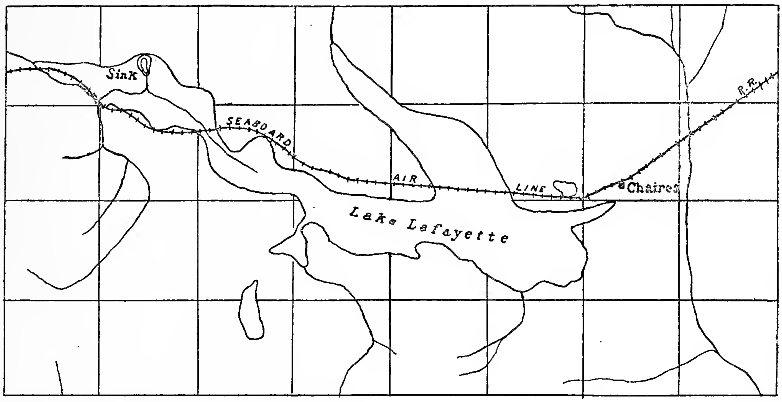


Fig. 6.—Sketch map of Lake Lafayette. Scale of map, 1 inch equals 2 miles.

down to the lake level, land which stood fifty feet or more above the lake and was being used previous to the subsidence as a cemetery.

That part of the lake basin which surrounds the sink lies at a slightly lower level than the more remote parts of the basin, and is the first to be submerged at the approach of the rainy season. This area is entirely devoid of trees, and during the dry season becomes a prairie. The greater part of the basin lying to the south of the railroad is thickly set with small cypress trees.

The soil in the basin is prevailingly a gray sand, usually darkened by the presence of organic matter. At a depth of from one to two feet the amount of organic matter is reduced, the sand being lighter in color. Sandy clays are reached as a rule at a depth of from two and a half to three feet. During a season of heavy rainfall this basin is occupied by a lake having a total area of approximately two thousand acres. Following a period of prolonged drought the basin becomes entirely dry, water remaining only at the sink. In times of excessive rainfall the lake overflows at the east end, the water discharged reaching streams tributary to the St. Marks River.

This basin has much the character of an elongated valley. The general course of the streams of this part of the county, the shape of the basin and particularly the topography of the surrounding country indicate that the drainage of this section was originally through these streams into the St. Marks River. The formation of sinks diverted the drainage to a subterranean course, the west end of the basin having been reduced to a level somewhat lower than the east end. The further enlargement of the basin is being carried on through the formation of sinks along the border. The largest of the newly formed sinks is found near the present drainage sink. The actual level of this basin at the present time is about 40 feet above sea, while the original plateau was more than 200 feet above sea.

MICCOSUKEE BASIN

Miccosukee Basin, or Lake Miccosukee, lies between Leon and Jefferson counties, the west border of the lake forming the county line. A small arm of the lake, however, near the north end reaches into Leon County. This basin has a total area of about 5,000 acres. In its northern part the basin is bordered by sharply defined bluffs, which rise from 50 to 75 or 100 feet above the lake bottom. Farther south these bluffs fall back and give place to a gradual rise of elevation from the lake border. At the south end bluffs are lacking. A drain known as Miccosukee drain enters from the east side. This drain consists of a low, swampy area from one-fourth to three-fourths mile in width. This swamp land supports a thick growth of hardwood trees. When full the basin is covered with water to a depth of from 2 to 5 feet. Toward the south end around the border of the lake grass and button bushes project above the water even when the lake is full.

The sink of Lake Miccosukee is located near the northwest corner of the basin, and is bordered by a bluff having an elevation of from 75 to 100 feet. Landslides along the border of the sink show recent enlargements of the basin. Numerous sinks are found along the border of the lake at this locality, showing enlargement of the lake basin through subsidence. The greatest depth of water in the sink when examined September 7, 1909, was 38 feet. A channel leads back from this sink across the prairie in a southeasterly direction. This channel has cut to a depth of from twenty to twenty-five feet. Followed back from the sink the channel is of gradually reduced depth, finally, at a distance of about two miles, merging into the general level of the lake bottom. When examined September 8, 1909, this stream was carrying water into the sink at a rate estimated to be 200 gallons per minute. Notwithstanding the inflow

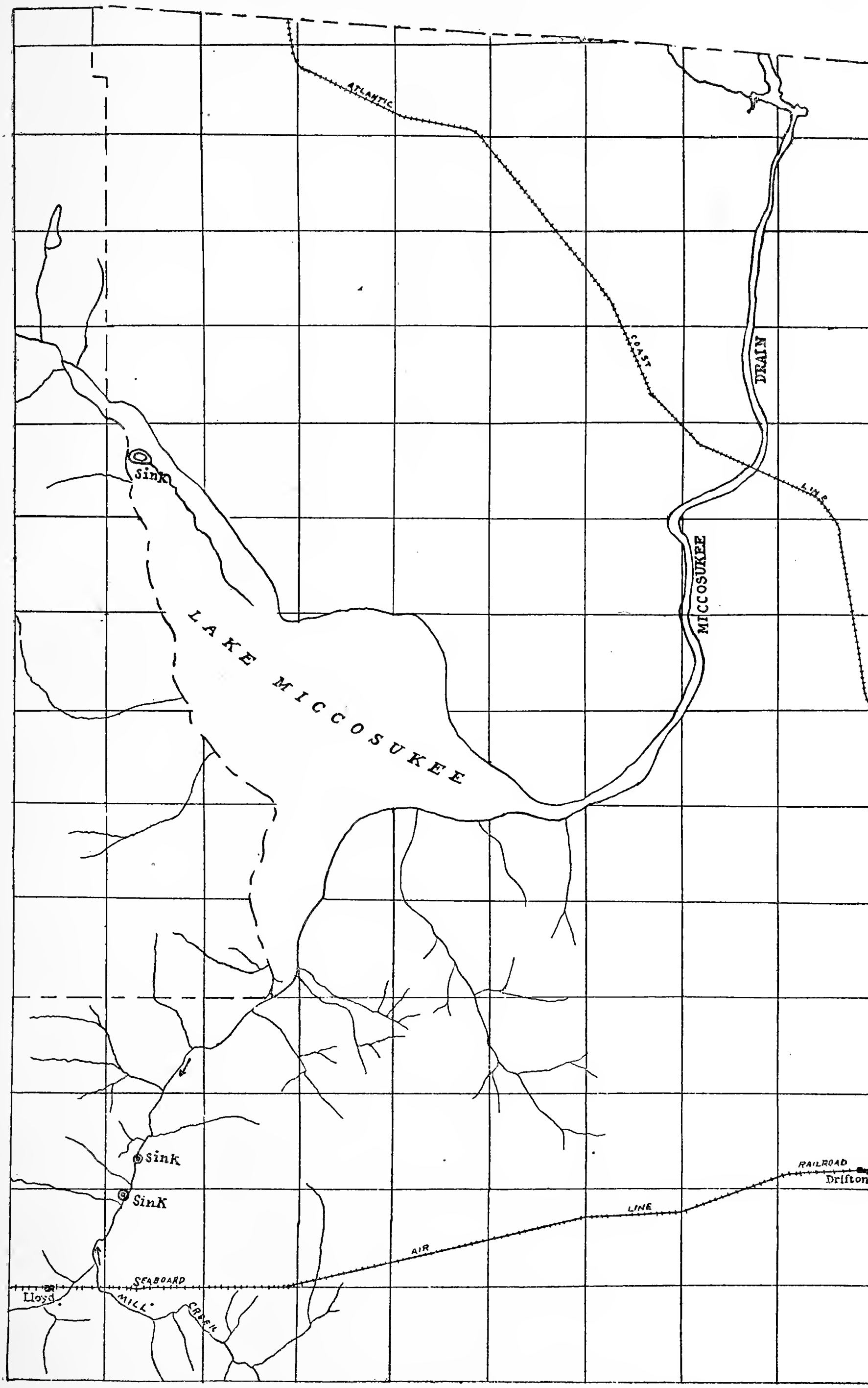


Fig. 7.—Sketch map of Miccosukee Basin. Scale of map: 1 inch equals 2 miles.

from the stream the water in the sink was being gradually lowered. Heavy rains occurred in this vicinity on September 21, 1909, and this stream when seen two days later was carrying approximately 7,000 gallons of water per minute. At this time the sink was being rapidly filled, having filled several feet during the two preceding days. From these observations it appears that the opening at the bottom of this sink permits the escape of water at a rate in excess of 200 gallons per minute, but much less than 7,000 gallons per minute. From the behavior of the sink it is probable that not more than 1,000 gallons of water are escaping per minute, and the rate of escape may be much less.

The principal escape of water from Lake Miccosukee when the lake is full is through a drain which leads out from the south end of the lake and enters a sink about two and one-fourth miles from the south end of the lake. This sink is formed in a light-colored limestone of Upper Oligocene age, probably representing the Chattahoochee formation. The drain from the lake as it approaches the sink passes through a narrow gorge cut in this limestone. About one-half mile farther south (Sec. 14) another sink is found. This third sink receives the flow from Mill Creek, a small stream draining considerable territory lying south of the Seaboard Air Line Railway and east of Lloyd.

During a season of excessive rains these sinks are unable to carry away the water. Under these conditions the overflow from Lake Miccosukee as well as from Mill Creek ultimately finds its escape by flowing to the southwest past Lloyd to the St. Marks River.

The surface in Miccosukee Basin is covered with muck to a varying depth. Borings put down near the north end of the basin, out from the margin of the drain, indicated the presence of muck for a depth of six inches to one foot. Beneath the muck in this part of the basin was found a gray sand. This sand is underlaid, at a variable depth, by the usual red sandy clay. At the south end of the lake the sand is largely absent, the muck which is from one to three or more feet deep, resting, so far as observed, directly upon the red clay.

Lake Miccosukee probably represents a basin developed by solution near the headwaters of streams originally tributary to the St. Marks River. Previous to the formation of Miccosukee Basin, the drainage of this part of the country doubtless passed through small streams, to the south past the present village of Lloyd, thence to the Gulf through the St. Marks River. The lake basin since its formation has enlarged to the northwest, the lowest part of the basin now being found near the sink in the northwest corner.

SMALL RELATIVELY DEEP-WATER LAKES.

LAKE HALL.

Lake Hall is in Leon County, about 5 miles a little east of north of Tallahassee on the Thomasville road. This is a small lake, compared to those just described, being about one mile long east to west and about one-half wide north and south. This is a very attractive lake located as it is among the hills, with beautiful open shores bordered with large oaks. This lake is connected on the west with Lake Overstreet by a small stream. The greatest depth of the lake as found when examined August, 1917, was 25 feet. The elevation of water level in the lake was then about 142 feet above sea.

LAKE OVERSTREET.

Lake Overstreet lies just northwest of Lake Hall and is connected with it by a small stream at its southeastern end. This lake is about the same size as Lake Hall, but the elongation is mostly from north to south and not from east to west, as in the case of Lake Hall. When full the lake has an overflow outlet through a drain to the southwest which flows into Lake Jackson. No subterranean outlets through sinks for the small lakes in this section are known to exist, the lakes during flood stages being connected with one another, and the larger lakes through surface streams.

LAKE ELIZABETH.

Lake Elizabeth is a small lake lying about three-fourths of a mile north of west of Lake Overstreet. Its size is approximately one-half that of lakes described above. The overflow from this lake apparently finds its way to Lake Overstreet and thence into Lake Jackson.

LAKE BRADFORD.

Lake Bradford lies about 4 miles southwest of Tallahassee, on the northern edge of the sandhill region of Leon County. For the most part the shores of the lake are surrounded with more or less swamp and the water is coffee-colored, due to the presence of organic matter in solution and suspension. On the southeast shore are sand bluffs which afford good building sites and provide excellent bathing facilities. The lake is regular in outline, being almost circular, covering an area of somewhat more than one-fourth square mile.

Tributary streams entering the lake from the northwest and northeast provide drainage for a considerable territory lying to the north and west. An eastern prong of this latter stream has its source just northeast of Tallahassee. During seasons of heavy rainfall when the lake becomes full, the overflow escapes through the stream on the northeast and flows into Lake Munson, about two and one-half miles south and east. From Lake Munson outlet is found through a surface stream on the south about one mile in length. At this point the stream sinks and makes its way underground, except at such times as the volume of escape is greater than the capacity of intake of the sink, when the flow is overland. The escape of the underground flow is presumably to Wakulla Spring, the natural outlet of the underground waters from the territory to the north. The lake is of moderate depth, averaging 12 to 15 feet, with probably some deeper places.

ORCHARD POND.

Orchard Pond is one of the small lakes in the northwestern part of Leon County. It is a moderately deep lake, having a depth of as much at least as 25 feet. The outlet of the lake is to the Ocklocknee River, although at the present time the lake has a surface overflow only at times of high water. The water level in this lake is about 111 feet above sea, while the uplands around the lake rise to an elevation in excess of 200 feet.

GENERAL CONSIDERATIONS.

DIRECTION AND COURSE OF STREAMS.

With regard to drainage, one of the striking features in this area is the prevailingly northeast to southwest course of the principal streams. The Ocklocknee, St. Marks and Aucilla rivers are approximately parallel, flowing from the northeast to the southwest. Why these streams should have taken this course is unexplained, unless possibly they follow minor original troughs or synclines, which seems possible. The course of the Ocklocknee in particular suggests that it may have flowed along the west side of a northeast southwest ridge until passing around the point of the ridge, when it turned southeast to the Gulf. This suggested structure, as indicated by the course of the streams, has not been sufficiently established from the surface exposures of the rocks.

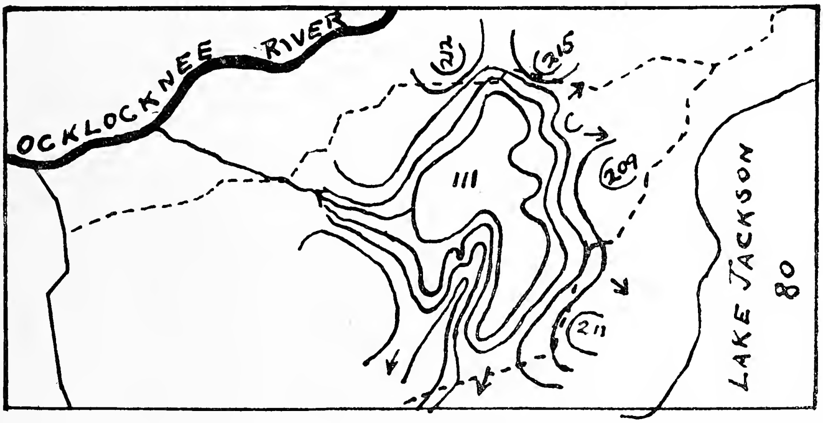


Fig. 8.—Topography around Orchard pond. Surface level of the lake 111 feet. Contour lines at 25 foot intervals.

A second striking feature about the drainage is the fact that practically all tributaries to the main stream enter from the west or northwest side. The direction of flow of tributary streams being from the northwest to the southeast. Few or no tributaries of any considerable size enter the stream from the east side. This fact is readily understood. The minor streams follow the dip of the formations, which in the main is to the southeast. Not only do the surface streams follow and flow with the dip, but the ground water likewise probably follows the dip of the formations. Many of the small streams originate in spring heads. The migration of these spring heads is more rapid to the northwest or up the dip, which thus accounts for the greater length of the tributary streams on the northwest side of the main streams. It is owing to these conditions that tributaries of the St. Marks and Wakulla Rivers reach to within a mile or so of the Ocklocknee River, while tributaries of the Ocklocknee in turn reach to within a few miles of the Apalachicola farther to the west. The drainage divide of the Ocklocknee on the east side is for the most part within one mile or so of the stream.

Another feature closely related to that just mentioned is the fact that as a rule the land lying directly to the east of each main stream is higher than that of the west, or the rise to high land on the east side is more abrupt than on the west or northwest side. Thus the slope to the Ocklocknee River in Gadsden County is as a rule very gradual, while on the east side of the river the rise to high or relatively high land is much more abrupt. This applies also, although possibly not in quite so marked a degree, to the Aucilla River, and is very pronounced for the Apalachicola River. This feature of the stream development is possibly accounted for by the fact that the prevailing dip is to the south or southeast, while the course of the stream is southwest. Under these conditions the streams tend to shift to the southeast. Also from the fact that there are few mostly small tributaries from the east side, it follows that the land surface to the east is much more slowly reduced in elevation by surface wash than is that on the west side. The suggestion that these streams with high lands to the east may lie in faults naturally presents itself. In the structure, however, presence of faults has not been found, and there seems to exist scarcely more than obscure indications of minor possible interruptions in the dip.

TOPOGRAPHIC FEATURES.

Another feature that can not fail to attract attention is the very pronounced differences in the topography directly east and that west of the Ocklocknee River. East of the river in Leon County are found many lakes and lake basins and topographic details controlled by solution, while the drainage is chiefly by underground streams. West of the river, on the other hand, lakes and lake basins are wanting and drainage is by surface streams. The plateau level west of the Ocklocknee is about 250 feet above sea. East of the river the maximum elevation is probably about 240 feet, a difference that can not of itself account for the pronounced differ-

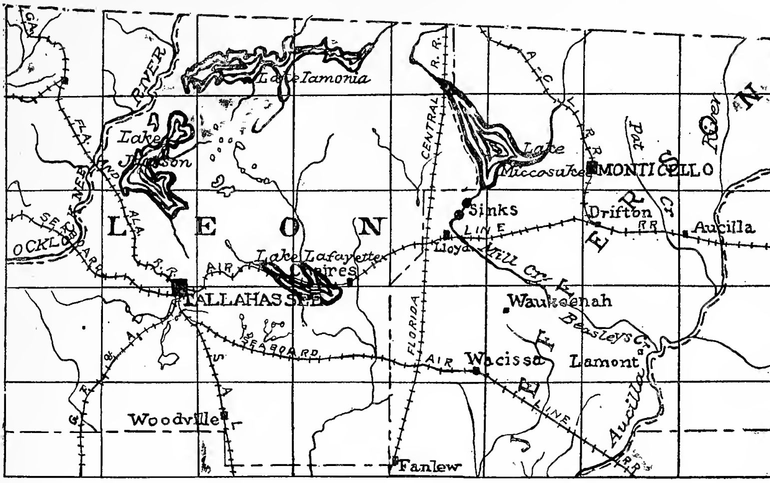


Fig. 9.—Sketch map to show the location of Iamonia, Jackson, Lafayette and Miccosukee solution basins, all of which at the present stage of development are shallow-water lakes. Scale of map: 1 inch equals 12 miles.

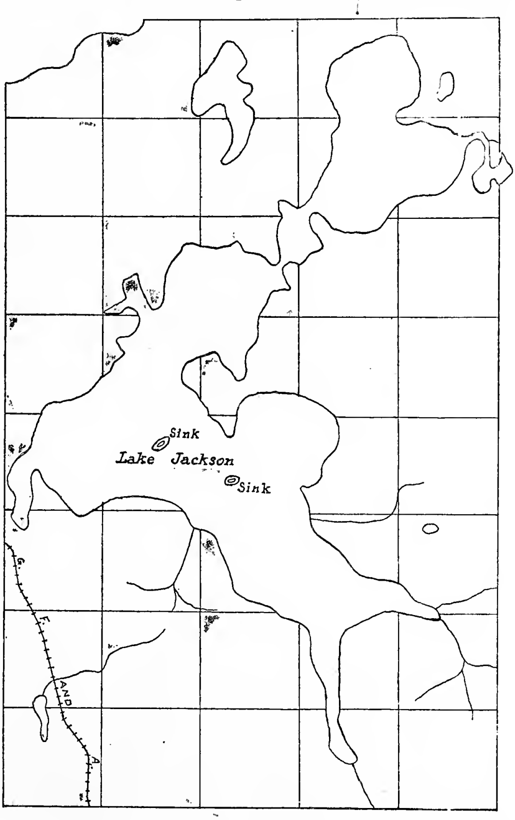


Fig. 10.—Sketch map of Lake Jackson. Scale of map: 1 inch equals 1 mile.

ences in topography. One may assume that east of the Ocklocknee River is a structural ridge which brings the limestone somewhat nearer the surface, and that it is the approach of the limestone to the surface that accounts for the differences in the topography. There is at present, however, no sufficient proof that such is the case. Another explanation seems possible, and that is the nearer approach to the Gulf Coast east of the Ocklocknee. From the Gulf inland in this limestone country the land surface is being lowered by the combined influence of surface erosion and underground solution. For some miles inland from the Gulf the land surface has been practically leveled. Farther inland is a belt in which the land surface has been but partly lowered, the basins representing the areas that have approached base level.

If the rock structure conformed to the present Gulf margin, the lake region belt or belt of present active erosion should parallel the coast. The coast line, however, from St. Marks bends abruptly to the southwest and thus falls back from the limestone rock substructure which extends northwest from Peninsular Florida.

STREAM DEVELOPMENT.

The stream basins as well as the lake basins have a progressive development. If it is true that the Alum Bluff formation, consisting of sands and clays, formerly extended as an uninterrupted and unbroken sheet across this whole area, of which apparently there is no reasonable doubt, it follows that the streams first developed were not streams flowing on or in the limestone, but on the contrary were surface streams flowing across the sand and clay deposits, and were similar perhaps to the surface streams of Gadsden County at the present time. At a later stage in development the stream, having lowered its channel in places to the limestone, becomes in part a subterranean stream, and most of the streams of this area at the present time are in part substerranean. At a late stage in development the streams will again be surface streams flowing through channels lying in the limestone. The lower courses of the Wakulla, St. Marks and Aucilla rivers have all reached this late stage of development in which the stream flows in the limestone. The middle part of the drainage system of the Wakulla and St. Marks rivers illustrate the development of the substerranean streams. In this stage natural bridges of limestone above the stream channel are numerous, and the progressive change from a subterranean to an open surface stream is seen in the occasional falling in of the overlying rock. The early stage in the stream development is illustrated by the headwater tributaries of all of the drainage basins. The smaller tributaries are surface streams which later become for a part of their course subterranean streams.

THE ST. MARKS DRAINAGE SYSTEM.

The course of development of a drainage system under the conditions which are found in this area are well shown by the St. Marks River. This drainage system, with little doubt, formerly extended directly across Florida in a north-east south-west direction. Its tributaries passing through the present Miccosukee and Lafayette basins. In this stage of its development this drainage system consisted wholly of surface flowing streams, no part, except possibly near the coast, touching the limestone or flowing into it. Subsequently the channels of the streams were lowered to or nearly to the limestone and through the formation of sinks the streams were diverted into substerranean courses. In figure 11 is given a sketch of the St. Marks drainage system as it may have existed at a comparatively early stage, before being diverted chiefly to a subterranean course. In figure 12 is given a sketch of this drainage system at the present time, when a large part of the drainage passing into Miccosukee, Lafayette and other smaller basins becomes subterranean. A late stage in the development of this system would show the streams again surface streams, although flowing at a lower level than the present land surface.

Numerous other streams serve to illustrate stages in development from surface to subterranean streams and from subterranean again to surface streams. The Aucilla River is chiefly an open channel stream lying at the limestone level, although some natural bridges yet remain. Wacissa River is likewise chiefly an open channel stream to its head at the Wacissa Springs. Pin Hook Creek in Jefferson County is an open stream for a short distance from the coast, beyond which its course at the present stage of development is marked by a succession of sinks and rises.

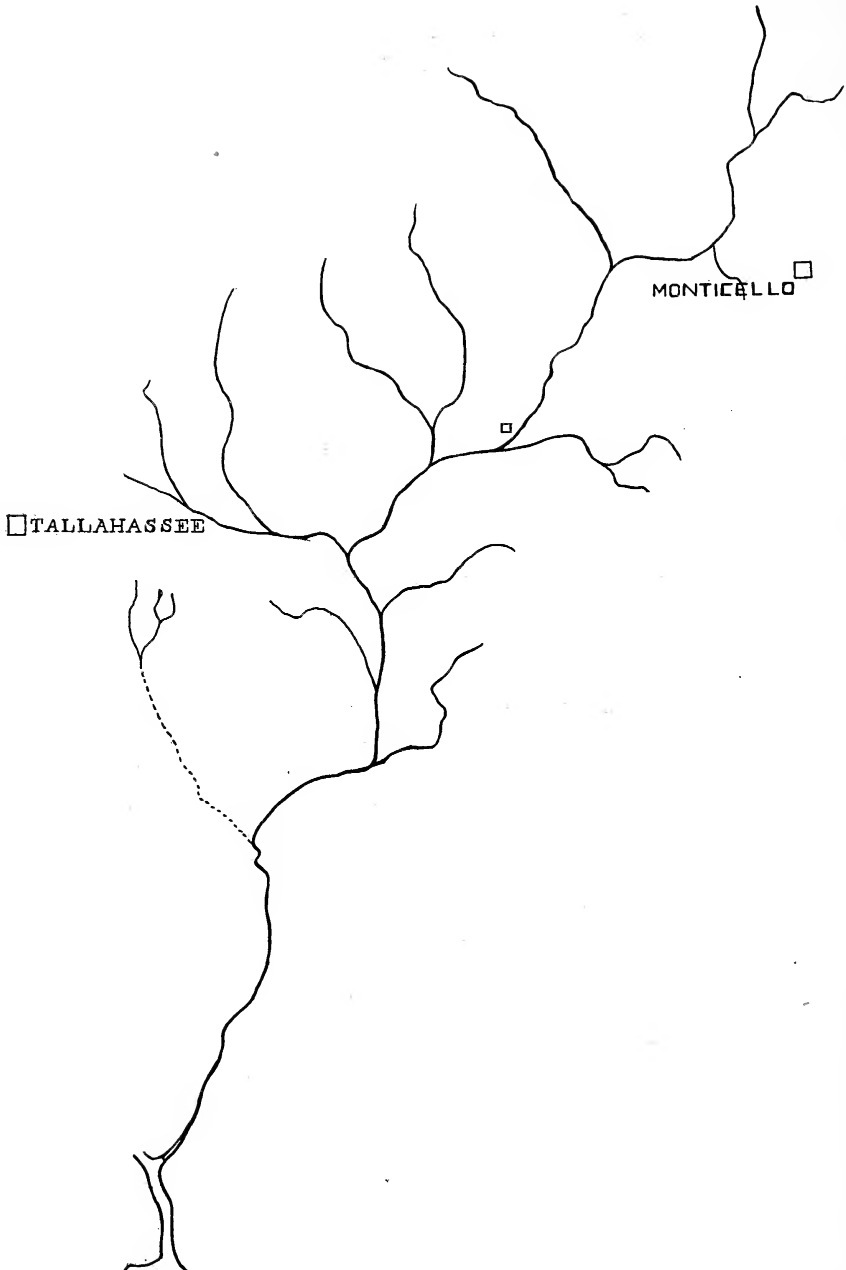


Fig 11.—The St. Marks drainage system, reconstructed as it may have existed at an earlier stage, all streams being surface streams.

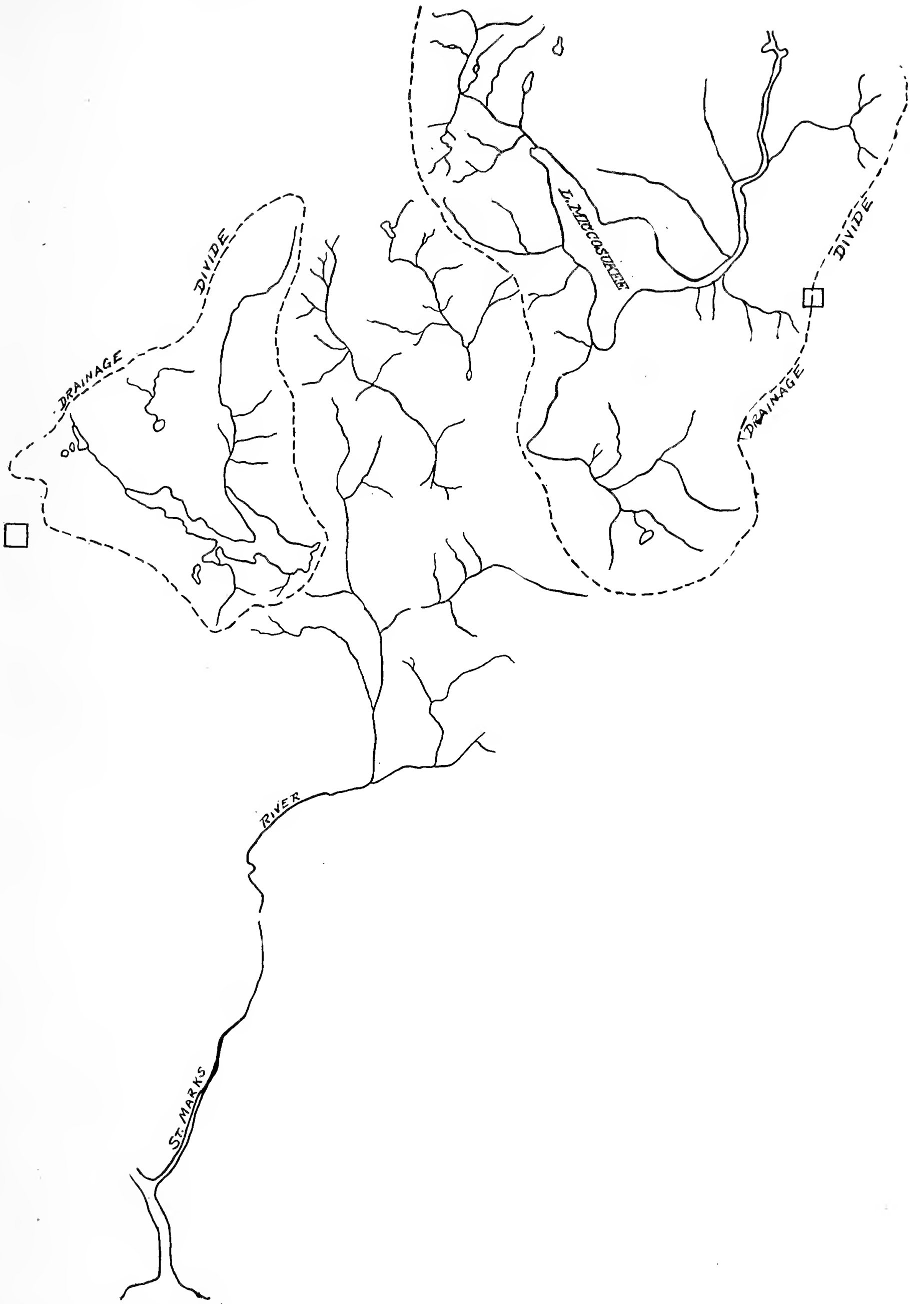


Fig. 12.—The St. Marks drainage system as it exists at the present time, a considerable part of the drainage near the headwaters of the system being subterranean, passing into the limestone through Miccosukee and Iamonia and other basins. In the lower part of its course the stream flows in an open channel in the limestone.

WAKULLA RIVER.

The Wakulla River was probably originally a tributary of the St. Marks River, although at the present time the two streams unite at tidewater level. The Wakulla River system originates in small surface streams which reach north-west to within one or two miles of the Ocklocknee River in Leon County. These tributaries flow as surface streams in a general south-east direction until they reach the

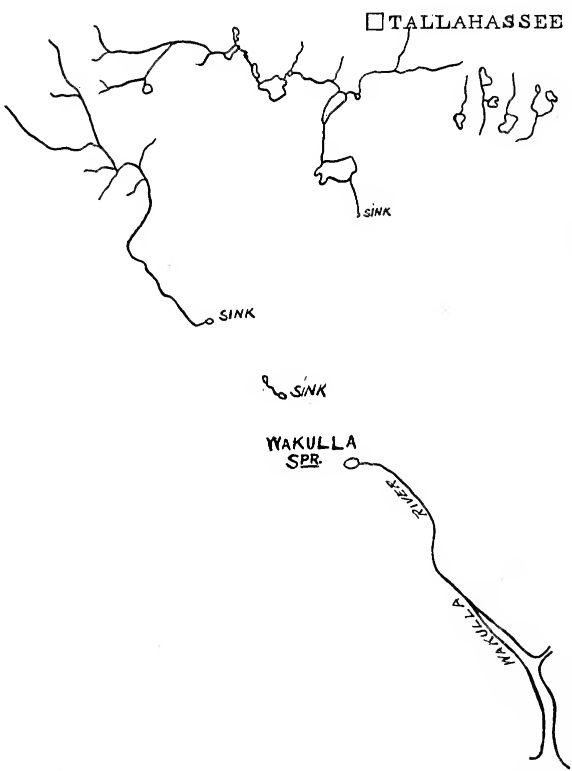


Fig. 13.—Sketch map of the Wakulla drainage system. The headwater streams are surface streams, but become subterranean on reaching the limestone. Nearer the coast the stream reappears as a surface stream with channel in the limestone.

limestone area, when they become subterranean streams entering the limestone through sinks. After entering the limestone they may occasionally be seen owing to the caving of the roof above

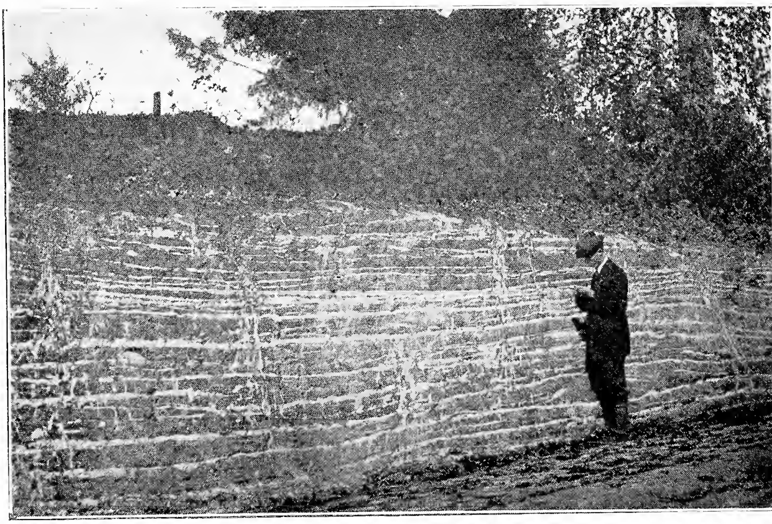


Fig. 1. Cut in public road one mile north of Thomas City, Jefferson County, showing laminated deposits referred to the Alum Bluff formation.

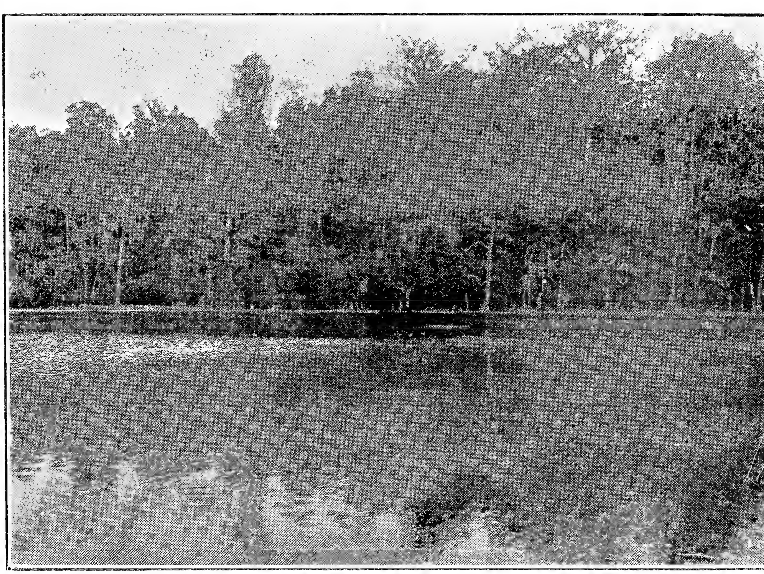
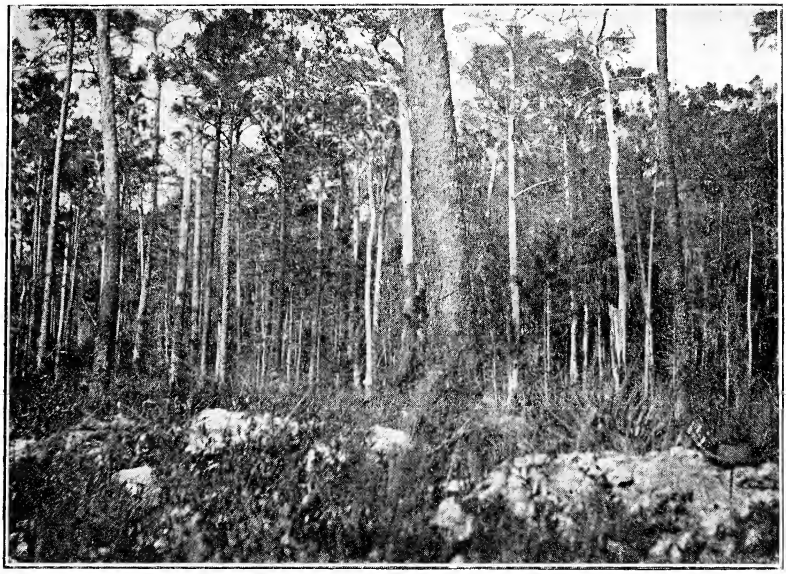


Fig. 2. Wakulla Springs in Wakulla County.

EXPLANATION OF PLATE 7.

Fig. 1. Flint rocks at the surface in the "Pin Hook" section of Jefferson County. These rocks as well as the similar limestone and flint rocks of Wakulla County are residual. Owing to their resistance to eroding agencies they have been left at the surface while the softer rocks have been removed.

Fig. 2. Wacissa Springs in Jefferson County



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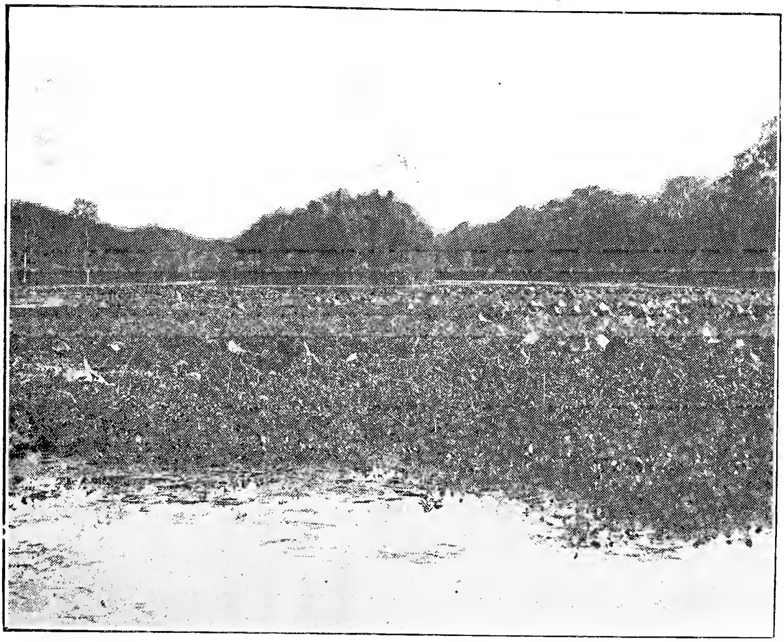

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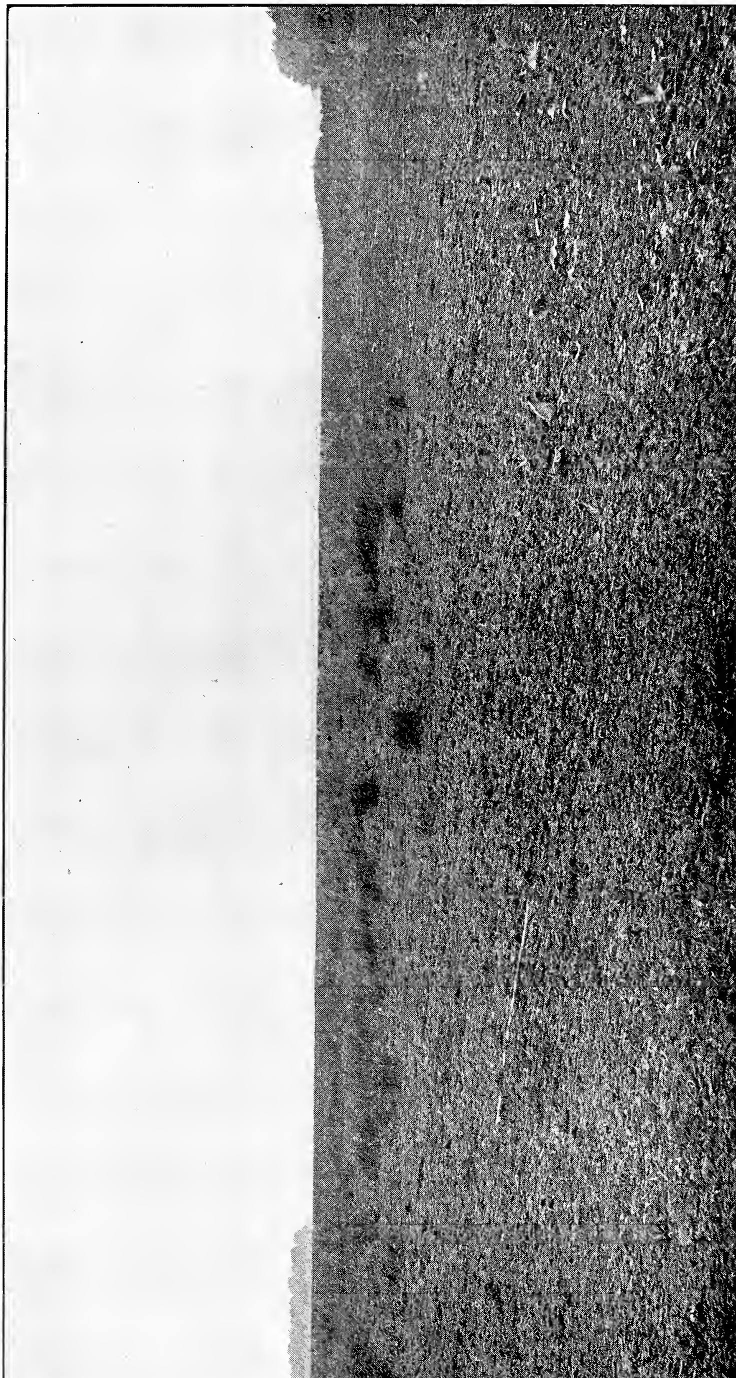

Miccosukee Basin low water stage, 1909, showing level floor of basin.

them. One such view of the stream making its way underground is to be had at what is known as the River Sinks in Wakulla County. These underground streams make their way, as we may believe, in a general southeast direction and re-emerge, in part at least, to form the great Wakulla Spring, and from that place continue as an open surface stream to the Gulf. The subsequent history of Wakulla River may be readily inferred. If the natural development of the stream is not interfered with, the open channel through the limestone will be extended to the northwest and ultimately, as in the case of the St. Marks River, the stream will lie throughout its whole course in the limestone.

PHYSIOGRAPHIC FEATURES.

It has been stated in the earlier pages of this report that the large lake basins of this area, of which Miccosukee, Iamonia, Jackson and Lafayette are examples, have been formed by the gradual processes of solution of limestone and disintegration of the overlying sands and clays, attended by subsidence and to some extent by surface wash. The sinkholes which form in and around the lake-basins vary in depth, some of them extending when first formed much below the level of the floor of the basin. The sink which receives water from Lafayette basin at the present time is 75 feet deep, while that of Lake Iamonia extends as much as 50 feet below the lake level. It is probable that in the history of development of the basins many such sinks have formed and subsequently refilled. The land surface is lowered chiefly by subsidence to a given level, while all sink-holes that extend below this level are subsequently refilled. The controlling agency in determining the level at which the plane of the bottom of the basin is formed is with little doubt the ground water level of the formation in which the basin lies.* So nearly is the plane of the lake basin at ground water level that while the basin usually is a shallow water lake in normal or rainy years, it is dry or nearly so in periods of unusual drought. The drainage sinks retain water continuously, and usually maintain their

*In reports previously published by the Survey, the writer has described the lake basins of the State, including a discussion of the relation of the lake basins to the ground water table, and the description of Iamonia, Jackson, Miccosukee and Lafayette basins in the present report is taken largely from the earlier report, which is no longer available for distribution, the supply being exhausted.

connection with the ground water table. Hence fluctuation in water level in the lakes represents at least in a measure actual fluctuation in the water table, although temporary obstruction in sinks may for a time disconnect the basin from the ground water and for a time the lake level may be independent of the ground water level. However, connection between the lake and the ground water in these large basins is the normal condition under which the basin has been developed.

That there is a relation between the ground water table and the plane of the basin is further supported by the actual level at which each basin has been formed. In passing inland from the coast the water table rises gradually, as may be shown by well records. Lake Lafayette, which is about 25 miles from the coast and is the nearest of the present large basins to the coast, has formed a plane at approximately 40 feet above sea level. Lake Jackson, which is somewhat farther inland, has formed a basin at an elevation of about 75 feet above sea level. The plane of Miccosukee basin is probably between 75 and 85 feet above sea level, while that of Lake Iamonia, which is the farthest north of the large basins, lies about 90 feet above sea level. It is thus seen that the nearer the basin lies to the Gulf Coast in this area the lower the level at which the plane or floor of the basin is formed, and that the basin lies close to the water table level, probably ordinarily somewhat above that level. With regard to the water table the basins are at or near base level.

In considering the history of these basins through geologic time it is well to bear in mind that the water table itself is subject to progressive change. As the stream channels are lowered the ground water outlet is likewise lowered and the course of flow of the water to the ocean becomes more direct, and hence the water table is lowered owing to reduced friction of flow of the water.

The whole time interval available during which the physiographic changes in this area have taken place is probably that from the close of the Lower Miocene to the present. Over the northern part of Leon and Jefferson counties where the largest of these basins are found there seems to be no good evidence of the presence of formations later than the Alum Bluff formation, which as shown by its vertebrate fossils is of Lower Miocene age.*

*Fossil Vertebrates from Florida: A new Miocene fauna; new Pliocene species; the Pleistocene fauna, by E. H. Sellards. Florida Geol. Survey, 8th Ann. Rpt. p. 91, 1916.

The progressive changes in the basins and in the drainage systems that have been described indicate progressive physiographic development. From the Gulf inland the land surface is being gradually lowered to base level. This process is more rapid where limestones lie near the surface than where there is no limestone or where the limestone lies deeply buried beneath other formations. Near the Gulf Coast the limestone country of this area has been reduced practically to base level and the streams have become surface streams flowing in the limestone. Farther inland base level has been reached only in limited areas in which have been developed the large basins, several of which have been described. The large area that has been base leveled probably was reduced in elevation through the same processes that are now active farther inland. The continuation of these processes in the future must result in the gradual lowering of the land surface in the present lake region of Leon and Jefferson counties until the whole area becomes a plane at base level when the location of the present basins will have become obscure and the basins as such obliterated, as others probably have formed and disappeared in the at present level areas nearer the coast.

At page 100 of this report is inserted a map showing contour lines and indicating the location of basins and plateaus. From this map may be seen the progress of topographic and physiographic development. The land in the south-eastern part of this area has been reduced to an approximately uniform level, while to the south-west where the limestones pass below the surface the land has been but little affected by erosion. In the northern part of the area is found a maximum of topographic diversity for this area, the basins having been carried essentially to base level, while in places the plateau still retains its original height.

SUPPLEMENT TO STUDIES IN THE PLEISTOCENE AT VERO, FLORIDA

E. H. SELLARDS

After the papers in this volume relating to the Pleistocene at Vero, Florida, were printed, but before they were distributed, three additional papers on this general subject appeared in the Journal of Geology. The papers referred to, which may be added to the bibliography given on page 69 of this report, include the following:

Note on the Deposits Containing Human Remains and Artifacts at Vero, Florida, by E. H. Sellards, Journal of Geology, vol. 25, pp. 659-660, October-November, 1917.

The Fossil Plants from Vero, Florida, by Edward W. Berry, Journal of Geology, vol. 25, pp. 661-666, October-November, 1917.

Further Studies at Vero, Florida, by Rollin T. Chamberlin, Journal of Geology, vol. 25, pp. 667-683, October-November, 1917.

The paper by Dr. Berry is an abstract from the paper on fossil plants at Vero, which is published in full in the present volume (pp. 19-33). The brief note by the writer is also included in substance in this report (pp. 69-82). The paper by Dr. Chamberlin contains an important modification of the hypothesis previously proposed by him, and in addition there is proposed a new hypothesis of the origin of certain of the fossils of the deposits. This contribution is based on observations made at Vero in March, 1917, at the time of Dr. Chamberlin's second visit to the locality.

It will be recalled that the essential features in which Dr. Chamberlin's former hypothesis differs from the views held by the writer are that the extinct vertebrates of the stream bed are secondary and not primary, and hence are not diagnostic of the age of the beds in which they are found. The assumed source of the fossils is an older formation lying farther inland. In the present paper he abandons this hypothesis of fossils washed from farther inland, so far at least as it has any practical or immediate application to the problem in hand, and concedes that the fossils of the lower part of the stream bed are essentially if not altogether primary. On the other hand, he holds to the idea that the deposits of the stream bed include two time divisions as was originally suggested by the present writer, and in addition now maintains that the human remains are confined to the upper of the two divisions which he believes to be of mid-Recent age. The extinct species of this fauna he regards as characterizing the lower of the two divisions of the stream deposit and assumes that those extinct species which are found with the human remains and artifacts in the upper deposit of the stream bed, or at least most of them, are inclusions from the lower bed. In other words, while the fossil vertebrates of the lower stream bed are now recognized by him as primary, the extinct species of the upper bed are held to be secondary.

The second hypothesis offered by Chamberlin is equally as untenable, the writer believes, as the first offered by him. The essential assumption of the first hypothesis, that the vertebrate fossils had washed from farther inland, fails to stand the test of field investigation, and the essential contention of the second hypothesis, that the extinct species found in stratum No. 3 of the stream deposit are secondary, is dispelled by evidence already at hand. The evidence as to the age of the deposits derived from the study of the fossil plants, although published in the same issue of the Journal of Geology as his own paper, was not, as the writer understands, available to Dr. Chamberlin at the time his paper was prepared. This evidence from the fossil plants, which is presented in full in the present report, as well as in abstract in the Journal, leads to the conclusion that stratum No. 3 of the section in the stream bed is of Pleistocene age. The association of the plants with the human remains and artifacts is intimate, and there is no question as to their place in the section. In addition, much new evidence has been added from the study of the vertebrate fossils. Among new mammalian species is the extinct deer which has now been fully described by Dr. O. P. Hay (this volume, pp. 50-57). This deer is one of the abundant fossils of stratum No. 3, its bones being found not only in such abundance, but also in such association of parts as to preclude any reasonable doubt that they are primary fossils in this stratum. The evidence from the mammals, however, is by no means confined to this one species, but includes that of the various other species that have been described from this deposit. Nor is the evidence among vertebrate fossils confined to the mammals. The bird bones, among which are found representatives of two species believed to be extinct, become distinctly more numerous in stratum No. 3. To assume that well preserved bird bones are secondary, especially when found more abundantly than in the deposits from which they are supposed to have been derived, is contrary both to expectation and to experience in the field. The progress of collecting has brought to light successive additional specimens of the extinct turtles of this deposit, either in the form of undisturbed carapaces or of bones associated in such a way as to indicate primary fossils.

Dr. Chamberlin's second hypothesis involves referring all the human remains found to stratum No. 3. The position of the human bones first discovered has been fully described. They lay beneath a heavy ledge of fresh water marl, which is now believed to be the equivalent of stratum No. 3. Their position is in the brown sands, which are believed to represent stratum No. 2. This ledge of rock itself, as noted, contains at least one extinct vertebrate species (p. 81). Some of the bones from the second locality at which human bones were found, which were collected by the writer, seem certainly to come from the brown sands of stratum No. 2. One of the flint spalls likewise was found in place and was very definitely in the light brown sand of stratum No. 2. All of this, however, has been fully recorded and indicates, the writer believes, that stratum No. 2 contains human bones and artifacts. The accumulated evidence that stratum No. 3 in which human remains and artifacts are so abundant is itself of the Pleistocene period, adds materially to the probability that the human remains extend, as the recorded discoveries indicate, through the deposit as a whole.

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