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VOL. 135

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN"—JAMES SMITHSON

(PUBLICATION 4386)

CITY OF WASHINGTON
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LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 135, NUMBER 1

THE CUSTOMS AND RELIGION OF THE CH'IANG

(With 16 Plates)

By
DAVID CROCKETT GRAHAM

(Publication 4300)

CITY OF WASHINGTON
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PREFACE

In the summer of 1925 the writer went on a collecting expedition for the Smithsonian Institution to Sung-p'an 松潘 and the Yellow Dragon Gorge. On the way to and from Sung-p'an he passed through Wen-ch'uan 汶川, Wei-chou 威州, Mao-chou 茂州, and Tieh-ch'i 疊溪, which are in the Ch'iang region, and on the return trip he also visited Kuan-chai 官寨, which is the center of the Wa-ssŭ 瓦司 people. He met a few of the Ch'iang people 羌人, and took pictures of them.

During the summer of 1933 the writer spent his summer vacation among the Ch'iang people, collecting natural history specimens for the Smithsonian Institution. Among the Ch'iang villages that he visited were K'a-ku, O-erh, Lung-ch'i-chai 龍溪寨, Tung-men-wai 東門外, T'ao-tzŭ-p'ing 桃子坪, and also Tsa-ku-nao 雜谷腦 in the country of the Chia-jung 嘉戎, and T'ung-lin-shan, the home of the hereditary ruler of the Wa-ssŭ. He witnessed the Ch'iang social dances at Chiu-tzŭ-t'eng, visited many Ch'iang homes, temples, sacred groves, and shrines, took notes and pictures, and collected their artifacts for the West China Union University Museum.

In the summer of 1941 the National Ministry of Education of China and the Border Service Bureau of the Church of Christ in China sent a group of 70 university students and professors to the borderland for social service and research. It was the good fortune of the writer to be included. With Mr. Ch'in Hsüeh-sheng 秦學聖, a student of the West China Union University, he was sent to the Min River valley to study the Miao who were supposed to be there. Finding that there were no Miao in that region, he turned to the study of the Ch'iang, visiting Mao-chou, Li-fan 理番, Wei-chou, Wen-ch'uan, K'a-ku, Mu-shang-chi, Lung-ch'i-chai, Tung-men-wai, T'ao-tzŭ-p'ing, Ta-ho-p'ing-chai 大和平寨, Ts'a-to, Ts'a-to-kou, and T'ung-lin-shan.

The following summer the writer was sent for further research among the Ch'iang by the Border Service Bureau of the Church of Christ in China. In addition to the places already mentioned he visited P'u-wa, P'u-ch'i-kou, P'u-ch'i-chai, Chia-shan-chai, Hsi-shan-chai, and Lo-pu-chai. Between 1933 and 1948 he made a number of shorter trips to the Ch'iang region, and in addition brought several Ch'iang men to Chengtu, where for weeks at a time they assisted him in his study. It was his privilege several times to witness the Ch'iang ceremonies of exorcism, and twice by special arrangement the great ceremonies performed in the sacred groves. Ch'iang folksongs, incantations, vocabularies, and the sacred chants that are regarded as sacred books were first written down in Chinese or in the International Phonetic Script and later translated into English. In China and in the United States old Chinese histories have been searched for references to the Ch'iang, and recent publications for descriptions of these people and their customs by modern Chinese scholars.

There is no information available as to the changes that may have taken place among the Ch'iang since China was "liberated" by the Communists. In this publication the customs and religion of the Ch'iang are described in the present tense, which means that these conditions prevailed up to the summer of 1948 when the writer last had contacts with the Ch'iang people.

The writer is indebted to Lin Min-chün, formerly assistant curator of the West China Union University Museum; to Dr. Cheng Teh-k'un, who succeeded the writer as curator of that museum; to Prof. Wen Yu, noted linguist and author, and in the United States to T. C. Hu and to Fred C. Hung, post-graduate students in the University of Washington, and W. S. Kow, a graduate of the University of Denver. He is especially indebted to the John Simon Guggenheim Memorial Foundation for the fellowship that made possible the final completion of these studies, and for a generous financial grant which made possible this publication. Prof. George A. Kennedy, of Yale University, and the editors of the Smithsonian Institution have also given helpful suggestions and made needed corrections.

PHONETIC TABLE

CONSONANTS

b	as in bite.
d	as in dig.
dʒ	as in judge, but without aspiration.
f	as in fat.
g	as in go.
G	is an uvular g.
Ŋ	is ng as in King.
h	as in hat.
X	is rough h as in the Scotch word *loch* and the German word *nach*.
j	is y as in young.
k	as in kind.
l	as in law.
l̥l	is the Welsh double l plus l.
ṁ	as in man.
n	as in new.
ɲ	as ni in onion.
ɱ	is m pronounced similar to the n above.
p	as in pin.
ɹ	is the ordinary fricative untrilled r, the initial r of southern English and American speech.
s	as in sit.
ʃ	as in shut.
T	is dental t.
t	as in tin.
ts	as in hats.
tʃ	as in child, weakly aspirated.
tʃ'	as in child, strongly aspirated.
v	as in vow.
ʒ	is the French j bordering on the English fricative r. Sometimes there is a slight uvular r sound following this ʒ.
ʒ̊	is the strong palatalized French j.
w	as in wit.
'	is used to indicate a strong aspirate.
¿	is a rare sound designated here by the inverted question mark. For this consonant, the mouth is opened wide, and the same sound is made as when gargling deep in the throat. It is generally followed by the vowels a·, ɛ, and ʌ.
ẟ	is a consonant closely resembling the internal sound in bird.

VOWELS

a·	as in shah or ah.
ae	as in hat.
ã	is nasal a.

i	as in pique.
i·	as in imp.
ε	as in end.
ɔ	as in hot. The mouth is opened slightly wider than in a.
ɔ·	as in haul.
u	as in put.
u·	as in pool.
o·	as pure close long o.
ʌ	as in nut.
y	is umlaut u (ü) as in the German language.
ə	is inverted e, and very slightly resembles the French mute e. It is sometimes written ĭ in the romanization of Chinese sounds.
õ	is nasal o.
ai	is like i in bite.
ao	is like ow in how with a pure o ending.
au	is like ow in how with an open u ending.
ei	as in eight.
ou	is o in go with a u ending.
ʌu	is like the Chinese ou (Wade) or eo in the romanization of the China Inland Mission.

CONTENTS

THE CUSTOMS AND RELIGION OF THE CH'IANG

By DAVID CROCKETT GRAHAM

(With 16 Plates)

I. INTRODUCTION

1. THE COUNTRY

The Ch'iang people of western Szechwan inhabit the region along the T'o or Tsa-ku-nao and the Min Rivers, between Tieh-ch'i on the north and So-ch'iao on the south, and from points just to the east of Mao-chou, Wei-chou, and Wen-ch'uan to P'u-ch'i-kou, which is 20 *li* west of Li-fan. This country lies between the 31st and 32d degrees latitude and the 103d and 104th degrees longitude. Formerly the Ch'iang extended southward as far as Yüeh-sui 越嶲 and northward into Kansu and Shensi. The principal cities are Li-fan, Mao-chou, Wei-chou, and Wen-ch'uan, and these and the numerous villages along the highways in the valleys are inhabited by the Chinese.

The valleys of the rivers and streams are narrow, and the mountains high and steep. Altitudes vary from less than 5,000 to over 18,000 feet above sea level. There are extensive loess deposits, and these and other kinds of soil have been terraced for convenience in farming. Maize is the main crop up to 8,000 feet, and above that up to 10,000 feet buckwheat can be raised. Forests begin at 9,000 feet, and from 10,000 to 12,000 feet is the realm of the great forests. Above that are the grasslands and the sources of medicinal herbs. The snow line begins at 18,000 feet, and above that is perpetual snow.[1]

Among the Ch'iang there are few trees and little underbrush below the altitude of 9,000 feet, owing to the activities of woodgatherers and to the pasturing of sheep and goats. The forests on the high mountains are the sources of fuel and of lumber. There is no coal in this region, and the coal of Kuan-hsien is considered too far away to be carried by men or pack animals over the mountainous roads.

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[1] Report on research in western Szechwan, The Chinese Ministry of Education, p. 56, 1943.
川西調査記　　教育部蒙藏教育司編.

The Ch'iang live in the Temperate Zone, and it is estimated that there is a variation of 3 degrees Farenheit for every 1,000 feet in altitude. While the rainfall in central Szechwan is abundant, even as far west as Ya-chou and Kuan-hsien, the climate in the Ch'iang region is semiarid, with occasional droughts. This is because the high mountains serve as watersheds. It is reported that there is more rainfall in the higher altitudes where the mountains are covered with forests than in the lower altitudes that are under cultivation.

The sides of the mountains are generally steep, with plenty of rocks and cliffs. The rivers and streams are so swift that ferryboats are not used. Even in the smaller streams men or women are sometimes drowned when trying to wade across. There are droughts and floods. In the forests are wild animals that sometimes attack human beings, the domestic animals, and the crops. People fall over the steep cliffs. Thunder reverberates through the mountains and valleys, and lightning strikes and kills man or beast. Earthquakes shake down houses and cliffs. In 1933 the writer witnessed an earthquake that sent innumerable rocks rolling down mountainsides, shook down many cliffs, and completely destroyed the city of Tieh-ch'i, killing all the people who were in it at the time. Rolling rocks are an almost constant danger, and at Tung-men-wai in 1941 the writer saw a stone house the upper wall of which had been smashed in by a large rolling stone. Pestilences decimate the domestic animals and cause sickness and death among the people. Life is a hard struggle against an adverse natural environment.

To the northwest are the Lu-hua and the Hei-shui people. To the west and the southwest are the powerful Chia-jung. To the north and the east, and in the cities and villages in the valleys, are the Chinese, and to the south are the Wa-ssŭ tribespeople who have cooperated with the Chinese in the subjugation of the Ch'iang.

2. HISTORY

References to the Ch'iang on the oracle bones and in Chinese histories are almost innumerable, and they cover, apparently, over 4,000 years of human history. A full account of these would require a large volume, but the writer will mention only such facts and events as he regards as most important and most interesting. The writer can say confidently that he has not found or heard of one reference on the oracle bones or in any Chinese history that would indicate that the ancestors of the Ch'iang of western Szechwan migrated eastward from western Asia, or that they are descendants of the Israelites. On

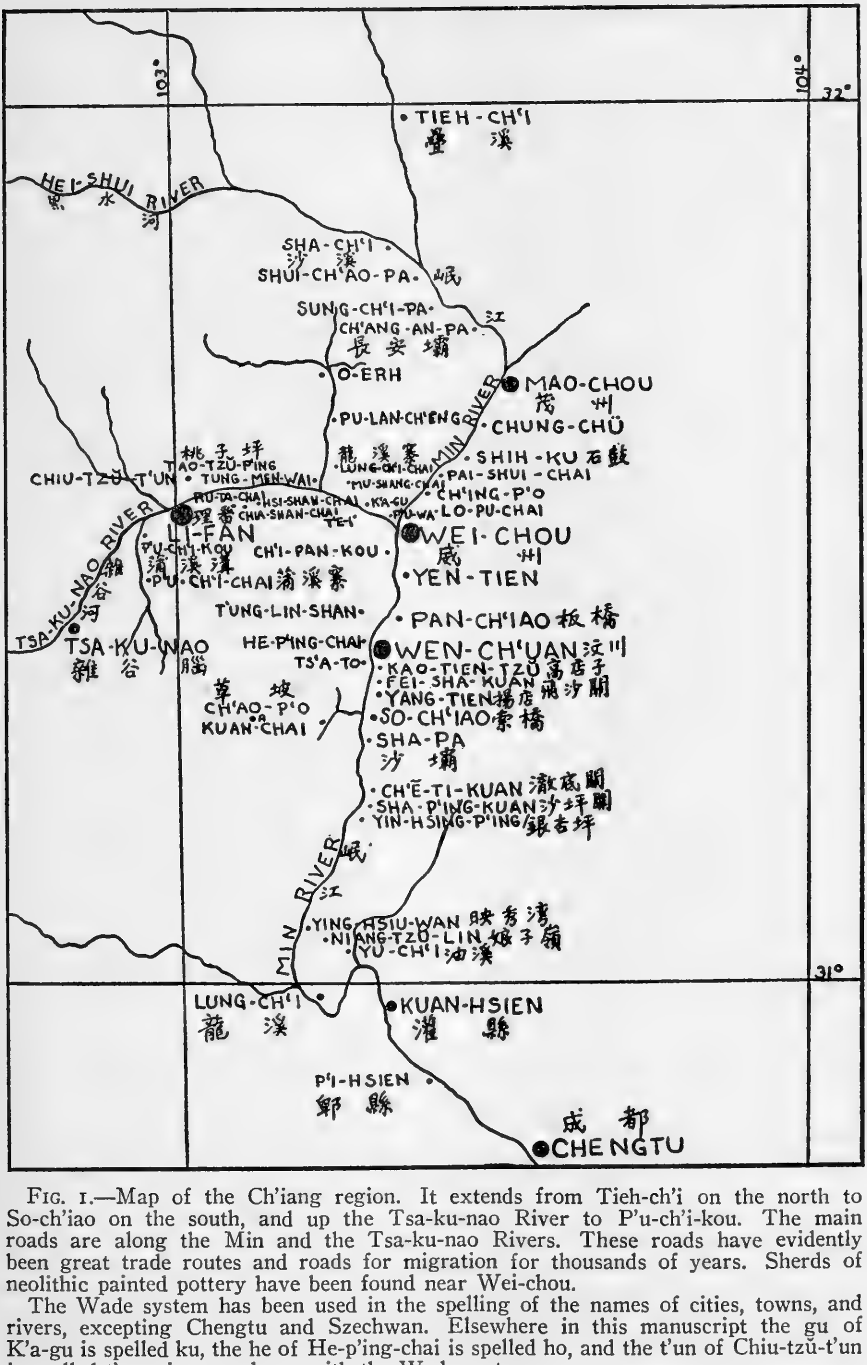

FIG. 1.—Map of the Ch'iang region. It extends from Tieh-ch'i on the north to So-ch'iao on the south, and up the Tsa-ku-nao River to P'u-ch'i-kou. The main roads are along the Min and the Tsa-ku-nao Rivers. These roads have evidently been great trade routes and roads for migration for thousands of years. Sherds of neolithic painted pottery have been found near Wei-chou.

The Wade system has been used in the spelling of the names of cities, towns, and rivers, excepting Chengtu and Szechwan. Elsewhere in this manuscript the gu of K'a-gu is spelled ku, the he of He-p'ing-chai is spelled ho, and the t'un of Chiu-tzŭ-t'un is spelled t'eng, in accordance with the Wade system.

the contrary there is strong evidence that in ancient times they lived in northeast China, and that they migrated westward, some proceeding on into Kansu, and others turning southward into northern and western Szechwan.[2]

In the Shu King, or Book of Historical Documents, it is stated that Shun "drove (the chief of) San-miao (and his people) into San-wei, and kept them there." In a note James Legge explains that "San-miao was the name of a territory embracing the present departments of Wu-khang in Hu-pei, Yo-kau in Hunan, and Kiu-kiang in Kiang-hsi. San-wei was a tract of country around a mountain of the same name in the present department of An-hsi, Kan-su.[3] The Chronological Handbook of the History of China dates this event as 3387 B. C.[4] Chinese histories state that the San-miao were Ch'iang.[5]

During the Shang dynasty the Ch'iang lived west of the Chinese, whose capital was at An-yang. There are many references to the Ch'iang on the oracle bones. The Chinese made military expeditions against them, captured them, used them as slaves, and even sacrificed them to the ancestors and the gods of the Shang people.[6] On the oracle bones the upper part of the character meaning Ch'iang is the horns of a sheep or goat, and means sheep or goat , and the lower part is man . It means people who raise sheep or goats. Today the Chinese word for Ch'iang 羌 consists of the character for sheep or goats above, and that for man below. A third character meaning magic 厶 is sometimes added 羗. The Ch'iang of West China are all farmers, and they depend much on their flocks of sheep and goats.

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[2] Creel, Herrlee Glessner, The birth of China, pp. 213-216. New York, 1937. Ssŭ-ma Ch'ien, Shih Chi. *ch.* 116, No. 56.

Liu Ch'ao-yang, The conquering of the Ch'iang by the Emperor Hsiao I. Studia Serica, vol. 5, 1946.

[3] Sacred Books of the East, edited by Max Müller, vol. 3, The Shu King, book 1, sect. 3, p. 41.

Hou Han Shu, by Fan Yeh, *ch. 77,* Commercial Press, 1932.

[4] Faber, Rev. Ernst, Chronological handbook of the history of China, p. 3.

[5] Hou Han Shu, Hsi Ch'iang chüan, *ch. 77.*

Tung Tso-pin, The Ch'iang and Shu of the Yin dynasty, Shuo-wen Monthly, *ch.* 3, No. 5, Aug. 15, 1942.

董作賓殷代的羌與蜀.

K'ang Hsi Dictionary, A. D. 1716.

Sung-p'an Hsien Chih, *ch.* 3, Frontier Defence, 1927.

松潘縣志卷三邊防.

T'ung Tien *ch.* 189, p. 1013.

通典.

Liu Ch'ao-yang, The conquering of the Ch'iang, Studia Serica, vol. 5, p. 49.

[6] Creel, ibid., pp. 213-210. Ssŭ-ma Ch'ien, Shih Chi, *ch.* 116, No. 56.

At the end of the Shang dynasty the Ch'iang united with the Chou people in a war under Wu Wang 武王, or King Wu, against the Shang people, which resulted in the overthrow of the Shang and the establishment of the Chou dynasty. The Ch'iang took a leading part in this war, a fact that is stated in many Chinese histories.[7] The dramatic and eloquent speech of the Chou leader to his allies at Muh is one of the bits of evidence that the Ch'iang were active participants in that great war. The opening words of that speech are: "And ye, O men of Yung, Shun, Këang, Maou, Wei, Loo, P'ang and Po;—lift up your lances, join your shields, raise your spears:—I have a speech to make." [8] A note on the next page of the same book says, "The country of Shuh was the present dep. of Shingtoo (新都) in Szechwan. West and north from this was the country of the Këang; while that of Maou and Wei was to the east." [9]

The grandmother of the Chou leader who overthrew the Shang dynasty was a Ch'iang woman. After the fall of the Shangs, the Ch'iang leaders were made feudal lords over four states including Ch'i. In 679 B. C., after the power of the Chou kings had greatly weakened, Duke Huan of Ch'i became president of the feudal lords with the power of King. "Thus the descendants of these people, who a few centuries earlier had been hunted down, enslaved, and sacrificed like cattle, came for a time to be rulers of the whole Chinese world." [10]

According to the Hsi-ts'ang T'ung-lan or History of Tibet, in 700 B. C. the western Ch'iang had trade and other relations with the Chinese. They lived in Lung Shan, 龍山, in the valleys of the I and the Lu Rivers, in the present provinces of Shensi and Kansu, and the northern part of Szechwan. The Great Wall was built about 241 B. C. Han Wu Ti, about 130 B. C., caused the western Ch'iang to dwell around the fortresses of the Great Wall. At the time of the Emperor Huai of the Chin dynasty (about A. D. 310) Yao Ch'ang, the son of Yao I Chung of the Ch'ih T'ing Ch'iang, vanquished the Fu Ch'in dynasty and became king. He lived at

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[7] Creel, ibid., chap. 4, sect 2, pp. 215-216.

Li-fan T'ing Chih *ch.* 4, sect. 2, History of the Border.

理番廳志.

Shih Chi, *ch.* 4, sect. 2, Annals of the Chou.

Chung Kuo Min Tsu Shih, chap. 11, The Ch'iang race.

中國民族史 第十章 羌族 呂思勉著 世界書局出版.

Tung Tso-pin, Shuo-wen Monthly, *ch.* 3, No. 7, Aug. 15, 1942.

[8] Legge, James, D.D., The Chinese Classics, vol. 3, pt. 2, pp. 301-302.

Shih Chi, *ch.* 4, Annals of the Chou.

[9] Legge, James, D.D., ibid., p. 302.

[10] Creel, ibid., p. 215.

Ch'ang-an, now Sian of Shensi. After two generations his kingdom was destroyed by Liu Yü.[11]

The histories of Yüeh-sui, and of the Ya-chou prefecture state that formerly some of the Ch'iang lived in the Ya-chou prefecture and southward toward Yüeh-sui.[12] Other histories tell us that they have lived northward in the region of Wen-ch'uan, Wei-chou, Sung-p'an, and northward in Kansu. The history of Yüeh-sui tells of a bloody battle in which thousands of Ch'iang were killed and captured.[13] Numerous were the wars with the Chinese. During the Western Chin dynasty, A. D. 265-313, the Ch'iang became powerful, and Li Hsiung became emperor of Shu or Szechwan.[14] Later Fu Ch'in became emperor of more than half of China, including Chengtu.[14] In A. D. 1441 a Tibetan tribe that assisted the Chinese against the Ch'iang was given lands near Wen-ch'uan, and since these people have been called the Wa-ssŭ tribe.[15] A war near Yüeh-sui in A. D. 1574 was caused by a Chinese official stealing the wife of a Ch'iang leader, but the Ch'iang were defeated and severely punished.[16] Near Tieh-ch'i in 1576 a number of Ch'iang leaders were buried alive.[17] Finally, in the reign of Ch'ien Lung, 乾隆, the Ch'iang took part in a great rebellion, but they were defeated, and have since been unable to dispute the power of the Chinese.[18]

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[11] Hsi-ts'ang T'ung-lan, History of Tibet, vol. 3, sect. 2, *ch.* 1.

西藏通覽.

[12] Ya-chou-fu Chih, vol. 1, Directions to Readers.

雅州府志.

Yüeh-sui T'ing Ch'üan Chih, vol. 6, *ch.* 2.

越嶲廳全志.

[13] Ibid, vol. 6, *ch.* 2.

[14] Hwa Yang Kuo Chih, *ch.* 9, p. 1.

華陽國志.

Chin Shu *ch.* 121, Records, No. 21, p. 1.

晉書.

[15] Wen-ch'uan Hsien Chih.

汶川縣志.

[16] Yüeh-sui T'ing Ch'üan Chih, vol. 6, sect. 2.

越嶲廳全志.

[17] Mao-chou chih, *ch.* 3.

茂州志.

Sung-p'an Hsien Chih, *ch.* 3.

松潘縣志.

[18] Li-fan T'ing Ch'üan Chih, *ch.* 4, p. 40.

理番廳全志.

In the Ch'iang region there have been unearthed in the sides of the loess terraces many tombs that were lined on all sides by slate slabs. They have been named the slate tombs, and at first it was assumed that they were graves of ancient Ch'iang people. In these there have been found, besides the skeletons, ancient bronzes and pottery, and sometimes Chinese coins. The Ch'iang tradition is that until very recent times the Ch'iang buried only by cremation, and that these are the graves of the Koh people, who at first disputed the possession of the land with the Ch'iang. Archeological evidence supports this tradition and dates the tombs at between 500 and 100 B. C.[19]

The following tradition was related to the writer by several Ch'iang men, one of whom was Kou P'in-shan, a Christian leader who was killed by the Communists. Some Ch'iang give the length of the migration as 3 years and 6 months, others as 1 year and 6 months, and still others as 1 year and several months. It was told the writer as given below by Ch'en Chen-shu, who lived above the village of K'a-ku.

Far away and long ago there were two nations, Tzŭ La and Gu La. In a war between them Gu La (the Ch'iang people—Tzŭ La is an old name for China still used by the Japanese) was defeated, and the Ch'iang migrated a long distance, traveling a year and several months before they reached the place where they now live. On the way they crossed a river, using round boats covered on the sides and below with cowskins. One of the boats leaked, and the sacred books got wet. While the books were being dried in the sun, some goats came and ate them. The Ch'iang therefore have no written language, and the contents of the lost books are handed down by word of mouth from generation to generation.

When the Ch'iang reached West China, the Chinese and the *Jung* were at war. The *Jung* were defeated and retreated to Tsa-gu-nao. The Chinese retired to Kuan-hsien, leaving the country between Kuan-hsien and Tsa-gu-nao vacant, and the Ch'iang came in and occupied it. At that time the Ch'iang had sheep and goats and planted wheat but did not have corn. In the reign of Ch'ien Lung (A. D. 1737-1793) the Wa-ssŭ tribe came from Wu Ssŭ Ch'ang in Tibet and helped the Chinese in a war with the Ch'iang that lasted 12 years. There was a great battle at Wei Kwan, where a person can walk from the top of the mountain to the river without being seen by the enemy. The Ch'iang were defeated, and the Wa-ssŭ were given the

[19] Graham, David C., An archaeological find in the Ch'iang region. Journ. West China Border Res. Soc., vol. 15, ser. A, pp. 34-39.

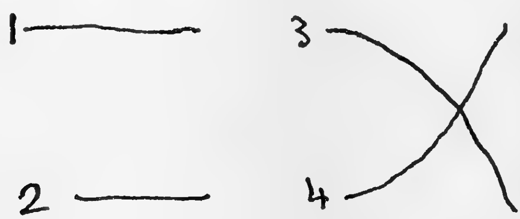
land which they now occupy, between the Ch'iang and the Chinese.[20]

Since there are a number of tribes in Burma that have a similar tradition of the lost sacred books, we seem safe in assuming that this part of the tradition is legendary.

In an article, "The Conquering of the Ch'iang" in Studia Serica, the author states his conclusion that in earlier times the Ch'iang lived farther east, and that they were pushed westward by the Yin Court and later Chinese governments, and that as they were forced westward one branch migrated in Kansu and another turned southward into Szechwan.[21] This seems to agree with historic facts and traditions, and indicates that the Ch'iang of western Szechwan, and probably several other ethnic groups, are descendants of the Ch'iang of ancient times.

3. THE LANGUAGE

The language is monosyllabic and tonal. The number of tones is generally four. According to the numbering of the writer, tone 1 is the high level tone, tone 2 is the low level tone, tone 3 begins high and the voice is lowered as the word is being pronounced, and tone 4 begins low and ascends upward. Tones 3 and 4 occur much less frequently than tones 1 and 2. These tones correspond rather closely to tones 1, 2, 3, and 4 as they occur in the Western Mandarin as spoken by the Chinese of Szechwan Province. Thus:



There is about an octave's difference between the high level tone and the low level tone as pronounced by the Chinese of Szechwan. Among the Ch'iang this difference is not so great. Tone 1 is slightly lower than that of the Chinese, and tone 2 is a trifle higher than the

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[20] Graham, David C., Journ. West China Border Res. Soc., vol. 14, ser. A, pp. 70-71, 1942.

[21] Liu Ch'ao-yang, The conquering of the Ch'iang by the Emperor Hsiao I. Studia Serica, vol. V, 1946. Published by the Chinese Cultural Studies Research Institute, West China Union University, Chengtu, Szechwan, China.

劉朝陽 "小乙征羌方考."

Chinese. Tones 3 and 4 as spoken by the Ch'iang and the West China Chinese are about the same.

Prof. Wen Yu, formerly on the staff of the West China Union University, has made an extensive study of the Ch'iang language and dialects, with the hope of writing a grammar and dictionary of the Ch'iang. This will be very difficult if not impossible to accomplish because of the great variations in different localities. The writer once hoped to compile at least a vocabulary of the Ch'iang, but was foiled by the differences and variations that he found, much greater than in any other ethnic group with which he has been in contact. There are rare and strange sounds such as the rough h, the uvular g, the Welsh double l, the dental t, the French j, and a consonant made deep in the throat with the mouth opened wide as when gargling, which the writer has indicated by the inverted question mark.

Prof. Wen Yu has stated that the Ch'iang language may be divided into five or six different branches, "between which there are morphological, philological and chronological differences perceptible, but not very considerable." In some branches he has found case distinctions, a feature which he has not found in any other Sino-Tibetan language.[22] He found in the Hou-erh-k'u dialect certain affricative consonants pronounced with considerable force. The word *ts'i* means "to replace" as ordinarily pronounced, but means "three" when pronounced emphatically. He calls these two pronunciations ordinary and emphatic.[23]

Prof. Wen Yu and others have compared the vocabularies of the Ch'iang with those of the Lolos, the Nashi, and others in the Burma-Tibetan language group, and in some cases they have found striking resemblances. Professor Wen regards the Ch'iang as an ancient form of the Burma-Tibetan.

4. THE PEOPLE

The Ch'iang people are dark yellow or brown in color, with eyes varying from dark brown to black, and hair coarse, straight, and black. Dr. W. R. Morse published anthropometrical measurements and observations of the Ch'iang.[24] In this publication only the bare measurements were included, none of the indices or conclusions being worked

[22] Wen Yu, On the languages of Li-fan. Journ. West China Border Res. Soc., vol. 14, ser. A, pp. 31-34, 1942.

[23] Wen Yu, On the origin of certain emphatic consonants in Ch'iang dialects. Studia Serica, vol. 6, pp. 209-215, Chengtu, 1947.

[24] Morse, W. R., Schedule of physical anthropological measurements and observations on ten ethnic groups of Szechwan Province, West China. Journ. West China Border Res. Soc., Supplement to vol. 8, 1937.

out. Later Dr. Yen Yin published an article in which the indices were included. Some of the main results are as follows:[25]

	Range	Mean
Stature	149–182	159.51 ± 0.42
Span	150–181	165.25 ± 0.48
Cephalic index	72–88	79.48 ± 1.22
Nasal index	53–91	66.85 ± 0.58

In an article by William R. Morse and Anthony Yoh,[26] "Measurements and observations on certain aboriginal tribes of Szech'uan Province," the Ch'iang were included, with measurements of 98 men. Some of the facts and measurements are as follows:

Stature	Range,	144–176	Mean,	101.2
Sitting height	"	79–96	"	87.8
Span	"	145–187	"	166.6
Head length	"	15–21	"	18.5
Head breadth	"	12–17	"	15.1
Head height	"	9–14	"	11.5
Hair color	Black, 90.68%; black-brown, 8.15%; brown, 1.16%			
Hair form	Straight, 48.20%; long waves, 39.40%, short waves, 2.25%.			
Hair texture	Coarse, 74.30%; medium, 17.95%; fine, 7.70%.			
Eye color of iris	Brown, dark, 27.70%; brown, medium, 43.60%; brown light, 28.70%.			
Epicanthic fold	Absent, 90.00%; trace, 6.90%; medium, .99%.			
Hair on body	Absent, 44.50%; trace, 55.50%.			
Shoveling of incisors (medial).	Absent, 4.76%; trace, 21.40%; medium, 28.67% marked, 45.20%.			

An official publication of the Li-fan government in 1942, during a time of drought, estimated the Ch'iang population at about 28,000.[27] Some Chinese might possibly have been included in this estimate, and the Ch'iang in the districts of Mao-chou and Wen-ch'uan were not included. It seems safe, therefore, to estimate the number of Ch'iang in western Szechwan at between 50,000 and 100,000. Estimating the Ch'iang population is difficult because in some localities people of Ch'iang descent speak the Chinese language and call themselves Chinese.

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[25] Yen Yin, The anthropometry of Ch'iang. Studia Seria, vol. 5, pp. 3-6, 1946.

[26] Morse, William R. and Anthony Yoh, Measurements and observations on certain aboriginal tribes of Szech'uan Province. Chinese Med. Journ., vol. 48, pp. 1267-81, 1934.

[27] Report of the Drought-famine in Li-fan Hsien Li-fan government publication, 1942.

理番縣三十一年旱災報告書.

II. ECONOMIC LIFE

To most of the Ch'iang people, the economic problem, that of earning a livelihood, with plenty to eat and to wear, and of keeping out of debt, is a difficult one, and the results are sometimes in doubt. Once a family is in debt, it is nearly impossible to get out again. As stated under the previous heading, "The country," the climate is semiarid, and droughts are not uncommon. Pestilences take the lives of human beings and also of domestic animals. By earthquakes, floods, fire, lightning, rolling stones, and in other ways, nature often strikes a hard if not a deadly blow. Wild animals attack human beings and domestic animals, and raid the growing crops. The poorer of the Ch'iang people are generally underclothed and underfed. On the other hand, the Ch'iang are an industrious and hard-working people, and men, women, and children join in the work of supporting the family.

1. COMMUNICATION AND TRANSPORTATION

The Ch'iang have no written language. There are therefore no newspapers, magazines, or books, excepting those published in the Chinese language for the Chinese, and few Ch'iang are able to possess or to read them. There is no radio or television, and no telephone or telegraph lines, for those connecting the Chinese towns and cities are for the use of the Chinese.

Chinese-built roads connect the cities and towns inhabited by the Chinese in the valleys. These are generally narrow and paved with stones or stone slabs which are arranged in ascending and descending stairlike steps. Some, however, are unpaved, and some are paved with rough, uneven and unhewn rocks. In many places the roads are steep and crooked. On these roads wheeled vehicles cannot be used, and the writer has not seen or heard of such vehicles being used anywhere in the Ch'iang region, not even a wheelbarrow. One travels on foot, in a sedan chair, or on horseback, or even on the back of a human being.

There are two main trade routes meeting at an almost right angle at Wei-chou. One comes from Kuan-hsien, crosses the Yang-tzŭ-lin pass and drops to the east bank of the Min River, which it follows northward all the way to Sung-p'an. Above Mao-chou a branch road turns westward up the Hei-shui River into the land of the Hei-shui and the Luh Hwa people. At Sung-p'an one road goes westward through the Po-lo-tzŭ country, one goes northward through the grasslands, and one turns eastward through the northern Szechwan. A second main artery of trade is a road that crosses the Min River at Wei-chou, follows the T'o or Tsa-ku-nao valley west to Li-fan, turns southwest to Tsa-ku-nao, then goes westward through the Chia-jung country into the marshes of Sikong and Tibet. These two main trade routes and their branches have been sources of migration, trade, and cultural diffusion for thousands of years.

The roads between Ch'iang villages are narrow, unpaved footpaths, often very steep. Sometimes they wind around the side of a mountain over the edge of a precipice. In some places they are built by skillfully cementing stones together and to the sides of perpendicular cliffs. There are places where the traveler is in danger of falling over a cliff or of being hit by rolling rocks.

Loads are sometimes carried by pack animals—horses, mules, or cattle—but more commonly by human beings. Chinese coolies generally use carrying poles or wooden racks, but Ch'iang men and women generally carry their loads on their backs by means of wooden carrying-racks, wicker baskets, or simply by ropes or straps tied around their loads. On account of the swiftness of the streams, there are practically no boats in the Ch'iang region.

A small stream may be waded or crossed by means of large stones conveniently arranged. Sometimes a log or a board is laid across a stream. A bridge sometimes consists of a single large bamboo cable hanging across a stream or river, with two hollow wooden half-cylinders tied securely around the cable and often greased inside. A person wraps his arms around this arrangement, or he and his baggage may be tied to it, and man and baggage slide on the cable more than halfway across. Then the man pulls himself hand-over-hand up the other side, or he or his baggage or both at once may be pulled the rest of the way across by means of a rope.

Large rope bridges have 9 or 10 bamboo cables on the bottom, on which boards are laid crosswise, and four or more cables on each side. The longest bamboo cables of this kind are held up and supported by several wooden trestles, the bridges sagging down between them. As a person walks over such a bridge, the whole bridge sways.

One type of bridge is the false or corbelled arch. From both sides large timbers reach out, each higher one beyond the one below it, toward the middle of the stream, where the space between the two sides is spanned by long timbers.

A very interesting type of bridge is called in Chinese a *p'ien Ch'iao,* or slanting bridge. This is used where a road must pass along the perpendicular side of a rock cliff over a swift mountain stream. Deep, round holes are chiseled horizontally into the perpendicular cliff about

3 feet apart, and wooden poles are inserted into these holes. Boards are laid on these poles parallel to the cliff and are sometimes tied to the poles by means of vine ropes. These bridges jiggle as people or animals walk over them, causing the poles gradually to slip out of the holes and allowing the bridge to become more and more slanting until finally part or all of the bridge falls into the roaring torrent below, and with it any people, baggage, or animals that happen to be on the bridge at the time. After a catastrophe like this, the bridge is, of course, repaired.

2. MONEY, MARKETING, BARTERING, AND BORROWING

For centuries Chinese money has been the currency of the Ch'iang. Even in the slate tombs, which have been dated between 500 and 100 B. C., only Chinese coins have been found. During the latter half of the Manchu dynasty, the money used was lump silver and brass cash. One ounce of silver was called a tael, and 10 ounces was a shoe or ingot of silver. The cash was a small, round brass coin with inscriptions giving the date and the value, and with a square hole in the center so that the coins could be strung on strings. One string was supposed to be 1,000 cash, but generally the count was from 10 to 100 cash short. Near the end of the Manchu dynasty, silver dollars and brass or copper coins without the holes in the center appeared.

The first silver dollars were Spanish or Mexican coins, but later the Chinese minted their own. The new brass and copper coins varied in value from 1 cash to 500. Early in the days of the Chinese Republic, paper notes appeared, with values of 5, 10, 20, and 50 cents, and values of 1, 2, 5, and 10 dollars and up. During the second world war the Chinese National Government "called in" all silver money and other silver objects, making it illegal to possess silver money, and some nickel coins were issued, but finally only paper money was minted and used. There appeared paper notes valued at $100, $200, $500, $1,000, $10,000, $50,000, and $100,000. In 1948 the writer paid one million dollars for a cheap straw hat.

There is some marketing in small villages, generally in temples, in homes, or on the streets. Bartering is still very common. If two objects of unequal value are traded, the difference may be paid in cash, or another object may be thrown in to make things even.

The principal market places are the Chinese cities and towns. Here the Ch'iang bring their products—firewood, hides, corn, beans, wheat, buckwheat, pepper, vegetables, chickens, beef, mutton, eggs, medicines, and other commodities, and with the money received for them they purchase salt, sugar, cotton cloth, vegetable oil, tea, tobacco, and other necessities.

The interest paid on loans is very high. It varies from 60 to 300 percent a year. This is one of the greatest hardships endured by the Ch'iang. If the borrower does not pay (as often he cannot), the lender may send a poor person to live with the borrower. This person stays in the borrower's home, eats his food, smokes his tobacco, drinks his tea, and sleeps in his bed. This costs the borrower a great deal, but in the end the borrower must pay all he owes, both interest and principal. He is not credited with what the poor man has cost him. Sometimes the lender comes and takes away a pig, sheep, goat, cow, or some other valuable object. The contract may stipulate that the interest is from 2 to 6 pecks of corn, so that the rate of interest depends on the market value of the corn.

3. HOUSES, TOWERS, AND VILLAGES

Ch'iang houses are made of stone, wood, and clay. The walls are built of unhewn stone plastered together with clay, and the doors, ladders, floors, roofs, and sometimes windows are made of wood. Before building the walls, trenches are dug 2 or 3 meters deep, and these are filled with stones cemented together with clay. On these foundations the walls are built. Advantage is taken of the flat and smooth sides of the stones, so that the sides of the walls appear to be flat and the corners square. The clay used is generally the loess dirt which is abundant in the Ch'iang region. It is merely mixed with water before using. The walls are thicker at the bottom than near the top, so that the walls slope inward very gradually toward the tops of the houses.

When building a house, saws, planes, chisels, and hatchets are used to shape the wood, and hammers to drive in the nails. A heavy wooden pounder with a handle through the top and a wide, flat bottom is used to pound the dirt on the roof level and firm, and an iron hammer, a wooden hammer or sledge, and a trowel are used in constructing the walls. Hoes and shovels are used to dig the trenches for the foundations.

The houses generally have two stories—sometimes three—besides the shed on the roof. The first story consists of an open court inside the front door, a latrine, and inner rooms or pens for the domestic animals. All the animals are shut inside these rooms or pens at night. The floors of the open court and the small rooms or pens are covered with straw, coarse grass, and twigs, and the animals tread on this for weeks or months, adding their urine and night soil. Of course, there is a bad smell. On this floor garden tools, hay, and fuel are stored.

People live on the second floor, where there are usually one or two bedrooms, a kitchen, and a large room used for entertaining guests, as a dining room, and for other purposes. On this floor dogs, cats,

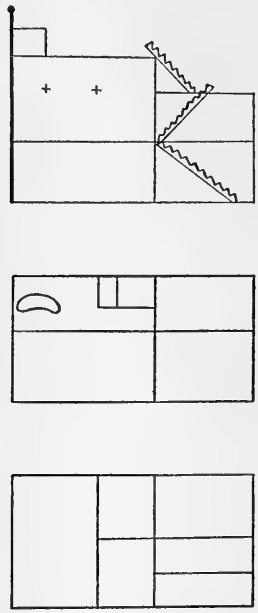

FIG. 2—Drawings showing the first floor of a Ch'iang house, on which are the latrine and the pens for domestic animals; the second story showing the main hall, a bedroom, a kitchen and a kitchen stove resembling Chinese kitchen stoves; and the side view of the same house. Ch'iang homes are made of unhewn stone, are generally two stories high, and have flat roofs. At the rear of the roof is a shed for storing grain and vegetables. On top of this shed, in the center at the rear, is a shrine, capped by a sacred white stone, at which the 5 great gods and the 12 lesser gods are worshiped.

chickens, and sometimes goats are allowed to range, which does not make for cleanliness. On this floor people sit around the fire, smoke tobacco, visit, eat, and sleep.

On the top of the house is a flat roof surrounded by a wall about 2 feet high. At the rear of the roof is an open shed in which grain and vegetables are stored, and where women sometimes do their weaving. Here clothes are dried, and grain is dried, flailed, and winnowed. Here in fair weather children play, and the inmates of the house visit with each other and friends and relatives on the same roof, or with neighbors on the roofs of other houses, or people enjoy simply gazing at the scenery.

The rear wall projects higher than the shed, and at the middle is a shrine with an opening in front in which incense is burnt. The incense is sometimes incense sticks purchased in the Chinese market, but generally it is cedar twigs. On the top of the shrine is a sacred white stone, and just back of this is a small hole in which a green cedar twig is inserted upright at the time of worship. In front of the shrine the family worships the 5 great gods and the 12 lesser gods.

To build this roof, large timbers are placed on top of or rather in the wall, parallel and a few feet apart. Thick boards are placed crosswise on these timbers. On the boards are placed brushwood, mountain bamboo, and twigs. Dirt is thrown onto the twigs, bamboo, and brushwood, and beaten hard. Thorns are mixed with the dirt and twigs to discourage the rats. There is a slight slope to the roof, so that the rain runs off instead of leaking into the house.

In the villages the houses are close together, often wall-to-wall, and the streets are narrow, generally about 3 feet wide and seldom over 10 feet in width. This gives a village the appearance of a fortification with high stone walls. The impression is heightened by the fact that nearly every village has one or more watch towers which are 17 or 18 feet square at the bottom and often over 100 feet high. The village of P'u-wa has seven watch towers.

The Ch'iang watch towers are always near villages, their location depending on the position of the villages, the lay of the land, and the need for defense. They are square and eight stories high. Each story or floor above the first floor is reached by inside ladders. The entrance to the first floor is reached by a ladder which can be drawn inside and the door closed. Each story has a wooden floor. On each side of a tower are eight small holes or windows, generally in the form of narrow crosses, one on each floor, for air, light, and formerly for shooting arrows at enemies. On the top, on the side of the higher land, the wall is built higher as a protection from enemies. In time of war women and children and the most valuable possessions are taken inside the towers for safety.

Many Ch'iang villages are on cliffs or promontories that make defense easier, and nearly all are called *Chai Tzu* or fortified places. They are always located near creeks or springs and near fertile fields that are good for farming.

Ch'iang houses often contain typical Chinese stoves made generally of stones and clay, with a fireplace underneath and two or three holes for cooking vessels, the largest being for the Chinese *kuo* 鍋 in which most of the food is cooked.

Many Ch'iang homes have on the second story an oblong fireplace filled with ashes so as to protect the wooden floor from the fire and sparks. In this oblong space there is an iron band or circle with three equidistant iron legs and with three pieces of iron reaching almost horizontally toward the center from the places where the three iron legs are joined to the iron circle. These three horizontal pieces of iron support a cooking vessel over the fire. The diameter of this iron stove is nearly 3 feet, and in homes where these is no Chinese cooking stove, it is used for the cooking. Where there is a Chinese cooking stove, the iron stove is used less for cooking and more for warmth, and during cold weather fires are built here daily and kept burning most of the time. Members of the family and relatives and friends often sit around the fireplace and visit. People must not put their feet on the iron circle or the legs, because the entire stove is sacred and the legs are gods.

4. OCCUPATIONS

All Ch'iang are farmers. Even the priests and rulers or headmen, generally the most highly honored people in their communities, have fields which they farm or rent to others. Land, houses, and tools are generally owned by families and not by individuals. Every able-bodied member of the family is supposed to work. Men do the plowing, for there is a taboo against this being done by women, and women do the weaving. Women and girls generally do the sewing, spinning, and cooking, but in such work as farming, herding the domestic animals, and carrying loads, all the members of the family generally cooperate and do their share of the work.

There are men, though few, who are blacksmiths, carpenters, painters, or masons, but these men are also farmers. There are no silversmiths or goldsmiths, for silver and gold ornaments are bought readymade from, or made to order by, Chinese silversmiths. Members of several families often cooperate in herding cattle, sheep, goats, and horses on the mountains. Few if any of the Ch'iang are merchants, although there are homes in which matches, vegetable oil, wine, salt, and a few other commodities are sold.

Wood is used for fuel, although this is supplemented by corn stalks or husks, and wheat, barley, and buckwheat straw. The wood is gathered in the forests on the mountains, where it is tied into bundles and carried home on the backs of men or women. Sometimes the bundles are thrown or rolled down precipices or steep hillsides to save labor. Most of the winter supply is gathered in the fall after the crops have been harvested. All loads are carried on the backs of men or women unless the family is fortunate enough to own one or two pack animals. Poor people often supplement the family income by carrying loads for other Ch'iang or for the Chinese.

During the winter months some of the Ch'iang go to the Chengtu plain and dig or clean wells for the Chinese. It is believed that they are experts at this work.

Most of the men enjoy hunting, which they generally do in the fall or winter months after the crops have been harvested. Several men with dogs cooperate and share the spoils. They kill leopards, pandas, monkeys, wild boars, deer, bears, wild mountain goats, pheasants, and other game, eating the meat and using or selling the skins of the animals.

Most of the farms have been tilled for centuries, and their fertility is preserved and prolonged by fertilization. Much of the soil is terraced. New land is sometimes secured by cutting down trees and bushes, then burning them after they have become dry. Such land is very fertile for a few years, after which it is abandoned and allowed to grow bushes and trees. Later the process may be repeated. This custom is widespread among the highlands of West China and is very destructive to the forests. Sometimes the freshly tilled soil is washed away by the heavy rains, leaving the place unfit for forests or for cultivation.

While the Ch'iang are farmers, they depend very much on their flocks, and especially their sheep and goats. Their flocks are the chief source of meat for food and for ceremonial offerings, and the wool and hides are used for bedding and for clothing.

5. TOOLS, IMPLEMENTS, AND FURNITURE

Most of the Ch'iang tools and implements are the same as those of the Chinese. In fact, they are made by Chinese for the Chinese, and are bought by the Ch'iang in the Chinese markets. The hoe is long and thick, and the handle is about 4 feet long. The ax and the hatchet are heavier and clumsier than those of foreign lands. The short, curved iron sickle is used to cut wood, wheat, barley, buckwheat, corn, and grass. The loom has a wooden frame, and the spindle is often a stick of wood around which the thread or yarn has been wound. The plow differs from that of the Chinese in that there is a short upright stick pierced at right angles by a small wooden handle. The plowman has to stoop when he plows, and when he turns the plow around he lifts it out of the ground. The long beam is tied to the yoke, and the yoke is tied to the shoulders of the horses, cows, or oxen. The plowman sings as he plows, and it is asserted that if he stops singing the animal stops pulling.

We have already described the Ch'iang stove which consists of an iron hoop with three legs. A variation of this is found in some homes and in many temples in the form of three pieces of stone skillfully chipped so that legs extend downward and the tops extend inward toward the center. The cooking vessel can rest on the extended tips of the stones in the center, and a fire can be built underneath.

The beds of the Ch'iang are made of wood and resemble those of the Chinese. Some families have round wooden tables, but poorer families merely use planks between two long, four-legged stools. Some families have wooden or bamboo chairs bought from the Chinese, but many use only the typical long, four-legged wooden *pan-teng* 板凳 or bench. Water is stored in stone vats or small tanks or in wooden barrels, and is carried in wooden barrels or tubs on people's backs. In the bedrooms are wooden chests or boxes to contain quilts or clothing. Among the kitchen utensils are a thick, wide iron chopper with a wooden handle, knives, spoons, and ladles, iron and wooden dippers, teapots, tea kettles, and a large iron *kuo* or cooking vessel with a round wooden lid.

The wooden rack or frame used for carrying loads on the back is widely used on the China-Tibetan border. A Ch'iang substitute for this is a wicker basket with straps that go over the shoulders and back under the arms. The basket is often filled up, and long objects like rolls of cloth or pieces of wood are laid horizontally across the top. Hunters carry daggers or short swords in their belts and generally use muzzle-loading guns. The Ch'iang eat with chopsticks out of small bowls, and food is placed on the table on plates or in large bowls.

6. FOOD AND AGRICULTURAL PRODUCTS

On the farms the Ch'iang raise hemp, wheat, barley, buckwheat, corn, beans, peas, squashes, cucumbers, turnips, Chinese cabbage, cabbage, walnuts, tree pepper, apples, pears, peaches, and apricots. In the forests and on the mountainsides they gather wild fruits, berries, and vegetables. During a summer trip in the mountains above Mu-p'ing we counted 22 kinds of wild vegetables that were being used. Corn is the main product of the soil, and rice is almost never planted, even in the valleys. Bees are raised, but sometimes they are robbed of their honey so late in the season that they die of starvation during the winter.

Their domestic animals and fowls are dogs, cats, cattle, horses, donkeys, mules, pigs, sheep, goats, chickens, ducks, pigeons, and geese. In the forests and on the mountains are deer, takin, pandas, monkeys, wild boars, mountain goats, bears, leopards, pheasants, and wild pigeons. The above paragraphs summarize the food of the Ch'iang people. Tea is bought from the Chinese and drunk by people of all ages. Practically everybody drinks wine when he can get it. Dog meat is sometimes eaten, and leopards and monkeys are considered to be both delicious and nutritious. Few of the Ch'iang can afford to buy rice, and when they do, it is generally for feasts and banquets. Wheat, barley, buckwheat, and corn are made into biscuits which are unleavened, for the Ch'iang do not leaven their bread. Corn is often ground and then boiled until it is nearly dry, then eaten with chopsticks from bowls as the Chinese eat their rice.

Among some of the Ch'iang there is a taboo against killing cattle and eating them, probably a Chinese influence, because cattle are used for plowing. This custom, however, is not universal. Eggs are eaten only on special occasions, and meat is a luxury not generally available for ordinary Ch'iang families.

7. CLOTHING AND ORNAMENTS

The clothing generally worn by the Ch'iang is made of undyed hemp cloth, white or nearly white because that is the natural color. They raise their own hemp, and the cloth is woven by the women. Warmer clothing made of dark wool is often worn in cold weather. A third kind of clothing, generally without sleeves, is made of animal skins with the hair left on. Some of the Ch'iang wear clothing made of cotton cloth bought from the Chinese. Both men and women wear trousers. Instead of stockings, which are seldom worn, woolen puttees are wrapped first around the feet, then around the legs up to the knees.

Straw sandals are seldom used, as the women make cloth shoes which are more comfortable and more durable. Those worn on special dress-up occasions are beautifully ornamented by flowers and butterflies which are embroidered or sewn on the shoes by the women. Both men and women wear cotton turbans wrapped around their heads.

The typical upper garment is a gown made of undyed white hemp cloth, which reaches a little below the knees. Those worn by the women are a little longer than those worn by the men, and are longer behind than in front, reaching in the back almost to the ankles. Those worn by the men are the same length in front and behind. The dark-brown woolen gown worn in winter is a little longer than the white hemp gown. In cold weather the sleeveless skin coat is worn with the hair turned inside, but in rainy weather it is worn with the hair turned outside.

In some localities the best hemp gowns of both men and women have borders of blue cloth around the neck and down to the waist. On this blue cloth border simple ornamental stars, flowers, and geometrical patterns are embroidered in white.

Both men and women wear cloth belts. Generally these are of white hemp cloth, but at Wen-ch'uan and at Li-fan there are many-colored woven belts of elaborate patterns. It seems evident that the Ch'iang at Wen-ch'uan have borrowed them from the Wa-ssŭ, and the Ch'iang at Li-fan, from the Chia-jung, their near neighbors, since the Ch'iang in other localities do not make and wear such belts, and they are extensively used by the Wa-ssŭ and the Chia-jung.

Many of the poor people do not have sufficient clothing to keep them warm in winter time, and they often catch colds and sometimes pneumonia.

The ornamented belts are believed to have power to protect their wearers from demons that poison people. Women's belts have parallel lines on both sides, the ornamental designs being in between the lines. The belts of the men have the ornamental patterns, but not the parallel lines. All belts are woven by women. It is believed by the Chia-jung that women have something dangerous about them, and that these ornamental belts, when worn by the women, have power to keep them under control.

Women and girls 12 years old and older wear earrings. Finger rings and wristlets may or may not be worn by men or women. Chinese silver hairpins are bought in Chinese silver shops and proudly worn by the Ch'iang women.

Chinese embroidery patterns are sometimes learned by Ch'iang women and embroidered on their sleeves or aprons. Beautiful Chinese lattice patterns are sometimes seen, although rarely, on the windows of important Ch'iang buildings. These have been done by Chinese carpenters who were accustomed to put lattice patterns on the windows of Chinese buildings.

Interesting patterns are carved on the handles of Ch'iang ceremonial drums and on the sheaths of ceremonial swords. These seem to be distinctly Ch'iang designs.

III. FOLKTALES AND "MOUNTAIN SONGS"

1. FOLKTALES

Folktales do not seem to have so large a place among the Ch'iang as among some other ethnic groups in West China, certainly not so much as among the Ch'uan Miao. The writer has heard only four among the Ch'iang, and at least two of these would be regarded as historical and etiological traditions, for they are considered to be real history by the Ch'iang.

The first of these is the story of the great migration estimated by some as requiring 1 year and several months and by others as 3 years and 6 months, during which migration the sacred books were lost through being eaten by goats. The second concerns the *koh* people, who, according to the tradition, disputed the possession of the land with the Ch'iang when the latter first arrived in this region. The tradition is that the Ch'iang were unable to win the struggle until they used the white stone as a weapon, after which they were victorious and the white stone became sacred.

The story of a daughter of a god who came to earth and married a mere man is widespread among the tribespeople of West China. The writer has found this story among the Ch'uan Miao, among the Lolos, and among the Ch'iang. What seems amazing to the writer is that the Ch'iang have included this story among their sacred books. At both Lo-pu-chai and Ho-p'ing-chai at least one section or sacred book consists of the relating of this story. According to the priest at Lo-pu-chai the name of the god's daughter was Mu Tseh and the name of the man who married her was Stu Ha. Both were unhappy and lonesome, and Mu Tseh suggested to Stu Ha that he speak to her father Mo-bi-da about the possibility of their getting married. The god asked Stu Ha what he had come for, and Stu Ha replied that he had come seeking a wife. The god told Stu Ha that he, a mere man, was no match for the god, and gave Stu Ha two almost impossible tasks to perform. One was to cut down and burn the trees in three great canyons, a method very common in the western highlands of China of preparing forest land for cultivation. "Cut with a knife (or axe) and burn with fire," is the expression used for this procedure. Then he must plant 30 bushels of rape seed and later reap the harvest. These tasks Stu Ha succeeded in performing and so was given Mu Tseh in marriage. The god told Stu Ha to bring, driving them in front, 100 domestic animals, apparently as a wedding gift to her parents. When Stu Ha returned home there would be 1,000 domestic animals following him, as a gift of the god to Mu

Tseh and Stu Ha. Stu Ha was exhorted to comb his hair beautifully and wear his silver rings properly, and to await a lucky day.

Mu Tseh gave birth to a son and a daughter. She was unhappy, for the Ch'iang home was dirty, the food was poor, and she was lonesome for her friends and the palace above. Out of sympathy for her Stu Ha advised her to return to her former home. Apparently she regretted leaving him, and asked what he would give her if she returned during the first lunar month. He replied, the jasmine flower, a yellow flower that blooms during the first moon in Szechwan, and is called "the welcome spring flower." To her question as to what he would give her if she returned during the second moon, he replied, the *shui tang* flower, a beautiful flower that blossoms on the edges of pools. If she should return during the third moon, he would give her roses, which blossom on the edges of terraces. If she returned during the fourth moon he would give her buckwheat blossoms, and during the fifth moon wheat and barley which appear to blossom at that time in the fields.

The following folktale is a translation by the writer from "Research in Western Szechwan," published in 1943 by the Department of Education of China.

In ancient times there were two shepherds, one named Ga and the other named Tsï Gai Bao. The former was strong, powerful, and wealthy, while the latter was poor and weak and was always oppressed by the former. One day Ga stole a cow, and Ga and Tsï quarreled and went to the Jade (Pearly) Emperor to settle the affair. The Emperor asked Tsï about it, but he dared not tell the truth for fear of Ga. The Jade Emperor therefore thought of a way to find out. He ordered them to open their mouths. A piece of meat was found between Ga's teeth, so that the facts were finally known. But because of this Ga hated Tsï, and asked him to return the money he had borrowed, together with a heavy interest of 500 percent. Tsï was poor and could not pay the money, so they again brought the case to the Jade Emperor.

The Jade Emperor urged Ga to reduce the interest, but Ga refused. The Jade Emperor realized the ambitious intentions of Ga, and decided to use a trick to punish him. The Jade Emperor took two sticks, one of flax and the other of willow, with the outer skin (or bark) peeled off so that one could not be distinguished from the other. He gave Tsï the willow stick and Ga the flax stick and ordered them to beat each other, saying to them, "The one who breaks the stick first will get the interest." Ga broke the flax stick with the first blow, and was pleased, but Tsï could not break the stick for quite a while. Ga, being greedy for the interest, endured the beating, and finally the willow stick also broke.

The two quarreled again, and the Jade Emperor thought of another trick. He gave them two stones, one of snow and the other of white-cloud stone (the white quartz of the sacred white stone), and ordered them to throw at each other, saying that the one who broke his stone first would win the case. He gave the white-cloud stone to Tsï and the snowball to Ga. Ga broke the snowball on the first throw and was very much delighted. Tsï threw the white stone and broke Ga's backbone. Ga, being hurt badly, ran away, and Tsï pursued him.

Later Tsï did not know where Ga was. He met a crow and asked the whereabouts of Ga. The crow was unwilling to tell him, although it had seen him. Tsï became angry and cursed the crow, saying that it had a black heart, a black skin, and black bones. It is said that from that time the crow has been black. Later Tsï met a magpie and asked him. The magpie had seen Ga and told Tsï that Ga admitted his wrongdoing and would not come back again. He was willing to give up all the principal and interest. Tsï was pleased and called the magpie the lucky bird. He asked it to take word to Ga that he should live in the places where snow does not melt even during the summer, and the places where good crops grow all four seasons would be the territory of Tsï. Thus the land was divided. Later Tsï and his descendants lived happily and peacefully and prospered. Today it is believed that the ancestor of all human beings is Tsï. The Ch'iang believe that Ga still lives in the snow mountains, where there is snow throughout the whole year.[28]

2. "MOUNTAIN SONGS"

The Ch'iang seem to be a cheerful people. As they carry heavy loads over the mountain paths or the main-traveled roads, or tend their flocks on the mountains, or work in their homes or in the fields, they often sing songs which they call "mountain songs." Some are in the Chinese and some in the Ch'iang language. The following were obtained in the Chinese and translated into the English language. They were obtained in the region of Li-fan and Wei-chou.

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[28] Report on research in western Szechwan, The Chinese Ministry of Education, p. 1, 1943.

1.

茂州下來九條街　十樹梅花九樹開
心想摘朵梅花戴　人生面熟口難開
只准摘來頭上戴　不准拿來懷內揣

Below Mao-chou is Chiu-t'iao-kiai.
Of 10 *mei hua* trees, 9 have blossomed.
I think of plucking one of the flowers (to wear in my hair).
I am unacquainted, so do not dare to speak.
We will only permit you to pick one and wear it on your head.
We will not permit you to conceal it in your breast.
(Sung by boys or young men to girls or young women.)

2.

茂州下來一朵雲　端端對着威州城
威州城來不算城　還有龍山太子墳
好吃不過龍山水　好耍不過牟瓦人

Below Mao-chou is a cloud
Just in front of Wei-chou.
Wei Chou cannot be reckoned as a city.
There is the Heir-apparent tomb on Dragon Mountain.
There is no water better to drink than on Dragon Mountain.
There are no people better to visit with than the
P'u-wa people.
(Sung by girls or women.)

3.

清早起來不新鮮　打開窗子望青天
好個青天不下雨　好個賢妹不團圓
月亮團圓十四五　賢妹團圓那一年

I rise early and am not refreshed.
I open the window and see the clear sky.
A good clear sky does not rain.
A fine girl and I are not together.
The moon is round on the fourteenth and the fifteenth
(of the lunar month).
In what year will the fine girl and I be together?
(Sung by men and boys. Roundness symbolizes the
completeness of a family; therefore this is a hint
at marriage.)

4.

芋麥包包黃又黃　勞煩親戚來幫忙
咪子吃的都沒有　蕎麵糖糖蘸蜂糖

The ears of corn are very yellow.
I'll trouble my relatives to come and help.
We have nothing for you to eat.
We will put honey on buckwheat biscuits.
(This implies that the girl has grown up and suggests that the boy seek her.)

5.

對門山上一株槐　槐枝槐椏掉下來
風不吹來槐不動　你不招手我不來

On the opposite mountain is a *huai* tree.
The twigs and shoots will fall down.
If the wind does not blow, the *huai* tree does not move.
If you do not beckon your hand, I will not come.
(Sung by a young man suggesting that the girl motion him to come.)

6.

我在唱來你在聽　你的耳朵生毛疔
你的毛疔還未好　老子山歌又來了

I am singing and you are listening.
Your ear will develop a boil.
While the sore on your ear is still uncured,
The mountain song of the old person will come again.

7.

一根樹兒九枝椏　又結葡萄又結瓜
又結河南姜豆子　又結四川牡丹花

One tree has nine twigs.
They bear both grapes and melons.
They also bear long beans from Honan Province,
and also bear peonies from Szechwan.
(Sung by a girl or young woman suggesting that she could bear him fine sons like *chiang tou,* a very long bean, and fine daughters like Szechwan peonies.)

8.

一窩樹兒九枝椏　　賣了樹兒接你媽
你媽嫌我鬍子長　　剃了鬍子來拜堂

One tree has nine twigs.
When I have sold the tree I will marry your mother.
If your mother does not like me because my beard is long,
After I have shaved my beard we will worship the family god.
(Sung by a young man ridiculing a girl. The last phrase implies marriage.)

9.

青天悠悠打大雷　　郎到山西永不回
山西有個望郎弟　　四川有個望郎回

On a clear day it thunders loudly.
My husband has gone to Shansi and never returns.
In Shansi there is a younger brother who wants my husband.
In Szechwan is a woman who hopes her husband will return.
(Sung by a woman or girl.)

10.

松潘下來一朵雲　　端端對倒茂州城
茂州城來修的好　　四門都是鐵皮包
只有西門修的好　　端端對着正西橋
正西橋上好跑馬　　鐘鼓樓上好吹簫

Below Sung-p'an is a cloud
Just in front of Mao-chou
The city of Mao-chou is built very well.
The four gates are well covered with iron plates.
Only the west gate is finely built.
It is just opposite the directly-west bridge.
On this bridge it is fine for horse racing.
On the bell-and-drum tower it is fine for playing flutes.
(Sung by a young man. Playing flutes is a good way to attract the girls. The character used implies that this kind of a flute is held at right angles to the face.)

11.

白銅煙袋黑桿桿　情嫂梳個長纘纘
人又抽條又好看　走起路來打閃閃

A white brass pipe has a black handle.
My sweetheart has a long lock of hair.
You are both straight and beautiful.
When you walk on the road you go swaying along.
(Sung by a young man.)

12.

白銅煙袋點翠藍　成都買成二百錢
你要煙袋拿起去　二回玩耍不要錢

A white brass pipe is dotted with blue.
In Chengtu it was bought for two hundred cash.
If you want the pipe, take it along.
When we visit again, do not desire money.
(Sung by a young man. The last phrase means, do not desire gifts that cost too much money.)

13.

我與賢妹隔條河　樹葉遮倒看不出
要想二人同相會　除非河乾樹葉落

I am separated by a stream from the fine maiden.
The leaves of trees hide us so we are invisible.
If we two desire to meet, it is necessary for the creek to dry up and the leaves to fall.
(Sung by young men and boys.)

14.

對門坡來對門坡　對門坡上好洋柃
扯把洋柃來墊坐　二人唱個分手歌

You are on top of the opposite hill.
On the opposite hill is a *yang ling* tree (possibly *Eurya Japonica*).
I'll pluck a handful of leaves and sit on them.
We two will sing a farewell song.

15.

我與賢妹隔條河　過來過去把溜索
只要賢妹心腸好　二人牽根鴛鴦索

I am across the river from the fine maiden.
When going or coming across we grasp the rope bridge
(slide-rope, or a single bamboo cable for crossing streams.)
If only the fine girl has a fine heart,
We two will pull a mating-rope.
(Sung by young men. The mating-rope implies marriage.)

16.

茂州下來九條河　新修磨子打絲羅
隔壁么妹來磨麵　口口聲聲要絲羅
你要絲羅拿起去　輕輕巧巧打幾羅

Below Mau-chou are nine streams.
There are new grinding-mills and sifters moved by the water.
The little sister in the next house comes to use the grinder.
Her voice asks for the sifter.
If you want the sifter, take it away
and use it very carefully.
(Often sung by young men or boys in a building where grinding and sifting is done. It implies that his heart is favorable to her.)

17.

喊你唱來你不唱　把你拉在殺凳上
三根連環高吊起　半斤四兩都不讓

When I ask you to sing, you do not sing.
I will take you to the slaughter bench (where pigs are killed).
I will use three chain hooks and hang you up high.
A half a pound or four ounces will not be left.
(Sung by girls or women. Implies that she will cut off all his flesh.)

18.

唱歌哇哇洞咚洞　背上揹個吹火筒
那邊喊你打油匠　這邊喊你活讀蟲

The singing boy sounds "dong, dong, dong."
On his back he carries a tube for blowing fires.
I call you over there a beater of oil.
Over here I will call you a stupid insect.
(Sung by a girl jeering at a boy.)

19.

油煎豆腐二面黃　兒罵老子沒心腸
今年送你讀書去　明年送你坐班房

Fry the beancurd in oil, cook both sides brown,
For the boy jeers at me, saying I have no heart.
This year I will take you to school.
Next year I will take you to prison.
(Sung by a girl or a young woman jeering at a young man.)

20.

白楊葉子圓又圓　你把山歌唱不完
你把山歌唱完了　把你送給濫桿桿

The leaves of the poplar tree are very round.
You cannot sing all the mountain songs.
When you have sung all the mountain songs,
I will take you and marry you to a rotten stick.
(Sung by boys or young men, The rotten stick implies a worthless man or rascal.)

21.

岩上砍柴岩下梭　一梭梭在猴兒窩
猴公猴母都走完　留倒猴兒唱山歌

When you cut wood on the cliff, you slide down the cliff.
When you slide you slide into a monkey's nest.
The male and the female monkeys have all gone.
There is left a small monkey who is singing mountain songs.
(Sung by girls or women jeering at boys or men.)

22.

遠看賢妹一丁丁　抱在懷中不忍心
叫聲情哥膽大點　稱錘雖小稱千斤

From the distance I see the fine maiden as a small speck.
I can not bear to think of embracing her to my bosom.
I call to my lover, have more courage.
Although the scale weight is small, it can weigh a thousand catties.
(The first two lines are sung by a man, the last two by a woman encouraging him.)

23.

郎是天上紫微星　妹是後園樹滕心
二人都在虛空坐　來來往往把細些

The groom is the north star in the sky.
The sister (the girl singing) is the heart of the wood-vine in the back garden.
The two are sitting in the (vacant) air.
When we meet we must be careful lest people see.
(Sung by a girl or young woman. It implies that it is dangerous for them because they may be found out.)

IV. SOCIAL CUSTOMS

I. SOCIAL LIFE

The social life of the Ch'iang is very simple. There are no theaters or movies, excepting those of the Chinese in the Chinese cities and towns. There are practically no games. The children's playthings are often broken pieces of tile or pebbles, and they are seldom seen playing. Play is regarded as a means of idling away time that should be used in the serious business of earning a livelihood. Even children have important tasks to perform and burdens to bear.

There is very little gambling among the Ch'iang. When at leisure, the men sit and gossip, smoke, or drink tea, and the women chat as they spin yarn or hemp thread, make shoes or embroideries, or sew clothing. Practically everybody smokes and drinks wine when he can get it.

Hunting is sometimes a serious business, and sometimes a pastime. The work in the fields is shared by men and women of all ages, and the workers generally sing "mountain songs" as they work. To all appearances they are happy. Sometimes they sing as they husk corn or do other work in their homes. Talking and singing are main pastimes of those who tend the flocks on the mountains.

While gathering wood in the forests, people from different homes often work together, chatting and singing songs. When carrying loads several people are likely to stop at a convenient place to rest, chat, and smoke.

During the first lunar month families invite friends and relatives to feasts where they eat, talk, smoke, and drink tea and wine. A popular amusement at such times is "playing lion." Two men, covered with an imitation lion's skin, pretend to be a lion and dance about and fight with a man, who is always victorious over the lion.

At funerals and weddings there are feasts, and people of all ages meet, eat, drink tea and wine, smoke, and talk. People often go to market together, visiting as they walk or stop to rest. Neighbors often visit each other on the housetops or in their homes.

The writer has heard of no social dances except those near Li-fan There is a taboo against using the funeral dance on any other occasion. In 1933 the writer witnessed an evening of dancing at Chiu-tzŭ-t'eng. The dance lasted several hours. There was a line of 12 women on the right and 6 men on the left. First the men would sing a line or sentence of a song, dancing as they sang, then the women would dance and sing the same line. Then the second line would be sung, and so on. As the men or the women danced rhythmically together, they swayed their arms and bodies from side to side, making graceful steps in unison, stamping the feet, quickly lowering the body, and turning completely around together while singing one sentence. There was a large jug of wine from which the dancers drank frequently through small bamboo tubes. When the wine became low, water was poured into the jug, so that the wine became weaker and weaker. Since this dance is common among the Chia-jung, whose boundary is only about 7 miles from Li-fan, and it is not practiced in most of the Ch'iang region, it seems safe to assume that the Ch'iang near Li-fan learned this dance from the Chia-jung. It should be emphasized that dancing among the Ch'iang is never two by two, a man with a woman. The men and women are opposite each other, and first the men, then the women, dance in unison. Some of the songs have been learned from previous dancers, and others are improvised. It is believed by the Chinese that such singing and dancing has been learned from the Chia-jung and the Hsi-fan 西番 within the last 40 years.[29]

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[29] Report on research in western Szechwan, The Chinese Ministry of Education, p. 24, 1943.

When people quarrel and fight, friends exhort them and try to make peace. If they are not successful, they may go to the local Ch'iang leader or headman, who is appointed by the Chinese government. If again they are not successful, the case may be tried in the Chinese yamen or court.

2. ENGAGEMENTS

Among the Ch'iang, engagements are family affairs. The family of the man chooses the girl or the woman whom he is to marry, and the engagements are made through middlemen or go-betweens. When the two families have agreed, a refusal by either of the young people is not expected. The main consideration is the value of the girl or woman as a worker to the family of the groom. The writer heard of a 12-year-old boy who was married to a girl of 26. She was an excellent worker. Engagements and marriages are very expensive to the families of the grooms, and often they have to borrow money. Every Ch'iang man or woman gets married sooner or later.

There is considerable flirting and lovemaking among the young people. Many of the "mountain songs" are songs in which lovemaking is encouraged.

If a young man and a young woman fall in love and want to get married, it is necessary to get the consent of their families, who will endeavor to make the engagement through go-betweens.

Sometimes, but not always, the horoscope is consulted. If it indicates that the marriage will be unlucky, the engagement is not consummated.

Always, when an engagement is made, the family of the groom must agree to give valuable presents to the family of the bride. These vary in different places, and with different families in the same locality. In 1933 the writer was told that near Tung-men-wai and Mu-shang-chai the family of the groom must give the family of the bride a pig's head, a couple of jugs of wine, pork, shoes, stockings, and other things. At Ts'a-to in 1941 he was told that the gift should include a piece of pork, 3 jugs of wine, 2 large pieces of bread, incense, candles, etc. At Ta-ho-p'ing-chai he was told that the gift should include 8 rolls of cloth, black or blue but not white, 24 catties of pork, 2 large wheat biscuits, 3 jars of wine, 1 large wheat cake called in Chinese a *kuo k'wei,* 1 pair of earrings, 1 piece of brass wire, and 1 pair of puttees. The objects, the amount, and the value vary according to the ability of the groom's family to give.

Men and women mingle freely, talk, and sing "mountain songs" when working in the fields. At night in the homes they sometimes husk corn and sing songs and talk until the wee hours of the morning. Sometimes in the songs they ridicule each other, and sometimes they make love. A man and woman may secretly give each other presents such as cookies, cloth, shoes, or embroidery. When two lovers cannot marry in this life, one may give the other a lock of hair as an expression of the hope that they may be married during a future incarnation. The woman's husband does not object unless they commit fornication.

The following notes on Ch'iang engagement customs are taken from a publication of the Chinese Ministry of Education:[30]

Engagements are made by parents through go-betweens, usually while those becoming engaged are very young. Sometimes parents make engagements for children while their mothers are pregnant and the children still unborn. If both children born are males, they will be regarded as brothers; if both females, as sisters; and if one is a girl and the other a boy, they will be engaged to be married.

Go-betweens do not give presents to the family of the girl until after they become engaged. When they go to try to make an engagement, they take money with them. If the girl becomes engaged to the young man in question, then the go-betweens buy wine and give it to her family. After a half a month, the groom's family buys more wine and gives it to the girl's family. This wine is called engagement wine. The amount of wine given varies with the size of the girl's family. The number of containers of wine also varies, but it must be an even number, for even numbers are lucky and odd numbers are unlucky. Among other things that are given are pork, sugar, rock candy, and money. The girl's family gives a feast to friends and relatives, and the engagement is regarded as completed.

3. MARRIAGE

Marriage customs vary in almost every village, and in different families. A lucky day is chosen for the wedding. Generally a man cannot marry a woman who has the same family name. Sometimes people are married when very young—before they have reached teen-age.

A family that has daughters but no sons to continue the family often adopts a son who marries a daughter, taking the family name. Of course the children have the same family name and belong to the

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[30] Report on research in western Szechwan, The Chinese Ministry of Education, pp. 21-23, 1943.

same family. The writer heard of one family in which this had been practiced for three generations.

If an older brother dies, leaving a widow, a younger brother marries the widow, and the children that are born to them belong to the deceased brother. An older brother cannot marry the widow of a younger brother, at least in some villages. If there is no younger brother to marry the widow, she may be married to a cousin of her husband, and the children born belong to her first deceased husband.

A Ch'iang who has attained to official rank under the Chinese government prefers not to marry a Ch'iang woman of lower rank, and often marries a woman of another ethnic group who is in a family of similar official rank. The headman at Chiu-tzū-t'eng in 1933 had married a Chia-jung woman, and in 1942 the official at P'u-wa had married a Chinese woman who could not speak the Ch'iang language and did not understand Ch'iang customs.

During a wedding at Ho-p'ing-chai the bride and the groom are each given a cup of wine. Each drinks half of his or her cup of wine, then gives the cup to the other, who drinks the remainder of the wine.

In 1933 the writer was told that near Ho-p'ing-chai and Lung-ch'i-chai the bride was taken to the home of the groom in a "flowery sedan chair," or a much decorated bridal sedan chair. On arrival two persons helped the bride into the house, where she and the groom kowtowed to the house gods, the parents and grandparents of the groom, and to other relatives and friends. At Ho-p'ing-chai in 1941 it was stated that the bride rode to the groom's home in an ordinary sedan chair, escorted by her brothers and sisters, but not by her paternal uncles; that the groom's family sent two boys and two girls 10-odd years old to help escort the bride. On their arrival at the home of the groom, the bride and the groom bowed to the house gods, the parents and grandparents of the groom, to the groom's uncles, then to other friends, relatives, and guests.

Of course there are always wedding gifts and at least one wedding feast.

Divorce is almost nonexistant among the Ch'iang. In rare cases when a man and his wife are not harmonious he sells her to another man, who takes her as his wife. An agreement is written in Chinese and sealed by the imprint of the husband's palm. In the agreement he promises not to make any trouble with the new husband or his former wife, and not to require the new husband to pay him more money in the future.

Sometimes a priest is invited to perform a religious ceremony as part of the wedding. He burns cedar twigs and possibly incense sticks as incense, chants his liturgies, and worships the gods at the shrines on the housetops. He informs the gods about the marriage, and invokes their blessings on the young couple.

The following information about Ch'iang marriages, apparently true in one or more Ch'iang localities, is from the previously mentioned publication of The Chinese Ministry of Education: [31]

When the young people are regarded as grown up, the man's family sends to the family of the woman a gift of wine, and notifies them that the time has come for them to prepare for the marriage. This is generally done during the sixth or seventh lunar months. From this time on the young people must not speak to each other, even if they happen to meet. The marriage usually takes place during the winter or near the end of the lunar year.

The day before the wedding the parents of the groom send from four to six people to escort or to fetch the bride. They take with them gifts, such as 6 Chinese feet of red cloth, 11 Chinese feet of rope, 1 comb, a bundle of firecrackers, a pair of red candles, 2 jugs of wine, cloth, and money. All these are placed on a large wooden platter, carried to the bride's home, and presented to her family. The firecrackers are set off when they arrive at the home of the bride. When the bride and her relatives hear this, they all weep to show their regret at parting. When the people from the groom's home enter the door, the relatives of the bride fire off guns to welcome them. The people from the groom's home greet and congratulate the parents. The family of the bride light the candles and burn incense. They warm the wine, first pouring some in bowls or cups and offering it to the gods. After supper, the hosts and guests, relatives, and friends drink wine together. At the supper are those who came from the home of the groom to escort the bride, and friends and relatives of the bride.

After supper the relatives and guests are encouraged to drink the wine according to their ages, beginning with the oldest. Sometimes and in some localities there are folkdances and singing. A typical song on this occasion praises the parents who worked hard to bring the bride up to womanhood. Now that she is leaving, it is hoped that after her arrival at her husband's home, she will be respectful and live peacefully with the brothers and sisters of the groom and will not bring shame to her family. During the singing friends and relatives are likely to weep. Later the unmarried girl friends give the bride

[31] Report of research in western Szechwan, The Chinese Ministry of Education, pp. 21-23, 1943.

some embroidered shoes, and these girls join in the singing. Sometimes the singing and dancing continue through the whole night.

At some time later in the night the girl friends and others sing that when a girl is grown up she has to get married, so one need not be sorry. If the bride is filial to her parents-in-law and she and her husband love each other very deeply, they will live happily together to the end. The bride sings in reply expressing regret at leaving her relatives and friends, and saying that she cannot help crying and being sorry to leave.

Next morning the bride, dressed in her wedding clothes, is carried on the back of her older brother to the family altar. If she has no older brother, some other male relative will do this. The parents sit near the altar while the bride kneels and kowtows, saying goodby to the ancestors and to the gods. After this the older brothers and sisters of the bride give her some chopsticks, and the older brother carries her on his back through the door. Before she enters her bridal chair (sedan chair), she throws the chopsticks over her shoulder behind her, and they are picked up by an older brother and his wife. This signifies that after the bride has left the family, they will always think of her while they are eating with the chopsticks.

After the bride gets into her bridal chair (in some localities the sedan chair is not used, but she rides on a horse or is carried on the back of an older brother or another male relative), six or eight older brothers and girl friends and those sent from the home of the groom escort her to her new home, most or all of them riding on horseback. At the door of the groom's home, members of his family give her some money and welcome her. No pregnant woman is allowed to be persent at this time.

During the wedding there is a master of ceremonies who says, "This is a lucky day, and heaven and earth are open wide. The bride has arrived, and everything is lucky. On the east side peach blossoms are blooming, and on the west side apricot blossoms are blooming. Flowers and trees are smiling at each other to welcome the bridegroom into the hall." At this time the bridegroom enters, and soon afterward the bride also comes into the room. The groom stands to the left and the bride to the right. The master of ceremonies calls to the bride and the groom to kowtow three times, "kneel, arise, kneel, arise, kneel, arise," and the young people kowtow accordingly. Then they kowtow four times to the groom's ancestors. Then the master of ceremonies says, "The ceremony is over. Let the groom remove the bride's veil. Let the groom go to the central hall and the bride to her room." After the bride enters her room he says, "Heaven and earth are long. Let there be long life and happiness, and a houseful of children and grandchildren for the new couple." This is the end of the ceremony.

Three days after the marriage ceremony, the bride and the groom bow or kowtow to the parents and other older relatives of the groom. Then they go to the home of the bride, carrying gifts with them. The gifts may be a black or a white sheep or goat, some lard, a pair of red candles, and other things. They remain 3 or 4 days, during which time they are feasted, and then they return to the groom's home. Later the bride returns to the home of her family, remains there until New Year, which is generally not a long time, and then returns to the groom's home.

We need to remind ourselves that these customs vary in practically every village and in each family.

The Ch'iang consider it to be shameful to be without offspring. To them it is therefore a disgrace not to be married, and there are no bachelors or old maids among the Ch'iang.

Some of the writer's informants among the Ch'iang stated, as noted above, that if an older brother dies a younger brother is under obligation to marry his widow, but that if a younger brother dies an older brother is not allowed to marry his widow. On the other hand, the report on research in western Szechwan by the Chinese Ministry of Education states that the older brother may also marry the widow of a younger brother.[32] This is very probably true among most of the Ch'iang people.

People who have the same family name are regarded as members of the same clan, and do not marry each other.

4. BIRTH

Until very recently there were no trained physicians, midwives, or nurses in the Ch'iang region. A small hospital has been opened at Wei-chou and a dispensary at Li-fan by the Border Service Bureau of the Church of Christ in China, but they reach only a limited number of the Ch'iang people. The ordinary Ch'iang midwife cuts the umbilical cord with scissors that have been washed in cow manure and does her work with hands, scissors, cotton, cloth, and other materials and implements that have not been sterilized. The natural result is that the death rate of mothers at childbirth is high, and that of new-born babies is very high.

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[32] Report on research in western Szechwan, The Chinese Ministry of Education, pp. 21-23, 1943.

For 40 days after the birth of a child, the mother must not leave her home. She is given presents of food and clothing by her relatives, and the girl's relatives are invited to a feast, and the child is given a name. At Ts'a-to the writer was told that the mother might be given a peck of ordinary rice, a bowl of wine rice, 100 eggs, 10 catties of pork, clothing, shoes, and other similar presents.

When the new-born baby is 40 days old, a ceremony of initiation is performed by the priest in front of the altar on the housetop or at the altar in the sacred grove. A goat is offered for a boy baby, and a chicken for a girl. A white string is tied around the baby's neck, which in some places is cut off and placed on the altar, and in other localities is left on the neck of the baby until it falls off. Blood of the sacrificial goat or chicken and melted fat are daubed on the forehead of the child. In some districts the child is given its name at this time.

As persons grow older and have children, birthdays are often celebrated. These celebrations grow more important on the fiftieth, sixtieth, seventieth, eightieth, ninetieth and one-hundredth birthdays. More honor is shown to great-grandparents than to grandparents, and to grandparents than to parents, according to rank and age. Husbands are more highly honored than their wives, brothers than sisters, older children than younger children.

There is a feast, and numerous guests and relatives are invited. Many of these bring presents such as rice, eggs, shoes, wheat biscuits, vermicelli, sweetmeats, candles, and firecrackers. At the table and elsewhere the old person is given a seat of honor, and many kowtow to him or her, or at least bow and express their congratulations and good wishes.

5. SICKNESS

While the Ch'iang are physically strong, diseases are very common among them, for they have little knowledge of the laws of health and sanitation. Many of the poorer families suffer from malnutrition.

The Ch'iang believe that all diseases are caused by demons, and when ill they seek the aid of the priest, who performs elaborate ceremonies of exorcism to remove the demon or demons that are causing the trouble. The writer has witnessed a number of these ceremonies of exorcism that were performed by priests, and some of these will be described later.

On the first floor of Ch'iang homes are uncovered latrines and pigpens, which often swarm with maggots. The remainder of this floor is covered with straw, twigs, and leaves which remain there for weeks and become saturated with the urine and manure of the domestic animals. The unsavory air and smells rise into the rooms above, where the air is often smoky and the windows few and small. The inmates and visitors have the habit of spitting on the floor, and there is also the night soil of dogs, cats, chickens and other animals that are allowed to roam about. All this means that the floor is covered with germs. Babies playing on the floor get the germs on their fingers and then into their mouths. Sweeping stirs the germ-laden dust which gets into the lungs. Fleas, flies, lice, bedbugs, mosquitoes, and rats help spread disease. Smoke causes eye troubles, and colds easily turn into pneumonia. Epidemics of dysentery, measles, smallpox, typhoid, and other diseases spread rapidly among the people. Above O-erh, near the timber line, the writer was shown a large stone house which was unoccupied. During an epidemic every person in that house died. Believing that this was the work of demons, nobody after that was willing to live in the house.

Medicines are often misused so that they are harmful and sometimes cause death. Practitioners who call themselves doctors are sometimes worse than useless. At Mu-shang-chai the writer saw a Ch'iang priest, with an unsterilized needle, practice acapuncture on a Ch'iang woman's hand. He pounded the big needle deeply into the flesh in several places, evidently to cure rheumatism. It pained her, and she cried out "Ay-yah." There was danger of infection from the wounds. A Ch'iang friend at P'u-wa told the writer about the death of his daughter. She had a discharge in one of her ears, and the doctor cleaned it by squirting into it unboiled and unsterilized water. She died the next day with severe pains in her head.

6. DEATH AND BURIAL

In spite of their apparent good health and physical strength, the death rate among the Ch'iang is very high. In 1941 the writer endeavored to conduct a survey of Ch'iang families to learn the approximate death rate. It was evident that of 1,000 births, less than 250 reached maturity. The percentage is much smaller than that, for babies that died under 2 years of age were not reported. The Ch'iang have a theory that babies that are stillborn or die at a tender age are not human beings at all, but a kind of demon that causes a woman to become pregnant, then is stillborn or dies soon after birth in order to cause troubles and hardships to the parents. Such babies are not buried in coffins or cremated. A hole is dug in the ground, and the corpse is thrown in and covered with dirt.

We have referred to the high death rate of women at childbirth and of new-born babies. There is also a high death rate from diseases and accidents such as falling over cliffs, drowning, being attacked by wild animals, snake bites, etc.

The Ch'iang believe that dreams are actual experiences. During dreams the soul is often away from the body and is in the locality where the dream is supposed to take place. During sleep, fainting, and unconsciousness, the soul wanders away, and if it does not return, the person dies. When it is feared or believed that the soul has wandered away, friends or relatives try to call the soul back. Soon after death the priest performs a ceremony of calling back the soul.

The writer once heard a mother, whose child was so sound asleep that it could not easily be wakened, calling back the soul of her child. In a loud, wailing tone she mentioned the child by name and urged it to return. Every time she called, friends and relatives who were present replied, "He has returned."

As soon as it is known that a person is dead, there is weeping. The person's newest and best clothing is put on him, and he is placed in a coffin. For 2 or 3 days he is left in the home, after which he is carried out in the coffin and cremated or buried. Generally a priest performs a ceremony to open the way of the soul to the other world.

The Ch'iang people say that formerly they did not bury in graves, but used cremation only. At present cremation is the only method in remote villages where Chinese influence is not strong. In localities where there is a strong Chinese influence, all are buried in graves excepting babies, whose burial has been described, and persons who die violent or unusual deaths—women who die at childbirth, people who are murdered, or die by drowning, falling over cliffs, from snake bites, from attacks by wild animals, from hanging, bleeding to death, etc.—all such are cremated.

Nearly every village has several crematory houses, each of which is used by people having the same family name. These houses are small roofed buildings about 10 feet square. Each house is set on a stone base that rises about a foot above the ground. The sides are not boarded up, but there are large wooden posts at the corners, and between them small wooden posts a few inches apart. Before each cremation eight or more men lift the entire building off its base and place it at one side. After the fire of the cremation has died out, the building is again put into place. The cremation is performed inside the stone foundation.

At Lung-ch'i-chai there is a large common grave which looks like a Chinese tomb. On the outside there is one large door, and inside there are two which are openings into two inner chambers or rooms. The doors are never closed. The cremation is done in two wooden sheds or crematory houses nearby, which are in a poor state of repair. The ashes of the men are deposited in the section of the tomb on the right (on the left or place of honor when one is facing away from the tomb), and those of the women on the left. The ashes of a great many people have been deposited here.

Near the place of cremation is a flat stone. The coffin is placed on this stone while the relatives perform a funeral dance. Then the coffin is carried to the place of cremation and the cremation takes place while the priest chants the "sacred books." The relatives weep while the coffin and the corpse are burnt to ashes. A bowl or jar is broken and the fragments thrown among the ashes. Next morning, after the fire has died out, the relatives come and gather up the ashes and deposit them in the tomb nearby.

In cases of burial, sometimes a shallow hole is dug in the ground and the coffin placed inside, and sometimes the coffin is simply set down on the surface. A mound of dirt is erected over the coffin, and a tombstone placed in front. Sometimes sacred white stones are placed on the tops of the graves to help keep away demons.

Near Ho-p'ing-chai and Ts'a-to a small house of two or three stories is sometimes built for cremation, furnished much like an ordinary house, and the coffin containing the corpse placed on the first floor. The largest of these houses, used by the better-off Ch'iang families, have 3 stories with 18 wooden pillars. The priest performs his funeral ceremony by dancing and chanting his sacred books and incantations. The house is set on fire and the corpse cremated. Often here and elsewhere two wooden birds are placed on the coffin or nearby before the cremation, and these, believed to represent the soul of the dead person, are carried away to their homes by sons of the deceased and there preserved and honored, or onlookers seize them and take them to their homes, where the sons redeem them by money or by a gift, taking them home to be honored and preserved.

When relatives and guests come to a funeral, they generally bring as presents such things as money, chickens, goats or sheep, wine, or spirit money. They remain and at funeral feasts eat the food and drink the wine and tea of the family of the bereaved.

When a wife dies, generally her relatives come before the funeral and make careful inquiries and investigate to find out whether or not adequate preparations have been or are being made for the funeral. They also investigate the nature of the disease or other cause of death, and whether or not reasonable attempts were made to prevent death. In some localities there is a taboo against using funeral clothing made of flax or wool. The relatives of the deceased woman may raise a quarrel if her funeral clothing is not good enough.

The corpse usually remains in the home for 3 days, after which the funeral is held, which must be on a lucky day. Where Chinese influence is strong, there is a ceremony to ferry the soul of the deceased across the river to Hades.

Near Wen-ch'uan, wealthy people build a funeral house of three stories, place the body of the deceased inside the house, then cremate the dead by setting fire to the house. Those less wealthy build a house of two stories, and poor families often cremate without erecting any such house at all. Still others do not cremate, but dig a hole, lower the coffin into the hole by means of leather or other straps, and cover the coffin with a mound of dirt.

V. RELIGION

1. THE SOUL AND THE FUTURE LIFE

The Ch'iang do not have a very definite idea of life after death, and like the language and the customs, it varies with different people and in different localities. Some say that after death the soul goes to a dark and shadowy place. Some have heard the Christian doctrine of heaven and hell, and many are acquainted with the Buddhist and Taoist beliefs concerning hell and paradise.

With many the idea of the soul does not seem to be very definite or clear, while others have adopted the belief of the Chinese in three major souls and seven lesser souls. As has already been stated, it is believed that the soul may leave the body during dreams and while fainting or unconscious and that if the soul does not return the person will die. Priests endeavor to call back the souls of persons who have recently died, and failing in this they perform a ceremony to open the way of the soul to the other world. The writer has heard mothers calling back the souls of children whose souls they believed had wandered away.

Such memorial ceremonies as the Ch'iang practice correspond to those of the Chinese, from whom they have probably borrowed them. They affirm that they love their ancestors, living and dead. Said one, "If we offer food or burn paper money, what good does it do? If we offer food or wine, they cannot eat or drink it. Spirit money when burnt turns into smoke." Some believe in reincarnation, and many believe in fate. Some, like the Chinese, commemorate their ancestors on the fifth day of the fifth lunar month, on the fifteenth of the seventh moon, and at New Year time. Some commemorate their ancestors in their homes on the first, fifteenth, and thirtieth of each month.

2. THE WORLD VIEW

The Ch'iang live on the sides and tops of mountains or in narrow valleys. The climate is cool and semiarid. Near them live the Chia-jung, the Wa-ssŭ, the Lu-hua, the Hei-shui, and the Po-lo-tzŭs, while in the main valleys and in the cities and towns are the Chinese. All these ethnic groups have at different times been dangerous enemies. Wild animals attack human beings, domestic animals, and the crops. People fall over cliffs, are struck by rolling stones, are drowned, are bitten by poisonous snakes, and are sometimes struck by lightning. While it is believed that all these and other calamities are often due to the work of demons, they also believe that nature is surcharged with a mysterious force that may do good or harm. The priests, the gods, and the sacred implements are believed to possess this mysterious power.

In the ceremonies the priests and the gods are believed to make use of this power to heal diseases, to bring good crops, to cause domestic animals to grow and to multiply, and to bring happiness and a satisfying life which includes food, sex, clothing, housing, protection from enemies and the forces of nature, prosperity, numerous descendants, social prestige, and long life.

Wherever the conception of a strange, mysterious potency—in other words, the mana concept—is found, there is also the taboo or taboos. Used in the right ways, this power is beneficial to man, but used in wrong ways it can be very harmful. The following is a partial list of Ch'iang taboos:

The funeral dance must not be used except during funeral ceremonies. Cattle, used for plowing, must not be killed and eaten or used for ceremonial purposes. Women must not plow. After childbirth, the mother must not leave her home for 40 days. During menstruation a woman must not sleep with her husband. People must avoid speaking the word demon. Trees in the sacred groves must not be cut down. The first 3 days after the ceremony in the sacred grove, strangers must not travel on the main roads near this grove. Women cannot be present during the ceremonies on the housetops or in the sacred groves, and during ceremonies inside the houses they must stand at a distance.

3. THE GODS

The Ch'iang are not monotheists, and there is no definite evidence that they ever have been. It is true that Rev. Thomas Torrance, in all his writings about the history, customs, and religion of the Ch'iang, has asserted that the Ch'iang are monotheists.[33] However, no other scholar or scientist who has made a careful first-hand study of the Ch'iang, such as Chuang Hsüeh-pen, the author and traveler, and Prof. Hu Chien-min of the National University of Szechwan, has come to this conclusion. On the contrary, they have affirmed that the Ch'iang worship many gods, and some of them have given lists of the Ch'iang gods.[34] The writer has interviewed a large number of Ch'iang men, both priests and laymen, and every one of them has affirmed or given evidence that the Ch'iang believe in and worship many gods, besides believing that the gods of other racial groups are real gods and worshiping them when they wish to do so. A few have admitted to the writer that they purposely deceived Mr. Torrance. Many have given the writer lists of the Ch'iang gods which, after checking and rechecking, were found to be approximately correct. Translations of the "sacred books" repeated verbally by the priests have revealed long lists of Ch'iang gods on whom the priests call for help during their ceremonies.

While the Chinese and the Tibetans make images of their gods, the Ch'iang gods have almost no images. The two exceptions are the god Abba Mula or Ndjei Dzu, the patron deity of the priest, and the King of Demons, whose head is sometimes carved on the top of the sacred cane.

In a very few localities the supreme god is Shan Wang 山王 or the mountain god, but in nearly all communities he is called Mu-bya-sei mʌ¹ bja·² sei²), Mu-byei-sei, Mu-bya-shi, Mu-ta-be-ts'e, M-byei-sei, or Ma-byei-chi. Ch'i, sei, shi or ts'e means "god," and the other two syllables mean "sky." Literally it means sky god. At least at Mu-shang-chai, Lung-ch'i-chai, and Tung-men-wai, where Christian influence has been strong, he is called Abba Ch'i. Abba means "father," and this word, used also in the same sense among the Hebrews, is used

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[33] Torrance, Rev. Thomas, The history, customs and religion of the Ch'iang, p. 28. The Shanghai Mercury Ltd., Shanghai, 1920. The religion of the Ch'iang. Journ. North-China Branch Roy. Asiatic Soc. vol. 54, pp. 151-152, 1923. China's first missionaries, London, Thynne & Co. Ltd., 1937.

[34] Hu Chien-min, Beliefs and practices of the Ch'iang, pp. 10-16. Frontier Studies, 1941.

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with this meaning very widely in the China-Tibetan border and in many other parts of China. The writer has been informed that abba for "father" is used by the Wa-ssŭ, by the Chia-jung, by the Chinese in the Ch'iang region, in parts of Yunnan, in northern Szechwan, near Shanghai, in Mukden, and in Fukien, Kuangtung, and Chekiang Provinces. Some Ch'iang have stated that the word abba is applied principally to Chinese gods, but in most localities among the Ch'iang it may be used with any god, and is always applied to the male ancestor god, Abba Sei.

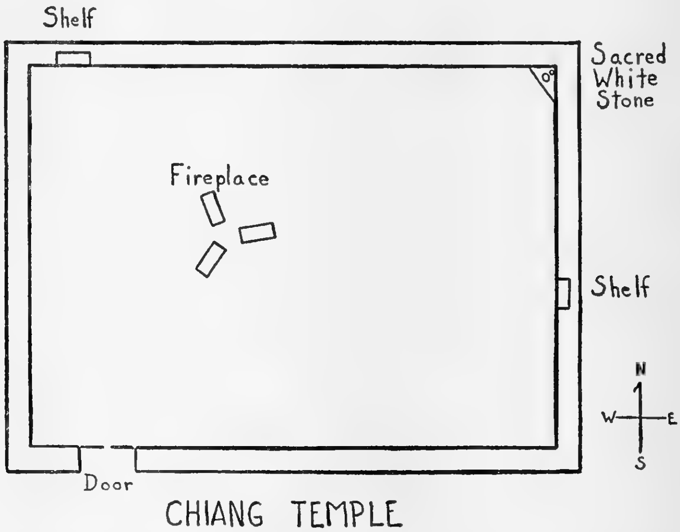

Fig. 3.—Drawing of a typical Ch'iang temple or sacred shelter in which part of the community ceremony of paying the vows is performed. The fireplace consists of three stones chipped into right angles, which are the fire god, the male ancestor, and the female ancestor.

Generally the Ch'iang worship, in addition to the Ch'iang gods, as many of the Chinese house gods, kitchen gods, and other deities as are worshiped among an equal number of Chinese. They regard Chinese gods as real deities and worship them.

The Ch'iang identify Mu-bya-sei with the Taoist supreme god, the Pearly or Jade Emperor. It seems to the writer that the conception of the Ch'iang in their god Mu-bya-sei is closely related to that of the Chinese T'ien or Heaven, the supreme god of the Chou people with whom the Ch'iang united against the Shangs, a conception which still persists among the Chinese people.

There are five great gods among the Ch'iang, who are worshiped in the sacred groves and on the housetops, where there is generally only one shrine for the worship of these five gods. However, in the sacred grove at Lo-pu-chai there are five different shrines, one for each of the great gods, and between Ho-p'ing-chai and Ts'a-to the writer saw a house on which there were five shrines instead of one. At Ho-p'ing-chai they are as follows:

1. Mu-bya-sei (mʌ^1 bja·^{2} sei^2), the supreme god. He gives good crops and rain, controls and protects people and families from illness and other calamities, and helps people if their hearts are good.

2. Ru-be-sei (ʒ(x)ʌ^2 bɛ^2 sei^2), who controls the earth and the soil, causes rain and good crops, protects people from illness and other calamities, and helps them. At least in some localities this is a female deity.

3. Lo-lo-sei (lo·^{1} lo·^{2} sei^2). He controls the snow mountains and the shrubs and herbs and trees that grow only a foot or two high near the snow line.

4. P'i-ru-sei (P'i^1 xu^2 sei^2), who controls the forests and governs and protects wild animals and birds.

5. Su-mu-sei (Su·^{1} mʌ·^{2} sei^2), who also controls forests and protects wild animals and birds.

The five great gods of Lo-pu-chai are:

1. Mu-bya-shi (mʌ^1 bja^2 ʃi·^{2}), the supreme god. He is also called Abba Shi (a·^{2} ba·^{2} ʃi·^{2}).

2. Ro-bo-shi, the earth deity (ʒ(r)o·^{2} bo·^{2} ʃi·^{1}).

3. Ts'u-ga-shi (ts'ʌ^2 Ga·^{2} ʃi·^{1}), who controls grain in the fields.

4. Shi (ʃi·^{1}), the female spouse of Ts'u-ga-shi.

5. Shi-wo-shi (ʃi·^{2} wo·^{2} ʃi·^{1}), the Chinese god Kuan Shen Ren, Lord of Szechwan. He causes it to rain.

All these five great gods are worshiped on the housetops and in the sacred groves during important ceremonies. The names of the gods and even the gods themselves vary in the different localities.

In every village there are 12 lesser deities that are worshiped and considered together. As might be expected, they vary in different localities. At Ho-p'ing-chai they are as follows:

1. Ji-gwe-sei (dʒi·^{1} gwɛ^2 sei^2), the family or house god who protects the family and its inmates.

2. Stu-ja-sei (stu·^{2} dʒa·^{1} sei^2), who controls and protects all domestic animals and fowls.

3. Ndzï-ju-sei (ndzə^1 dʒu·^{2} sei^2). He controls wealth, gold, silver, etc.

4. Yi-mu-sei (ji·^{2} mʌ^2 sei^1). She gives sons, protects women after they have conceived and during childbirth, and protects children.

5. Mya-wei-sei (mja·^{1} wei^2 sei^2), a goddess who protects men and boys.

6. Sti-per-sei (sti·^{1} P'ʌr^2 sei^2). This deity protects women and girls in matters connected with childbirth.

7. Do-dzu-sei (To·^{2} dzu·^{2} sei^1), a door god on the right side of the door, who keeps demons out of homes.

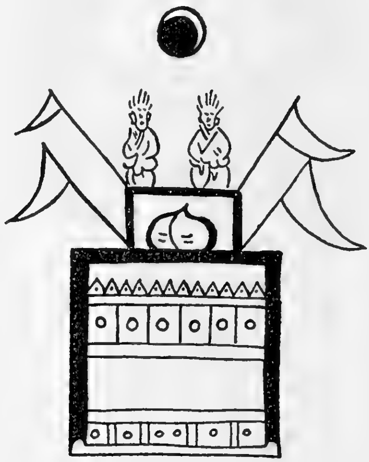

FIG. 4.—Drawing of a shrine, copied from a Ch'iang priest's sacred book used only for divination. The humanlike figures at the top are, right, the god of the sky or heaven, left, the earth goddess. The priest said that the three other great gods should have been drawn but that there was not room for their pictures. Drawing in the square beneath the figures resembling a peach is supposed to represent a large sacred white stone. (It is poorly shaped.) The 12 triangles in a row at the top represent 12 small white stones for the worship of the 12 lesser gods. The 12 small round holes represent cavities for burning incense to the 12 lesser gods. On either side at the top are four sacred white paper flags. The circles at the top may (?) represent the sun being eclipsed by the moon. Here is definite and concrete evidence that the Ch'iang are not monotheists.

8. Nu-nga-sei (nʌ^2 ŋa·^{1} sei^2), a door god on the left side of the door who also keeps out demons.

9. Sbe-pri-sei (sbɛ^2 Pri^1 sei^2), who controls the five grains after they have been harvested and are in the house or bin.

10. Mo-bo-sei (mo·^{2} bo·^{1} sei^2), a fire god who controls fire in the home and prevents it from burning the house.

11. A-ba-sei (a·^{1} ba·^{2} sei^2), the male ancestor. He does not control anything, but is revered and worshiped.

12. A-ta-sei (a·^{1} Ta·^{2} sei^2), the female ancestor, who also controls nothing, but is worshiped and revered.

We have mentioned the Ch'iang stoves consisting either of three stones chipped so as to form angles, or of strong iron rims or bands with three iron legs. One of these, the iron leg that has in it a small hole in which an iron ring hangs, or the corresponding stone leg, is the fire god. At Lo-pu-chai he is called Mo-go-i-shi (mo·² Go·²i·¹²ʃi·¹), and at Ho-p'ing-chai Mu-bo-sei (mʌ¹ bo·² sei²) or Mo-bo-sei (mo·¹ Bo·² sei²). The other two legs are A-ba-sei, the male ancestor, and A-ta-sei, the female ancestor. This might be called the Ch'iang triad.

Generally the sacred white stones are not believed to be deities. There are, however, some white stones and other stones not white that are worshiped as living gods.

The 12 lesser gods at Lo-pu-chai, as named and explained by the local Ch'iang priest, are:

1. Mo-ts'o (mo·¹ ts'o²), male, regarded as the equivalent of the ancestors.

2. Tsche-shyo-gi (tʃɛ² ʃjo·² dʒi·¹), male, who controls, helps, and protects all domestic animals.

3. Zyei-dje (ʒ̊eï² dzɛ¹), male, who controls and helps men and women when cutting firewood and grass for making fertilizer (thrown on the floors of the animal pens and rooms in the homes).

4. Ŭ-mo (y² mo·²), male, who helps obtain numerous descendants.

5. Shi-shto (ʃi·² ʃto·¹), male, who assists all who have trades—carpenters, masons, even priests, helping priests remember their ceremonies and incantations.

6. Mbje-p'er (mbjɛ¹ pδ¹), the male ancestor, who helps men and boys.

7. She-p'er (ʃɛ¹ pδ·¹), the female ancestor, who helps women and girls.

8. Stro-je (Sᴛʀo·² dʒɛ¹), male, who controls people's souls. People worship him when they are worried lest their souls depart and they die.

9. Shi (ʃi·¹), female, who controls grains in the bins or granaries.

10. Mo-go-i-shi (Mo·² Go·² i·² ʃi·¹), male, the fire god who controls fire and protects from fire.

11. La-nga-du-du (la·² Ŋa·² Tu·² Tu·²), male, who prevents people from coming in and quarreling.

12. Ch'ai-shen (ts'ai² sʌn²) (no Ch'iang name), male, the god of wealth.

The following is the list of 12 lesser deities as given by Mr. Kou, the priest at Mu-shang-chai, with such explanations as he was able to give.

1. Nyei-Wüi (ɲei^{2} wyi·^{2}), a god on the northwest corner of the main room in the house.

2. Tzo-wü (tzo·^{2} wy^{1}).

3. P'u (p'u·^{2}).

4. Tshu (tʃ'u·^{2}).

5. Ŭ-mu-p'i (y^{2} mu·^{2} p'i·^{2}), who is above the wall of the house near the center.

6. Ŭ-du-p'e (y^{2} Tu·^{2} p'ɛ^{2}), who is below Ŭ-mu-p'i.

7. Mu-nga-dwe-dwe-dze-swe-tshi (mu·^{2} Ŋa·^{2} Twɛ^{2} Twɛ^{2} dzə^{2} swɛ^{1} tʃi·^{2}), who is on the central pillar of the house.

8. P'er-shi-jei-ts'e-mye (p'δ^{1} ʃi·^{2} dzei^{2} ʃi·^{2} tʃɛ^{1} ɱɛ^{2} (ɱjɛ^{2})). On the west wall of the house.

9. Dzu-si-ji-go-wa-la-tshe (dzu·^{2} si·^{1} dʒi·^{2} Go·^{2} wa·^{1} la·^{2} tʃɛ^{2}), the god of the big water jar.

10. Nyu-ge-ze (ɲu^{2}· gɛ^{2} zɛ^{2}), the god on the right side of the front door.

11. Su-gu-be (sʌ^{2} gʌ^{2} bɛ^{2}), the god on the left side of the front door.

12. Jei-tzu-ze-tzu-tse-mye (dʒɛi^{1} tzʌ^{2} zɛ^{2} tzu·^{2} ʃu·^{2} tsɛ^{1} ɱɛ^{2}), the god of the four corners of the house.

There are white stones worshiped as deities at O-erh, at Ho-p'ing-chai, and at Hsiao-chai-tzu. At Chia-shan-chai in the temple is a white stone worshiped as a local deity. It is on a stone altar on the wall above a table and is called White Stone King. There is another white stone on the floor of the temple which is the fire god.[35] In the sacred grove at Lung-ch'i-chai is a slender black stone extending about 22 inches above the ground which is worshiped as a local deity. In the temple is a white stone that is worshiped as a mountain god. In the upper village of K'a-ku is a shrine in which is a white stone that is worshiped by some as the grain god, and by others as Ts'ang Chieh 倉頡, a Chinese god of scholars. Near Hsiao-chai-tzŭ and Lo-pu-chai is a large rock that is not white, as big as a Ch'iang house, which is worshiped as a god that heals diseases.

On a mountain across the river from Li-fan is a temple called Pai (white)-k'ung-ssŭ. In it are three large white stones that are worshiped as gods. Four Chinese priests care for the temple and its gods, and Ch'iang, Chinese, and people of all other ethnic groups in this region worship these gods in order to be healed of their diseases.

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[35] Report on research in western Szechwan, The Chinese Ministry Education, Division of Mongolia and Tibet, *chap.* 2, Worship of the White Stone, Division 1, 1943.

In their worship they burn incense and make offerings. Yak and sheep and cattle are sometimes released near this temple, not as sin-bearers, but as a means of gaining merit by releasing or saving life, or lives, of creatures that would otherwise in due time be slaughtered and eaten.

There are trees that are worshiped as gods. Near Ho-p'ing-chai such trees are called P'o-shya-sei (P'o· ʃja· sei). About 15 *li* from T'ao-tzŭ-p'ing is a tree that is worshiped as a deity. At Ru-ta-chai (ɹʌ^2 Ta·^{2} tʃai^1), which is near Chia-shan-chai, there is a Chinese temple in a sacred grove. Behind this temple is a great pine tree called Me-p'ok-sei or pine tree god and worshiped as the chief god of Ru-ta-chai. Incense is burned to it and offerings are made to it—on important occasions a black goat and two chickens.

Every village or locality has a special local deity, so that theoretically the gods of the Ch'iang are as numerous as there are villages and places that have names. When the priest chants his "sacred books" in his ceremonies, he mentions many localities, and with each locality its local god, calling on them to come and assist him in the ceremony. Lists of those from Lo-pu-chai and Ho-p'ing-chai will be found in the section devoted to sacred books or sacred chants. Below is the list as found in the "sacred books" of the priest at Mu-shang-chai.

Mu-shang-chai, the god Gwe-be-ch'i (gwɛ^2 bɛ^1 tʃi·^{2}) (the founder).
Pu-lan-ch'eng, the god Bo-o-sei (bo·^{2} o·^{1} sei^2, or bɛ^2 sə^2 o·^{1} tʃei), (the founder).
Lung-chĭ-chai, Ge-tsu-ch'ei (gɛ tsu·^{1} tʃei^2) (the founder).
P'u-wa, the god Mu-ni-o-chi or ch'ei (mʌ^2 ni·^{2} o·^{1} tʃi·^{2} or tʃei^2).
Lung-chĭ-chai, the god Jei-t'a-ch'i (dʒei·^{5} t'a'^{1} tʃi·^{2}) (local deity).
Bu-lan-ch'eng, the god Ge-ts'u-ch'i (gɛ^2 ts'u^2 tʃi·^{2}) (local god).
Ta-han-chai, the god Ru-wa-sei (ru·^{2} wa·^{2} sei^2).
Chin-tu, the god Ch'iung-tu-sei (tʃjoƆ^2 Tu·^{1} sei^2).
Hsin-ch'i (upper), Zu-kwe-sei (zʌ^2 kwe^1 Sei^2).
Hsin-ch'i (lower), Gan-dzu-sei (gaen^2 dʒu·^{2} Sei^2).
Kwei-chai, T'a-bo-sei (t'a·^{2} bo·^{1} sei^2).
P'a-p'o-sei (p'a^2 p'o·^{1} sei^2).
Seh-ro-chai, Ze-jo-sei (zɛ^2 dʒo·^{2} sei^2).
P'u-ch'i-chai, Ze-jo-sei (zɛ·^{2} dʒo·^{1} sei^2).

The heads of many of the sacred canes used by the priests to exorcise demons are carved so that they resemble human heads. These represent the god who is king of demons and assists the priests in controlling the demons.

Every priest has a patron deity called Abba Mula, Mo-lo-sei, or Abba-mo-lo-sei. In a few localities he is called Ndjei Chu, or Nyei-dzu. He is the patron or guardian deity and instructor of the Ch'iang priest, and without him the priest could no nothing. It consists of a skull of a golden-haired monkey wrapped in a round bundle of white paper. Its eyes are old cowry shells or large seeds. Inside are also dried pieces of a golden-haired monkey's lungs, intestines, lips, and fingernails. It is so wrapped that the face of the skull is visible at one end, and the other end is closed. After each ceremony in the sacred grove, the priest wraps another sheet of white paper around it, so that it gradually increases in diameter. Some priests will not allow another person to touch his Abba Mula and only the priest worships this god.

There is a god of the great roads who is worshiped on the great roads. It is like the wayside deity of the Chinese, except that there is no image. At Ho-p'ing-chai he is called Z(or R)ei-shwa-sei (ʒei^{2} ʃwa·^{1} sei^{2}). A thunder god who is a lesser deity in the sky, is called at Ho-p'ing-chai, Mu-er-go (mʌ^{2} δ^{2} go^{1}). There is a creek god called at Ho-p'ing-chai K'we-swa-sei (K'wɛ^{2} swa·^{1} sei^{2}). This list of the Ch'iang gods is far from complete.

The gods of the Chinese and the Tibetans are regarded by the Ch'iang to be real, living deities, and the Ch'iang seem to be very willing to worship them when they consider it to be to their advantage to do so. Moreover, some of the Chinese gods meet what the Ch'iang regard as real and important needs and are worshiped as if they were Ch'iang gods.

Among the Chinese gods that the Ch'iang worship in their homes, in wayside shrines, and in Chinese temples are Wu Ch'ang and Mei Shan, the two gods of hunters; Lu Pan 魯班, the god of carpenters; the two Chinese door gods; the kitchen god; T'ai Shan Shih Kan Tang 泰山石敢當; the t'u-ti 土地; Kwanyin, the goddess of mercy; the goddess who heals measles and smallpox; the goddess who gives sons; Shan Wang 山王 the mountain god; the river god Wang I who also helps lumberman in the forests; Lin Kuan 靈官 the efficacious god of the Taoists; Lao Tzŭ the founder of Taoism; Iang Miao P'u-sa 秧苗菩薩 or Iang Miao T'u-ti, the god of growing grain; Shui Kuan the water god; the earth mother; the horse god; the god of cows and buffaloes; the god of sheep and goats; Ch'uan Chu 川主, the lord of Szechwan; Kuan Shen Jen 關聖人, Yü Huang the Pearly Emperor; Yao Wang the medicine god; Ti Chang 地藏 and Tung Yüeh Wang 東嶽王, the two gods of hell; Ku Wang, the grain god; the military and civil gods of wealth, and the Buddhist gods Wei T'o and Amitabha.

4. THE PRIESTHOOD

The Ch'iang are a reverent and devout people. They consider their religious ceremonies and rituals to be very important, and these must be conducted with exactness, reverence, and decorum. Since they have no written language, their sacred chants, which are their equivalents of "sacred books," are taught by word of mouth, memorized, and passed on from generation to generation, from father to son or from teacher to pupil. Since there must be no incorrectness in the performances and repetitions, there is a special priesthood. The priests, however, are also farmers and have wives and children. They are regarded as very important people and are highly respected by all. They do not have a distinctive dress.

In some places the priest is called a *bi bo*. At Mu-shang-chai he is called a *bi bu*. At P'u-wa he is called a *bi mu*. At Hsi-shan-chai he is called a *bi to*.

One reason that the priests hold a very large place in the lives of the Ch'iang people is the belief that by controlling and exorcising demons he can prevent and heal diseases. He is constantly sought by those who are sick. Moreover, the mysteries in his chants and incantations which others do not understand and the priest himself is often unable to explain, increase the reverence and respect for him and his ceremonies. Add to all this the fact that he is believed to have contact with and the help of the gods, and that he possesses a mysterious, marvelous power that enables him to do very important and unusual things for the good of his fellow men, and it is not difficult to understand why the Ch'iang priest is held in high esteem by the Ch'iang people.

At P'u-ch'i-kou it was affirmed that the red and the white priests wear the same kind of clothing, but that the red priests specialize in the exorcism of demons and also perform the great ceremonies of paying the vows. They asserted that the white priests perform ceremonies to pray for sons and good crops and for rain, ordain priests, and dedicate or initiate infants. The priests, they said, eat any kind of meat and drink wine, but the eating of pepper and pickles is taboo. The white priests perform the great ceremonies of paying the vows to the great gods for families on the housetops and for communities in the sacred groves. The red and the white priests, they said, worship different patron dieties. The patron dieties of the red priests are Sen Hou Tzu (a deified monkey), Sa Ho Sang, and Tsu Sa Chin. The white priests, they said, worship as a patron diety Hsi T'ien Fuh Chu, or Lord Buddha of the western paradise. They said that the red priests use more of the demon language that cannot be understood, and the white priests use more of the Ch'iang language that can be understood. At Hsi-shan-chai it was asserted that red priests primarily emphasize the exorcism of demons and the white priests the performing of the great ceremonies of paying the vows on the housetops and in the sacred groves. In most Ch'iang localities there is no distinction between red, white, or black priests, who are simply Ch'iang priests and who perform all the functions of priests as practiced by the Ch'iang. At Lo-pu-chai, however, the priest said that he belonged to the *Wu Chiao,* or religion of black magic, although he did about the same things and in the same way as the priests do elsewhere.

One who wishes to become a priest must study under another priest from 3 to 15 years, paying well for his privileges, the length of time depending on his ability to memorize. When he has finished his studies, there is a ceremony of ordination. In the sacred grove the old priest repeats his sacred books or rather chants them, until daybreak. At midnight a goat or a rooster is killed. The new priest is ceremonially washed around his eyes with water from a certain waterfall to enable him to see demons. This also purifies him and causes his head not to become confused and his hands not to fumble. The sheep, goat, or cockerel is offered to the gods, then boiled and eaten by those who are present. Each person present also eats a wheat biscuit. All is eaten up on the spot, and the family of the new priest pays for the meat and the wheat biscuits. Thereafter he is a priest, and all know about it and call on him when a priest is needed.

The following are some of the functions of a Ch'iang priest:

1. In the spring he performs a ceremony in which he prays for a good harvest and a prosperous year, promising or vowing in return to perform the great ceremony in the sacred grove in which the vow is paid, generally by the offering or sacrificing of one or more goats, but sometimes of chickens or a yak.

2. On the first day of the fifth, eighth, or the tenth lunar month he performs the great ceremonies in the sacred grove in which he pays the vows. He dances, beats his drum, and chants his "sacred books."

3. He ordains new priests.

4. He performs ceremonies of cremation.

5. He exorcises demons. To accomplish this, he has many different ceremonies and incantations.

6. He conducts funerals, either by burial or by cremation.

7. He performs a ceremony to open the way of the newly deceased soul to the other world.

8. He performs ceremonies at weddings in which he informs the gods that the young couple are married and invokes the blessings of the gods upon them.

9. He performs the ceremonies of setting up new gods in homes.

10. He divines to determine lucky and unlucky days — for funerals, for weddings, to begin a journey, to begin to build a house, and many other things. Sometimes he tells people where a missing person or a lost object can be found. In divining he sometimes uses split bamboo roots, sometimes a book in which there is no writing, but which contains pictures of the 12 creatures of the zodiac and other objects, people, and deities.

11. He makes arrangements with the Earth Mother and the Earth Dragon so that they will permit the deceased to be buried and protect him.

12. Formerly the clothing and some other objects belonging to the deceased were burned, but now they are purified by a ceremony performed by the priest in which he smokes the clothing and other objects over a fire.

13. He informs the gods including the 12 lesser gods that the person has died.

As we have already stated, the priest is one of the most highly respected men in Ch'iang society, and he is always given money or food or other useful objects for his services.

5. THE SACRED IMPLEMENTS

The implements used by the priest in his ceremonies are holy and are therefore treated with reverence and respect. They are believed to be surchargd with supernatural power, so that they add to the efficiency and power of the priest. Their sacredness and potency are believed to increase with age.

1. The hat. This is made of a golden-haired monkey skin and is believed to be very efficacious, greatly adding to the dignity and potency of the priest and his ceremonies. The eyes and ears of the monkey are left on, and the tail is sewed on at the back. The eyes enable the hat to see and the ears to hear, and add to the efficiency of the hat. The tail also adds to its efficiency. The front of the hat is ornamented with old cowry shells arranged in ornamental designs, one or two polished white bones that are said to be the kneecaps of tigers, and sometimes with carved sea shells. These ornaments im-

prove the looks of the hat and also add to its efficiency. Other ornaments believed to add efficiency when used are two cloth pennants, one or two small circular brass mirrors, and one or two small brass horse bells much like sleigh bells, on which the Chinese character *wang* 王 meaning king is carved. Near Wen-ch'uan the priests some-

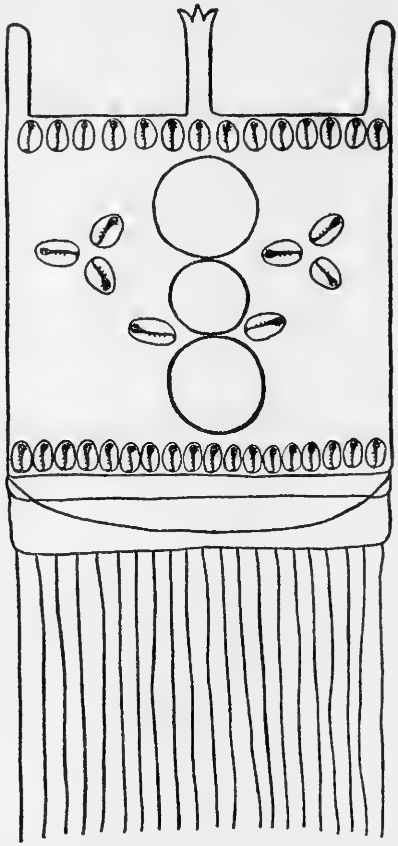

Fig. 5.—Drawing of the ceremonial hat worn by the Ch'iang priest at Mu-shang-chai. It is ornamented by round white bone disks and cowry shells.

times assist the magistrate in praying for rain and in turn are presented with a small, thin silver plaque to be worn on the hat, on which is stamped the Chinese word *shang* 賞, or "reward." This plaque also adds dignity and efficiency.

2. The drum, called at Mu-shang-chai *bo* (bo·) or *mbo* (mbo·²) and at Hsi-shan-chai, Ho-p'ing-chai, and Ts'a-to, *bu* (bu·) or *r bu* (ɹbu·²). One side only is covered with goatskin, and inside is a

wooden handle on which there is generally some simple carving. On one edge strips of paper are fastened to represent hair, and inside there is sometimes a small brass bell which jingles as the priest dances and beats his drum. There is only one drumstick.

3. The sacred cane, which has a sharp iron tip at the bottom enabling the priest to stick the cane into the ground, and sometimes at the top a humanlike head carved to represent the king of demons. The sacred cane must be knotted or rugged in appearance. Sometimes on the side of the cane is the imprint of a wild vine that grew around the limb while the limb and the vine were alive, and at the top a snake head is carved so that the imprint of the vine and the carved snake head give the appearance of a snake coiled around the cane. The snake and the king of demons make the cane more efficacious in exorcising demons, which is the only use made of the sacred cane by the Ch'iang priest. The king of demons controls and commands the demons, and the snake frightens them. This sacred implement closely resembles the sacred cane of the Taoist priests, which is used for the same purpose, and it is very likely that the Ch'iang priests borrowed it from the Taoists, making some adaptations of their own.

4. A circular brass gong, 6 to 8 inches in diameter, concave on one side and convex on the other, with a tapper on the inside and a leather handle on the outside. This is very similar to the ceremonial brass gong used by the Nashi or Moshi and by the black lamas in Tibet and on the China-Tibetan border.

5. A short sword or dagger used to kill the sacrificial goat or cockerel by cutting its throat. It also inspires fear in the demons.

6. An iron or brass seal, on which are elaborate Chinese characters, used to print charms on paper. It is exactly like the seals used to make charms by Chinese Buddhist and Taoist priests and by the Chinese *tuan kungs* or magicians.

7. Carved boards for printing charms on paper. The charms consist of Chinese characters.

8. A leather bag in which the priest puts meat and other things given him for his services.

9. A sacred bundle. It includes horns of wild mountain goats, halves of sea shells, scapulas and other bones of small animals and birds, shoulder blades, feet and claws of hawks and eagles, Chinese brass or bronze coinlike charms, small, round brass horse bells, and tusks of musk deer, wild boars, bear, leopards, tigers, and musk deer.

10. A long, naturally-notched antelope horn which is used in the exorcism of demons. It was identified by Dr. Dolin of the Philadelphia Museum as *Panthrolops hodgsoni,* a Tibetan antelope ranging

from the borders of Kashmir to Chinghai. If a person has a pain in his hand, eye, back, or leg, the priest sticks the point of the horn into the ground, repeats his incantations, pours water into the disturbed ground, and the patient is healed.

11. A brass hollow circle on the outside of which is carved the eight trigrams of the Chinese, and inside of which is a metal object so that the implement jingles when it is shaken during the ceremonies.

Sometimes the Abba Mula or Ndjei Chu of the priest, his patron deity, is thought of as one of the sacred implements of the priest, probably because it is carried about by the priest or his helpers when he performs the great ceremony of paying the vows in the sacred groves.

The sacred ceremonial implements are not destroyed or buried with their owner after the death of a priest. They are either given or sold to another Ch'iang priest who desires to own and use them. Some priests have more than one set of ceremonial implements. Thus these objects, becoming more and more holy and efficacious with age, are passed on from priest to priest, from generation to generation.

6. THE SACRED CEREMONIES

In every home there are ceremonies of various kinds. In some homes there is the worship of the family gods on the first, the fifteenth, and the thirtieth of the month. There are also special occasions of worship and the payment of vows, and weddings and funerals. In these a member of the family officiates, except that on more important occasions the priest is called in. Friends and relatives may attend, but women are regarded as impure and unworthy and are not allowed to attend or witness the ceremonies on the housetops. They can witness the ceremonies inside the house, but must stand respectfully at a distance and cannot participate.

In the spring of the year the priest conducts a ceremony in which he prays for good crops and a prosperous year and promises or vows in return to sacrifice to the gods goats or cockerels, or yak or *p'ien niu*. The date of this ceremony varies in different localities.

The most common sacrifices to the gods are full-grown goats—never a lamb. Very poor people offer chickens. Cattle are not offered, for they are used to plow the soil and should not be killed. More rarely yak or *p'ien niu* (half yak and half cattle) from the highlands are killed and offered. While the "sacrifices" are offered to the gods, only a very little of them is burned. The flesh and the blood are boiled and eaten by the worshipers at the end of the ceremony. What cannot be eaten at this feast is divided up between the families represented, taken to their homes and eaten there.

The great ceremony of paying the vows in the sacred grove is one in which the whole community participates. There are one or more representatives from every family. It is regarded as the most important religious ceremony. The writer persuaded the priest and his assistants in two different villages to perform this great ceremony in his presence, and to permit him to take pictures, ask questions, and make observations. In addition, several priests have given rather complete detailed descriptions of these ceremonies as conducted by them in their sacred groves. The following is an account of this ceremony as performed at Ho-p'ing-chai:

This, the most important ceremony of the year, occurs in different localities on the first day of the sixth lunar month, or the first day of the eighth moon, or the first day of the tenth moon. It is believed that formerly the ceremony was observed in many localities on all three dates, but that in recent years it is observed in each community only once a year. At Ho-p'ing-chai, Ts'a-to, Mu-shang-chai, and Lung-ch'i-chai it is observed on the first day of the eighth moon. At Lo-pu-chai it is observed on the first day of the tenth moon. The ceremony lasts all night, the five great gods are worshiped, and the vows made earlier in the year are paid by killing and offering goats, chickens, yak, *p'ien niu,* and rarely, pigs.

At Ho-p'ing-chai, on the morning of the thirtieth day of the seventh moon, the priest, and the goats to be sacrificed, are purified by being bathed in the smoke of cedar twigs. While this is being done the priest rings the ceremonial instrument called *Gga r sï.* Toward evening the priest again bathes in pure water as a means of purification. The goats, which must be all black or all white, not black and white, are tied in the temple or shelter in the sacred grove. They must be watched and cared for by two men, who feed them grass and leaves. The goats must be male, full-grown, without blemish, and preferably 5 or 6 years old.

About dark or just after dark the procession starts from the village toward the temple. Only men and boys are allowed, and women cannot even witness the ceremony from a distance. The men are dressed in white homespun hemp clothing, which is undyed. The first master of ceremonies goes in front, and others follow in single file. He carries the Abba Mula, or patron deity of the priest, on a wooden platter. Before the Abba Mula is taken down, the priest worships it, chanting some of his "sacred books" and burning incense to it. Then follows the second master of ceremonies, carrying three flags made of white paper. These flags are stuck up on the way at important points, and at the altar where the goat is offered. The third master of ceremonies follows, leading the goat. The fourth carries sacred water. The fifth is the *bi bu,* or the priest himself. He carries the goatskin drum, which he beats as he chants and dances. All the others follow. They proceed to the simple, unornamented building called a temple, where a fire is built under the three triangular stones that constitute the fireplace. Incense is burned before the sacred white stone, and the priest continues to beat his sacred drum, dance, and chant his sacred books until daylight. In the temple is a large jug of wine from which the worshipers sip wine through small bamboo tubes. As the wine disappears, they add cold water and continue to drink. At daylight the goat and one cockerel for each family are killed. The throat of the goat is cut, and the blood is caught in a vessel. A little of the blood is sprinkled on the white flags, and the remainder is boiled and later eaten. The horns of the goat are cut off and deposited in front of the sacred white stone in the temple.

This great ceremony is called in the Chinese language *huan yuen,* or paying the vows. The priest at Ho-p'ing-chai, on the fifteenth day of the first moon, goes to the sacred grove and prays to the sky god, Mu-bya-sei, and the earth god, Ru-bya-sei, for rain, good crops, protection, and a prosperous year, and promises or vows in return to offer goats and chickens to the gods on the first day of the eighth moon.

The rope by which the goat is led to the sacrifice must be new and clean. The goats must be full-grown and without blemish—that is, there must be no imperfections, out of respect for the gods.

On the wooden platter on which the Abba Mula is carried, there is some barley and rice. Near the end of the ceremony the people kneel and the priest scatters this grain. Each person catches as much as he can. This grain is carried home and scattered into the granaries, which brings good luck and makes it more likely that all will go well in the homes during the year.

White paper flags pasted or tied to small bamboo sticks are used in the ceremony of paying the vows. They have definite, accepted shapes and sizes, but vary in size and shape in different villages. One of the larger flags is stuck up by the roadside on the way to the sacred grove, and one or more on the altar near the white stone in the sacred grove. Smaller flags are carried to the homes and stuck up on the walls. At one ceremony witnessed by the writer, paper flags were stuck into the ground, and one large flag behind the patron deity of the priest and one smaller one on each side of the patron deity.

The following notes were taken by the writer as he witnessed the ceremony of paying the vows to the five great gods in the sacred grove at Mu-shang-chai.

The priest ceremonially washed his face and hands before beginning. He heated the sacred drum over a fire, beating the drum as he chanted. This makes the drum more resonant. Then he beat his drum with rhythmical beats as he continued to chant. After this had continued for about an hour, he hung up a small bundle of wheat straw on the wall of the building outside the door. (This building was a small Chinese temple which was also used for a schoolhouse in the village of Mu-shang-chai.) Near its top the small bundle of straw

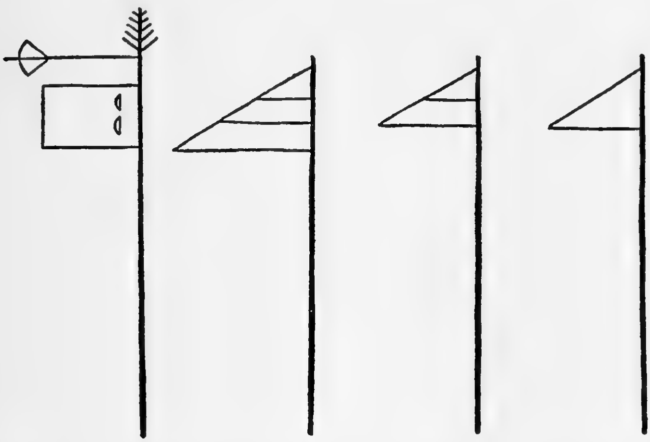

FIG. 6.—Drawing of white paper ceremonial flags used at Lung-ch'i-chai. On the largest and most important flag, which is square, are a miniature bow and arrow, a tiny fir or cedar twig, and two holes representing eyes.

was divided into three branches, on the three ends of which he stuck three small, round pieces of unleavened and uncooked dough made of wheat flour.

Following this the priest continued to chant or repeat his "sacred books" and to beat the drum. He burned incense to the wheat-straw bundle that he had hung up. At this time he was wearing his ceremonial hat and near him was his Ndjei Chu, or patron deity.

Before leaving the temple he chanted six sections of his "sacred books." Then the procession began. On the way he continued to beat the drum and to dance as he chanted his liturgies.

In the parade were, first, the master of ceremonies, called the *gwɛ*^{2} *sə*^{1}-*mu·*^{2}. He carried the Ndjei Chu, the patron deity of the priest, and the largest paper flag, and led the goat, which was entirely black, for it must be without blemish and of only one color. The second person (they walk in single file) is called the *gwe*^{3}*-t'ai*^{2}*-mu*^{3}. He carried on his back a large basket in which were paper flags, wine, pork, the unleavened bread, the executing knife, wheat straw, and cedar twigs. This is the second master of ceremonies. The third person is merely a helper of the other masters of ceremonies.

The fourth person was the priest, who continued to beat his drum and to repeat his sacred chants. He carried the sacred drum and the drumstick, wore his ceremonial hat, and carried the skin bag, the sacred bundle, and a ceremonial sword.

All wore or preferred to wear undyed hemp clothing. The priest had no ceremonial gown.

At a designated place, before reaching the shrine where the ceremony was to be performed and the goat killed, water was poured into the ears and onto the neck and shoulders of the goat. In such circumstances, if the goat shakes, shivers, or trembles, it is regarded as evidence that he is acceptable to the gods. If he does not, he must be changed for another goat that is acceptable. While this was being done, the priest knelt, repeated his sacred books, and beat his drum. Here one of the paper flags was stuck upright in the ground. The goat did shake himself vigorously.

After his arrival in the temple or sacred shelter, the priest chanted 14 sections of his sacred books, dancing and beating his drum. All this took a long time, as the priest added trills and sometimes merely beat his drum. He often spoke too rapidly to be understood.

Later they again poured water into the ears of the goat, to make very sure that he was acceptable to the gods. The priest pulled out some of the goat's hairs and put them in a crack at the top of the stick that formed the handle of the largest flag, tying them on with a string. Water was splashed on the flag. Then this flag was stuck up on the wall of the temple. The writer was told that the flag now would keep away demons and help avoid calamities that might come.

The priest chanted six of his sacred books in the schoolhouse (Chinese temple), then started for the Ch'iang temple and the sacred grove. In the Ch'iang temple he chanted 14 sections of his sacred books. He chanted the final sacred book while the goat was being killed and the ceremony was being finished.

On the big round cake of unleavened bread used in the ceremony, the priest placed a small goat made of dough, a lamp made of dough, and a small lump of dough.

When the procession first arrived at the temple, the priest chanted and danced, burned cedar twigs as incense before the sacred white stone, and lighted a fire. Later they marched to the shrine near the temple where there was a sacred white stone standing upright like a tombstone. In the procession as they marched to this shrine, the person walking in front carried a flat, circular stone on which were placed the dough image of a goat, the dough lamp, and the small lump of dough. The second man led the goat, carried the large flag, and also carried the patron deity of the priest, Ndjei Chu. A third person carried the large round piece of unleavened bread on which was a knife for killing the goat, and some cedar twigs. The fourth man carried a dipper with which to catch the blood of the sacrificial goat.

The stone circle with the dough objects on it was placed in front of the sacred white stone on the shrine. Here were also placed the round cake of unleavened bread, lighted candles, and incense. The priest remained in the temple and continued his chanting. At a signal a man cut the goat's throat so that the goat soon bled to death, and firecrackers were set off. The blood of the goat was caught in a large dipper. The right ear, the testicles, and the penis of the goat were cut off. The penis and testicles were offered to the gods by being burned on cedar twigs on the circular stone. The ear was stuck on the top of the largest paper flag.

They skinned the goat while the priest, before the shrine in the temple, continued to chant the last section of his sacred books, beat his drum, and dance. When the animal was partly skinned, the sheet of fat around the abdomen and whatever other fat could be found was cut off and placed on a fresh twig.

Then, while the priest continued to chant, dance, and beat his drum, the four men encircled the shrine in the sacred grove four times. The first man carried the circular stone, the second man carried flags and the large wheat cake, and the third carried cedar twigs on which the tallow had been placed, and the fourth carried on his back the dead goat. The intestines of the goat had been removed and washed in the creek. They were brought back and cooked and later eaten.

The procession, followed by the priest, went back into the temple, the priest meanwhile chanting, dancing, and beating his drum. In the temple they finished cutting up the goat, and one front leg and the skin, one ear of which had been cut off, were given to the priest.

At the time that the goat was killed, the largest flag was splashed with blood, the left ear was cut off and stuck on top of the large paper flag, and the horns and the flag were placed on the shrine in the temple, which was supposed to have, but did not, a sacred white stone on it. The meat and blood were cooked, and there was a feast in which all present shared. Before beginning to eat, the brain and the kidneys of the goat were placed in a separate bowl, cooked, then offered to the gods before the shrine in the temple.

The Ch'iang custom is that the meat and blood that cannot be eaten at the feast is divided up among the families represented, taken home, and there eaten by the people in their homes. This time the meat and the cooked blood were taken to the school-temple, where next morning the men came together for a feast to which the writer was invited.

At the end of the feast in the Ch'iang temple, when all were through eating, the priest began to chant and beat his drum, and the masters of ceremonies burned some cedar twigs as incense. The Ndjei Chu was placed beside the priest, with the skin and the meat which the priest was given as his reward. The priest gave a little of the fat of the goat to each worshiper, to be taken home and there offered to the gods.

7. THE SACRED GROVES

Every village or community has a sacred grove. Its trees, some of which are oaks, are sacred and must not be cut down. In or near it is an altar capped by a sacred white stone, and near the altar are one or more trees that are more sacred than the others.

In front of this altar the sacrificial animal is killed. In or near the grove is a very simple building called a temple, the walls of which are made of beaten clay or unhewn stones plastered together with clay. In the floor is a three-legged stove and in one corner is an altar and a sacred white stone.

Most of the great ceremonies are performed at night and very early in the morning. The sky and the mountains above, the darkness and the silence, the sacred trees and bushes and the altar below, the priest and the worshipers, give an atmosphere of awe and wonder so that the worshiper believes that he meets his gods and feels their very presence. He experiences an emotional thrill that is realized through the belief that he has had actual communion with his gods.

In recent years many of the trees in the sacred groves have been cut down, some by Chinese soldiers, some by Communists, and some by the Ch'iang themselves. In one village a number of the sacred trees were cut down, with general approval, in order to build a schoolhouse. The Ch'iang people of this village who wanted to cut down the trees obtained the moral support and approval of the magistrate of Li-fan as a guarantee that nobody would be able to make trouble.

8. THE "SACRED BOOKS"

It is well-known that the Ch'iang have no written language. How, then, can they have sacred books?

A Ch'iang priest sometimes has a book which contains many pictures, but not a word in writing or printing, which is used for divination. This book is called in Chinese *t'ieh suan p'an* 鐵算盤, or "iron abacus." It is used for divination of all kinds, including the determination of lucky days for weddings, for beginning a journey, to begin to build a house, to plant crops, and many other things.

On one of these books there are pictures of the sun and other heavenly bodies, of trees, of priests, of the 12 creatures of the zodiac, of manlike beings said to represent diseases, and on one page a picture of the sky god, the earth god, of 12 shrines for the worship of the 12 lesser gods, and of 4 ceremonial flags. The writer has not seen any two of these books that are alike.

The pictures in another book were as follows: On the first page a solo tree on which a bell hangs, and under it a deer; on succeeding pages are a blacksmith and a forge and a man for whom the blacksmith is working, making an ax to cut wood, and above the blacksmith smoke; a priest and a demon of one who died from loss of blood; a man covering up the ashes after cremation; the picture of a priest with a drum, and near him a cremation grave or heap of ashes and a temple in which is a Taoist priest; a priest burning spirit money and performing a ceremony to exorcise demons; a demon of a person killed by a knife, sword, or spear; a priest and a tree with roots—on this page priests divine to determine lucky days to begin journeys and other important undertakings; a silversmith and a forge, and a man digging for gold, indicating a lucky day; a golddigger's house, and a man with an umbrella; a priest and a pavilion; a man and two objects representing ingots of silver and indicating good luck; a man, and a tree without roots; next, the demon of a man who died from drowning; a priest and a design representing a jug, and a man; a man and another person with a ferryboat, indicating good luck; and on the next few pages are a grave, a shed or house for cremating, an oblong object that indicated that several will die, a flowery mountain, and a worship shed or shrine.

Priests who possess these books claim that they are indispensable for divination. With them they tell the future and solve many difficult problems.

The other kind of "sacred book" is not written, but memorized by the priests and repeated from memory during their ceremonies. They are the equivalents of the sacred books chanted by Buddhist and Taoist priests in China and by Tibetan lamas. Some of them are in the ordinary Ch'iang language and easily understood, some are at least in part not understood by any but the Ch'iang priests, and at least parts of some are not understood even by the priests themselves. Some sacred books or parts of them are said to be in an archaic form of the Ch'iang language. All this increases the sense of mystery, sacredness, and potency. The number of sections or "books" varies in different places and with different priests. At Ho-p'ing-chai the priest gave the number as 12, at Lo-pu-chai as 18, and at Mu-shang-chai as 21.

All the sacred books are chanted or repeated in the great ceremonies in the sacred groves, and in some of the ceremonies by the priests on the housetops, but fewer at weddings, funerals, when enthroning new gods in the homes, and when exorcising demons.

The sacred books are committed to memory by the Ch'iang priests, and only the priests know them. If paid enough, one priest will teach another, and so these books are handed down from father to son or from teacher to pupil, from generation to generation. In recent years some Ch'iang priests have died without teaching any successors, so that in some villages, including P'u-wa and Tung-men-wai, the line has ceased and there are no Ch'iang priests.

Believing that valuable light might be thrown on the religion of the Ch'iang by the translation of these sacred chants, the writer persuaded several priests to repeat their sacred books to him and to help translate as much as possible. All priests regard these chants as very important, and to be remembered and repeated accurately and with due reverence and respect, whether they are understood or not.

The lists of gods as found in these "sacred books" is not complete, for the Ch'iang have many other gods, including stones and trees that are worshiped as deities. These lists ought to convince any person with an open mind that the Ch'iang are not monotheists, for every priest calls on many gods to help him in his ceremonies. The attitude expressed in the "sacred books" of Lo-pu-chai toward these sacred books reminds us of that of the Sikhs of India toward their granth or sacred book, which they worship as a living god.

The following translations of the sacred books of the priests at Ho-p'ing-chai and at Lo-pu-chai were published in an article by the writer in the Journal of the West China Border Research Society, vol. 14, series A, 1944, and are reprinted here because they are the best that the writer has been able to obtain. The sacred books of the priest at Mu-shang-chai were carefully written down in the International Phonetic Script, but the priest understood and could explain so little that they are omitted here.

The following are the sacred books or chants of the priest at Ho-p'ing-chai. The words and phrases were taken down in the International Phonetic Script, and the translations and interpretations are those given by the Ch'iang priest. The place names were taken down as pronounced by the priest.

THE SACRED BOOKS OF CHANTS OF THE PRIEST AT HO-P'ING-CHAI IN THE CEREMONIES TO PAY THE GREAT VOWS

SECTION 1, ER BO OR BO (δ^{2} bo·^{1} or bo^{1})

mʌ^{2} Ti·^{2} zwɛ^{2} (or ʒɛ^{2}) Ti·^{2},
zwɛ^{2} To·^{1} jo·^{2} Ti·^{2}
Ti·^{2} jo·^{1} Ti·^{2} jɛ^{2}, Ti·^{2} Ti·^{1} jo·^{2} Ti·^{2}
sɛ^{1} jo·^{2} Ti·^{2} jɛ^{2}, sɛ^{1} Ti·^{2} jo·^{2} Ti·^{2}
o·^{2} jo·^{1} Ti·^{2} jɛ^{2}, mi·^{2} tzə^{1} bɛ^{2} bɛ^{2}
ntzə^{2} ɲa·^{1} lʌ^{2} jɛ^{2}, so·^{2} la·^{1} bɛ^{2} bɛ^{2},
nTɛ^{2} p'i·^{1} nTɛ^{2} jɛ^{2},
mɛ^{2} ʒɛ^{1} (or ɹɛ^{1} or zwɛ^{1}) dʒjei^{2} Ti·^{2}
be^{2} ʒɛ^{1} nTɛ^{2} ji·^{2}
bɛ^{2} k'o·^{1} nTɛ^{2} ji·^{2}
Ti·^{1} bɹa·^{2} mʌ^{1} bja·^{2} a·^{1} no·^{2} sei^{2}
p'i^{1} ɹu·^{1} (sei^{2}) lo·^{1} lo·^{2} a·^{1} no·^{2} sei^{2}
su·^{1} mo·^{2} sei^{2}, su·^{1} mo·^{2} jei^{2} sɛ^{1} na·^{2} ja·^{2}
gwɛ^{2} Ta·^{1} stu·^{2} Ta·^{2} sei^{1} zə^{2} nTa^{1} ʃja·^{2}
a·^{2} ba·^{2} sei^{2} Tʌ^{2} ɹ^{2} wei^{2} ʃa·^{2}
tʃi·^{2} gwei^{2} sei^{2} nTɛ^{2} wei^{2} fa·^{2}
ʃtu·^{2} dʒa·^{1} sei^{2} nTɛ^{2} wei^{2} ʃa·^{2}
ntzə^{2} ndʒu·^{2} sei^{2} nTɛ^{2} wei^{2} ʃa·^{2}
ji·^{2} mu·^{2} sei^{2} nTɛ^{2} wei^{2} ʃa·^{2}
mʌ^{2} bu·^{2} sei^{2} nTɛ^{2} wei^{2} ʃa·^{2}
mbja·^{1} wɛ^{2} sei^{2}, nTɛ^{2} wei^{2} fa·^{2}
ʃti·^{2} pδ^{2} sei^{2} nTɛ^{2} wei^{2} ʃa·2
sbɛ^{2} pɹi·^{1} (or pi·^{1}) sei^{2} nTɛ^{2} wei^{2} fa·^{2}
To·^{2} ndzu·^{2} sei^{2} nTɛ wei^{2} ʃa·^{2}
Ɖa·^{2} Ɖa·^{1} sei^{2} nTɛ^{2} wei^{2} ʃa·^{2}
a.^{2} Ta·^{2} sei^{2} nTɛ^{2} wei^{2} ʃa·^{2}
bi·^{1} bu·^{2} dʒu·^{2} pi·^{2} ʃa·^{1} la·^{2} nTɛ^{2} ʃwa·^{1} ʃa·^{2}
p'o·^{2} pa·^{2} To·^{2} t'u·^{2} nTɛ stʌ^{2} ʃa·^{1}
ji·^{2} ʃñʌ^{1} i·^{2} stɛ^{2} i·^{2} t'u·^{2} i·^{2} sɛ^{2}
hu·^{2} bɛ^{1} dʒo·^{2} ʃtja·^{2} lju·^{1} sɛ^{2} ʒi·^{1} ʒi^{2}

SECTION 2, ER (δ)

δ^{2} bi·^{1} Ti·^{1} mu·^{2}, mi·^{2} jɛ^{1} δ^{2} mja^{1}; swa·^{2} swa·^{1} mi·^{2} jɛ^{2}
δ^{2} sə^{2} mɛ^{2} Ɖa^{2}, δ^{2} mi·^{1} ʃi·^{2}
δ^{2} sə^{1} Ɖa·^{1} mo·^{2}, δ^{2} lɛ^{1} ʃjɛ^{2}

SECTION 3, K'U (K'u·^{2})

k'u·^{2} sə^{2} mɛ^{2} Ɖa·^{2}, k'u·^{2} mi·^{1} ʃi·^{2} ɹa·^{2},
k'u·^{2} sə^{2} Ɖa·^{2} mo·^{2}, k'u·^{2} lɛ^{2} ʃi·^{2} ɹa·^{2},
mʌ^{1} Ta·^{2} mae^{2} mʌ^{2}, a·^{2} bu·^{1} dʒi·^{2}
bu·^{1} dʒi·^{2} ɲo·^{2} δ^{2} bo·^{1} dʒo·^{2}
mʌ^{1} ɹo·^{2} sə^{1} ʃwa·^{2} δ^{2} go·^{1} dʒo·^{2}
mʌ^{1} ɹo·^{2} dʒae^{2} bae^{2}, δ^{2} go·^{1} dʒo·^{2}
sei^{1} mi·^{2} Tɛ^{2} δ^{2} go·^{1} dʒo·^{2}

Section 4, Ngo

Ti·^{2} ᗡo·^{2} gɛ^{2} tza·^{2}, nʌ^{2} ᗡo·^{1} nTɛ^{2} ji·^{1}
nʌ^{2} ᗡo·^{1} Tɛ^{2} tsa·^{2}
si·^{2} ᗡo·^{1} gɛ^{2} tsa·^{2}, zə^{2} ᗡo·^{1} Tɛ^{2} ji·^{2}

Section 5, Shpa (Calling the local gods)

nTjei^{2} Ta·^{2}, tsʌn^{2} juɛn^{2},
p'i·^{2} ʃjɛn^{4}, saen^{2} juɛn^{2}
ntjei Ta dʒi ge, wɛ ba· sei,
p'i ʃjɛn dʒi· gɛ^{2}, To·^{2} wa· sei
Ta·^{2} gu· dʒi· gɛ, To· ʃwa· sei
bɛ^{2} sa·^{1} dʒi·^{2} gɛ^{2} k'wɛ^{2} δ^{2} bo·^{1} sei^{2}
ju·^{2} tʃi·^{2} dʒi·^{1} gɛ^{2}, bu^{2} δ^{2} Ga·^{2} sei^{2}
jaᗡ^{2} tzə^{1} lin^{2}, lo·^{2} ʃjo·^{2} sei^{2}
Ta·^{2} δ^{1} p'i·^{2}, zɛ^{2} bɛ^{2} sei^{2}
tsoᗡ^{1} dʒi·^{2} lo·^{2}, su·^{2} ʃti·^{2} sei^{1}
jin^{2} hɛ^{1} p'i·^{2}, lo·^{2} p'ɹi^{2} sei^{2}
t'ao^{2} gwa·^{1}, k'wɛ^{2} bo·^{1} sei^{2}
da·^{4} jei^{2} p'in, ʒɛ^{2} bɛ^{2} sei^{1}
xa·^{2} su·^{1}, tʃɛ^{2} hwa·^{2} sei^{2}
baᗡ^{2} tʃjo·^{2}, la·n^{2} Ga^{2}· sei^{1}
mo·^{2} To·^{2} tʃi^{1}, ɹa·^{2} bɛ^{1} sei^{2}
tʃi·^{2} p'a·^{2} gʌu^{1}, k'wɛ^{2} δ^{2}bo·^{1} sei^{2}
tʃi·^{2} paᗡ^{2} lo·ᗡ^{2}, mbʌ^{1} δ^{2}ka·^{2} sei^{2}
ts'u·^{1} ts'a·^{2} dʒi·^{2}gɛ^{2}, To·^{2} ʃwa·^{1} sei^{2}
jɛn^{4} mʌn^{2} dʒi·^{2} gɛ^{2}, ɹa·^{2} Tjo·^{1} sei^{1}
tʃi·n^{1} p'o·^{1} dʒi·^{2} gɛ^{2}, ɹɛ^{2} bɛ^{2} sei^{1}
wʌn^{2} tsʌn^{4}, dʒi·^{2} gɛ^{2}, wei^{2} ba·^{1} sei^{2}
bɛ^{2} swei^{2} tsai^{4}, tʃwa·n^{1} tsu·^{3} sei^{2}
tʃi·^{2} ʃin^{1} gwa·^{1}, ɹa·^{2} Tju·^{1} sei^{2}
tsoᗡ^{1} tʃy^{2}, ɹɛ^{2} bɛ^{2} sei^{2}
xgae^{2} ɲo·^{1}, wɛ^{2} ba·^{1} sei^{2}
t'oᗡ^{2} ts'ao^{2} dʒi·^{1}gɛ^{2}, tswan^{1} p'u^{2} sei^{2}
p'o^{2} gɛ^{2}, p'o^{2} Ti·^{2} sei^{2},
ɹa·^{2} gɛ^{1} dʒi·^{2} gɛ^{2}, ɹa·^{2} Ti·^{2} sei^{1},
bu.^{2} dʒu·^{1} dʒi·^{2} gɛ^{2}, wei^{2} ba·^{1} sei^{2}
gaen^{1} tʃi·^{2} dʒi·^{2} gɛ^{2}, ɹa·^{2} bɛ^{1} sei^{2}
t'oᗡ^{2} hwa^{2}, ɹa·^{2} dʒo·^{2} sei^{2}
tʃɛ^{2} jɛ^{2}, ɹa·^{2} bɛ^{1} sei^{1}
saen^{1} p'in^{2} dʒi·^{2} gɛ^{2}, ɹɛ^{2} bɛ^{1} sei^{2}
ʃin^{1} tʃjao^{2}, k'wɛ^{2} δ^{2}bo·^{1} sei^{2}
gɛ^{2} Tɛ^{2} bo·^{2} bji·^{1} ʃy^{2} Ga·^{1} sei^{2}
Ga·^{2} Ta·^{2} bo·^{2} bji·^{1}, ʃy^{2} ɲi^{2} sei^{2}
Tu·^{1} li^{2}, sei^{1} dʒo^{2} sei^{2}
mbja·^{2} p'i·^{2} dʒi^{1} gɛ^{2}, wɛ^{2} ba·^{1} sei^{2}
¿ɛ^{2} mʌ^{2}, su·^{1} nʌ^{2} sei^{2}
xa·^{2} p'i^{2} dʒi·^{2} gɛ^{2}, ɹɛ^{2} bɛ^{2} sei^{1}
Ga· sa· dʒi·^{2} ge^{2}, δ^{2} gwɛ^{1} nʌ^{2} sei^{2}

k'o·^{2} ɹo·^{1}, bu·^{1} dzu·^{2} sei^2
ts'u·^{1} ji·^{2}, bu·^{1} dzu·^{2} sei^2
mɛ^2 δ^2 gwɛ^1 sə^2 gwɛ^2, sgwɛ^1 ɹɛ^2 Tu·^{2} ʃja·^{2}
ʃi·^{2} tzu·^{1} Ga·^{2} ɲo·^{2} dʒju·^{2}, p'i·^{2} ʃja·^{1} na·^{2} nTɛ^2
ʃja·^{1} ʃja·^{2}, si·^{1} δ^2 mɛ^2, t'ɛ^2 ʃja·^{1}, sɛ^1 tzʌ^2 gɛ^2 ju·^{2}

Section 6, Mu Dje A Dyu (mʌ^2 dʒɛ^1 a·^{2} Tju·^{2})

mʌ^2 djɛ^1 tzu·^{2} la·^{2} mi·^{2} ʃjo·^{1} δ^2 gu·^{1} mi·^{2} ʃjo·^{2}
zwɛ^2 zwɛ^1 gɛ·^{2} go·^{2}, sa·^{2} xu·^{1} lju·^{2} wu·^{2}
mʌ^2 Ta·^{1} wei^2 go·^{2}, sɛ^2 Tjo·^{2} bɹa·^{2} gɛ^2 go·^{2} Tju·^{1} ɹɛ^1 dʒo·^{2} jɛ^2
nTɛ^2 wu·^{1} tzə^2 ɲa·^{2}, tzə^2 ju·^{1} wu·^{2} tzə^2 jɛ^2
nTɛ^2 wu·^{1} tzə^2 ɲa·^{2}, tzə^2 ju·^{1} wu^2 tzə^2 jɛ^2
mo·^{2} Ta·^{1} wɛ^2 go·^{2}, Tju·^{2} Tɛ^1 Ŋgʌu^2 jɛ^2

Section 7

nTɛ^2 Tɛ^1 lɛ^2 bo·^{2}, ʃi·^{2} zɹi·^{1} ʃɹi^1 ji·^{2}
mʌ^2 dzu^2 nTɛ^2 dzu·^{2}, ts'u·^{2} ji·^{2} tzə^2 Gɛ^1 si·^{2} tzə^1
ʃi·^{2} pɹi·^{1} ʃi·^{2} Tɛ^2, ji·^{2} Tɛ^1 si·^{2} jɛ^2,
zi·^{2} pɹi·^{1} tzu·^{2} Ta·^{2}, Tju·^{2} Tɛ^1 gei^2 jɛ^2,
mba·^{2} bu·^{2} tju·^{2} Tɛ^1 pɛ^2 ji^2, su·^{1} bʌ^1 Tju·^{2} Tɛ^2,
pɛ^2 ji^2 su·^{1} bu^1 na·^{2} Gɛ^2, tzə^2 gɛ^1 si·^{2} tzə^2,
ʃi·^{2} Tɛ^2 xɛ^2 ju·^{1}, stɛ^2 jɛ^2 ts'wei^2 tzə^1 t'wa·^{2} tzə^2
Tɛ^2 δ^1 sa·^{2} jɛ^2, mɛ^1 tzə^2 zei^2 so·^{2} gwɛ^1 zi·^{2} na·^{2} jɛ^2
tzo·^{2} bo·^{1} zi·^{2} so·^{2}, gwɛ^2 zi·^{2} na·^{2} ji^2,
gwɛ^2 Ta·^{1} ʃtja·^{2} lju·^{2}, stu·^{1} Tɛ^1 ʃtja·^{2} lju·^{2}
gwɛ^2 Ta·^{1} stu·^{2} Ta·^{2}, sei^1 zə^1 zTə^1 ʃja·^{2}

Translation of the Sacred Chants or Books Used by the Priest at Ho-p'ing-chai in the Ceremonies to pay the Great Vows

Section 1

Heaven, earth, we call you from all about.
From afar you have come together.
I have called the many gods here from distant places.
I call them, using the stone platter and small candles and wheat biscuits.
Twelve grains of barley, fir tree seeds (from fir tree cones),
Lung and heart (as offerings), all are prepared.
I have purified with water.
Rice I scatter, barley I scatter.
Great Heaven, I have called you here.
P'i-ru-sei and Lo-lo-sei, I have called you here.
Su-mo-sei of the forests, your throne is prepared.
Goats and cokerels, O gods, I offer to you.
Abba-sei (male ancestral god), I call you here;
Ch'i-gwei-sei (house god), come thou here;
Shtu-ja-sei (god of domestic animals), come thou here;
Ntzu-ndja (god of wealth), come thou here;

Yi-mu-sei (goddess who gives sons, etc.), come thou here;
Mu-bu-sei (fire god), come thou here;
Mbya-we-sei (goddess who protects men and boys), come thou here;
Shti-per-sei (goddess who protects women and children at childbirth), come thou here;
Sbe-pri-sei (god of grain in the bin), come thou here;
Do-ndzu-sei (door god on the left), come thou here;
Nga-nga-sei(door god on the right), come thou here;
I, the priest, with three (or nine) sticks of incense and candles lighted,
Wheat biscuits (bread), pork, set down below,
Chicken blood, heart, lungs, liver,
Cedar twigs (burning); we receive all the gods together.

Section 2

Male gods, female gods,
If there were no gods, I would not call.
All that there are I will invite.

Section 3

Rolled here have, all have come.
Sky, sun, can lighten,
Rolled here have arrived,
In the sky all have come,
Stars of the sky have come,
Gods all have come.

Section 4

Cow born, two cows have,
Two cows, plows,
Three cows, four cows (for sacrifices).

Section 5, Calling the Local Gods

Chengtu, (the Chengtu god) Tsun-yuen;
Pi-hsien, (the god) San-yuen;
The (god of) the large gate of Chengtu, We-be;
The gates of Pi-hsien, the god Do-wa;
Kuan-hsien the god Do-swa;
Pai-sha-ch'i, the god Go-k'we-er-bo;
Yu-ch'i, the god Su-er-ga;
Yang-tzŭ-lin, the god Lo-shyo;
Ta-er-p'i, the god Ze-beh (the earth god);
Chung-chi-lo, the god Lo-pr'i (a white stone god).
T'ao-kuan 桃關, the god Kw'e-bo.
Ta-yeh-p'ing, the god Zre-beh (an earth god).
Wen-ch'uan 汶川, the god Ch'êng Huang (a city god).

Pan-ch'iao 板橋, the god Lan Kan.
No-to-ch'i, the god Ra-beh (a cliff god).
Ch'i-p'a-u, the god Kw'e-we-bo (a creek god).
Ch'i-p'ang-lung, the god Mao-erka (dragon mouth).
Ts'u-sha Ji Geh, the god Reh-be (a small earth god).
Yen-men Ch'i Geh, the god Ra-dyo (cliff door).
Ch'ing-p'o 青坡 Ji Geh, the god Reh-be (a small earth god).
Wen-ch'eng 汶城 Ji Geh, the god We-ba.
Bai-shui-chai 白水寨, the god Ch'uan Chu
Ch'i-hsin-kua, the god Ra-dyu.
Tsung-ts'u (or Ch'u), the god Re-beh.
Mao-chou 茂州, the god We-ba.
T'ung-ch'ao Ji Ge, the god Thuan-p'u (probably a Chinese god).
P'o Ge, the god P'o-di (or Ti) (p'o means tree).
Ra Ge Ji Geh (cliffs), the god Ru-di (a cliff god).
Li-fan, the god We-ba.
Kan-ch'i 乾溪, the god Ru-beh (a cliff god) [36]
T'ung-hua, the god Ra-jo (clifflike gate god);
Ch'eh-yeh, the god Re-beh;
Ksing-ch'iao (new brige), the god K'we Erbo (gulch or creek);
The larger Mu-p'ing, the god Shü-ga (god of animals);
The small Mu-p'ing the god Shü-nji (lesser god of animals);
T'ung-lin-shan, the god Sai-jo (god of pointed cliffs among mountains);
Ma-liu-p'ing, the god We-ba (god of the flat);
Geh-mu, the god Su-nu (or Su-mu, one of the five great gods);
Ho-p'ing-chai, the god Re-beh (said to be a large rock near Ho-p'ing-chai, worshiped as an actual god);
Ga-sa Gi Geh, the god Er-gwe-nu;
K'o-ro (a canyon or creek), the god Bu-dzu;
Ts'u-yi, the god Bu-dzu.
I have called you all here.
I, the priest, have lighted incense and candles, and have called the names of the gods; do not blame me.[37]

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[36] In the lines above in which the priest is calling his gods, the Ch'iang language was used, but the names of cities, towns, and places, and also of Chinese gods, were pronounced the same as in the Chinese language of West China, and the Ch'iang words and names as in the Ch'iang language. All cities and places (left) excepting P'o Ge and Ra Ge (which are Ch'iang) have Chinese names. All the gods excepting Ch'eng Huang, Ch'uan Chu, and probably Lan (or Nan) Kan (which are Chinese) are apparently Ch'iang gods and their names are in the Ch'iang language. Some of the places named are very small, and the Chinese characters could not be obtained. The priest could not explain all the Ch'iang words—for instance, for Gi Geh. The Wade system has been used only for the Chinese words.

[37] It is possible that the priest feared that the gods would blame him for mentioning their names to the inquirer, and injected this request that they should not blame him.

Section 6

Daughter of the sky god came down, could not marry men,
people did not dare to go up;
earth everywhere, came down and instructed people;
Returned to the sky, god's door big, brother and sister came out.
They came down to earth, male a man and a woman then were;
Gods went up to the sky again.

Section 7

In the beginning a sickle was made.
Told him to prepare a road on the old mountain,
Around right sent him up (to prepare the road) for the gods in the great festival (or ceremony).
Flat make right, above must go and prepare the road on the mountain. The man Tze Ge Si Tzi carried knife on his back, thorny bushes, brambles, cut them off. Emperor road for paying vows, officials' road. Come and receive, goat and all complete, God, I give to you.[38]

The Sacred Books or Charts of the Ch'iang Priest at Lo-pu-chai

Section 1 (ʃε or ʃjε)[39]

ʃε^{1} bi·^{3} ɲεδ^{2} mʌ^{2}, zə^{2} δ^{2} wε^{2},
ʃε^{2} ɱa·^{2} ŋεδ^{2} mʌ^{2}, g^{2} dzu·^{1} wε,
mʌ^{2} Gε^{1} Tε^{2} Gε^{2}, mʌ^{2} Gε^{1} ʃε^{2},
ji·^{2} Gε^{1} Tε^{2} Gʌ^{2}, ji·^{2} Gε^{1} ʃε^{2},
k'a·^{2} Gε^{1} Tε^{2} gε^{2}, k'a·^{2} Gε^{1} fε^{2},
Twa·^{2} Gε^{1} Tε^{2} Gʌ^{2}, Twa·^{2} Gε^{1} fjε^{2},
k'o·^{2} Gε^{1} Tε^{2} gε^{2}, k'o·^{2} Gε^{1} ʃε^{2}
δz^{2} bu·^{1} Gε^{2} Tε^{2} Gε^{2}
δz^{2} bu·^{1} Gε^{2} ʃjε^{2},
ʃjε^{3} bi·^{3} ɲεδ^{2} mo·^{2}, o·^{2} ɲa^{1} wε^{2},
ʃjε^{3} dʒi·^{3} ʃtʌ^{3}, ʃjε^{3} ɱε^{2} ɲaδ^{2} mo·^{2},
ʃɹu·^{2} zgu·^{1} wε^{2}, ʃjε^{2} dʒi·^{1} ʃtʌ^{2},
sə^{2} ʒ̊bi·^{2} ʒi·^{1} ʒ̊bi·^{2}, ʃjε^{2} mo·^{2} ji·^{1},
nʌ^{2} ʒ̊bi·^{2} ho·^{3} ʒ̊bi·^{2}, ʃε^{2} mo·^{2} jε^{1} (or ji·)^{1},
ʃi·^{2} ɹo·^{2} Tε^{2} t'ɹo·^{1}, Ga·^{2} ʃjae^{1} bo·^{2} mi·^{2},
ʃjei^{2} mo·^{2} jε^{1}, ɹsgo·^{2} ɹo·^{2} Tε^{2} tɹƆ :^{2},

[38] The sky god had three daughters. One came down and married a human, being. The name of the god's daughter was Mu Je, and the name of the man she married was Ze-bi-ge-swa. Before that time there was only this one human being on earth. After the marriage the daughter of the god gave birth to one son and one daughter. Later she returned to the sky and left her son and her daughter on earth. So it is related at Ho-p'ing-chai.

It seems certain that the sacred books from Ho-p'ing-chai, as here given, are very much abbreviated both in number and contents.

[39] Sections 1 and 2 have to do with the exorcism of demons.

ba·^{2} tʃa·^{1} wɛ ɲɛ^2, ʃjɛ^2 mo·^{2} ji·^{1},
ʃjɛ^2 mo·^{2} ji·^{1}, ʃjɛ^2 mo·^{2} p'ɹɛ^1,
ʃjɛ^2 mo·^{2} ji·^{1}, ji·^{1} To·^{1} wa·^{2} ᵹ^2 ʃjɛ^2,
ʃjɛ^2 ·mo·^{2} p'ɹɛ^1 To·^{1}, na·^{1} Tʌ^2 tsi·^{2}.

Section 2 (Twɛ)

mo·^{2} ɹo·^{2} Tɛ^2, xo·^{1} ɹo·^{2} Tɛ^2,
tʃa·^{2} Tʌ^1 tʃa·^{2} wɛ^2, mo·^{2} pja·^{1} Twɛ^2,
mo·^{2} pja·^{1} Twɛ^2 ʃjɛ, Tzwɛ^2 wo·^{2} Twɛ^2,
tzwɛ^1 li·^{2} zgo·^{2} ʃja·^{2}, Twɛ^2 o·^{1} lTa·^{2}
Twɛ^2 tza^1 ᵹ^2 ljo·^{2}, ʃtu·^{1} zsgo·^{1} ʒi·^{2},
ʃi·^{1} tzʌ^1 ᵹ^2 ljo·^{2}, sa·^{2} ksɹi·^{1} ʒi^2,
Twɛ^2 tzə^2 ᵹ^2 ljo·^{2}, a·^{2} Go·^{2} mi·^{2} ʒo^2,
a·^{2} dʒi·^{1} ʒo·^{2}, ʃi·^{1} stə^1 ᵹ^2 ljo·^{2},
a·^{2} dʒi·^{1} mi·^{2} ʒo·^{2}, a·^{2} dʒi^1 ʒo·^{2}
sʌ^2 ᵹ^1 ɲo·^{2}, ᵹ^2¿a·^{2} ᵹ^1 ɲo·^{2}

Section 3 (ma·^{2} wi·^{1} ʃi·^{2})

ma·^{2} wei^1 ʃi·^{2}, i^2 ʒTi·^{2} ts'wei^1 ʃi·^{2},
ma·^{2} wei^1 ʒTi·^{2} ts'wei^2
ʃi·^{2} zə^2 ʃtu·^{2}, sba·^{2} wei^1 y^2 ts'wei^2
zə^2 zə^1 ʃtu·^{2}, dʒɛ^2 mo·^{2} i·^{1} sə^2,
dzə^2 zə^1 Ga·^{2}, so·^{2} bo·^{2} p'ɹɛ^1,
sə^2 dzʌ^2 bo·^{2} p'ɹɛ^1, bɛ^2 mo·^{2} ma·^{2} bɛ^1,
lʌ^2 zə^2 tʃi·^{2}, tswei^2 ts'wei^1 ma·^{2} bɛ^1
gu·^{2} zə^1 ʃja·^{2}, tzu·^{2} ma·^{1} a·^{2} k'si·^{2}
Tʌ^2 ts'u·^{1} ʃju·^{4}, bɹi·^{2} ni·^{1} a·^{2} Twɛ^2
sə^2 lʌ^2 ʃju·^{4}
k'o·^{2} ma·^{1} a·^{2} k'si^2, sa^2 ko^2 ʃy^4,
zbu·^{1} mo·^{2} a·^{2} k'si^2, sə^2 p'a·^{2} ʃy^4
sbo·^{2} ma·^{2} a·^{2} ʃtu·^{1}, sə^2 dʒa·^{2} ʃy^4
hwei^1 mo·^{2} a·^{2} k'si^2, sə^2 hwei^1 ʃy^4
xʌ^2 mo·^{1} a·^{2} k'si·^{2}, sə^2 p'ɛ^1 ʃy^2,
ɹo·^{2} ɲi·^{2} a·^{2} k'si·^{2}, a·^{2} dʒa·^{1} ʃy^4
dʒɛ^1 ɹa·^{2} zə^2 ɹa·^{2}, Tʌ^2 zə^1 ʃy^4
ʃi·^{1} dʒi^3 ʃy^4,
zo·^{2} wɛ^1 li·^{4}, gwɛ^2 dʒɛ^1 ʃy^4
ʃtɹo·^{2} wɛ^1 li·^{4}

Section 4, Calling the God Ro (ɹo·^{2} ʃi·^{2})

ɹo·^{2} dʒi·^{2} mi·^{2} dji·^{2}, dʒi·^{1} mi·^{2} ɹo·^{2}, ɹo·^{2} ʃja·^{1} mi·^{2} ʃja·^{2}
ʃja·^{2} mi·^{1} ɹo·^{2}, ʃi·^{1} ɹo·^{2} ɹo·^{2} ɹo·^{2}, bo·^{2} Gɛ^2 ɹo·^{1},
mo·^{2} ɹo·^{2} su·^{1} ɹo·^{2},
Gʌ^2 so^2· ɹo·^{2}, ᵹ^2 sgʌ^2 ɹo·^{2} spja·^{1} ɹo^2, ma·^{2} Ta·^{1} ɹo·^{2}
tzə^2 dzə^2 Twɛ^2 xa·^{2}, Twɛ^2 dʒi·^{1} ɹo·^{2}, li·^{2} ɲɛ^2 Tʌ^2 ɹo·^{2}
ʃja·^{1} dʒi·^{2} ɹo·^{2}, xʌ^2 p'ɹɛ^1 Tʌ^2 ɹo·^{2}, ʃa·^{1} dʒi·^{2} ɹo·^{2}
dʒɛ^2 mʌ^2 Tʌ^2 ɹo·^{2}, dʒɛ^2 tʃɛ^2 bi·^{2}, y^2 mo·^{2} Tʌ^2 ɹo·^{1},

y^2 sgɛ^2 ɹo·^{1}, ʃi·^{2} mʌ^2 Tʌ^2 ɹo·^{2}, ʒ̊ɛ^2 ʃi·^{2} p'ɹɛ^1,
ʃi·^{1} ts'u·^{1} ʃy^2, zu·^{2} wɛ^1 li·^{2} gwɛ^2 dʒɛ^1 ʃy^2, sto·^{2} wɛ^1 li·^{2}

Section 5 (Tɛ^2 ʃi·^{2})

ʃi·^{1} Tɛ^1 i·^{2}, ɹo·^{2} dʒo·^{1} ji^2, mʌ^2 Tɛ^1 ji^2, sto·^{2} dʒo·^{2} ji·^{2},
ʃi·^{1} Tɛ^2 ɹo·^{2} Tɛ^2, Tɛ^2 ʃi·^{2} ʒ̊ɛ^2, mo·^{2} Tɛ^1 sto·^{2} Tɛ^2, Tɛ^2 ʃi·^{2} ʒ̊ɛ^2,
mo·^{2} dʒi·^{2} dʒi^2 gu·^{2}, dʒi·^{2} ʃi·^{2} ʒ̊ɛ^1, mo·^{2} ɱa·^{1} dzi^2 go·^{2}, Ɔɛ^{2}ʃi·^{2} ji·^{1},
bɛ^2 sə^1 dʒi^2 go·^{2}, ja·^{2} ʃi·^{2} ji^2, zu·^{2} bɛ^1 dʒi·^{2}, gu·^{2} k'u·^{2} ʃi·^{2} ji·^{2},
tzo·^{2} k'u·^{1} dʒi^2 gu·^{2}, dza·^{2} ʃi·^{2} ji^1, zə^2 Tɛ^2 dʒi^2 gu·^{2}, ʒ̊a·^{2} zə^2 ji^2,
sbi.^{1} Tɛ^1 dʒi^2 gu·^{2}, bo·^{2} ʃi·^{2} ji^2, ð^1 Tɛ^1 dʒi^2 gu·^{2}, dɹu·^{2} ʃi·^{2} ji^1,
dzə^2 Tʌ^1 dʒi^2 gu·^{2}, ts'a·^{2} ʃi·^{2} jɛ^2, dʒu·^{2} Tʌ^1 dʒi^2 gu·^{2} stɛ^1 ʃi·^{2} ji^1,
ʃi·^{1} ts'o·^{1} ʃy^2, ɹo·^{2} wɛ^1 li·^{2}, gwɛ^2 dʒi^1 ʃy^2, sto·^{2} wɛ^1 li·^{2}

Section 6 (ʃi·^{1})

ʃi·^{1} dʒi·^{2} mi·^{2} dʒi·^{2}, dʒi·^{1} mi·^{2} ɹo·^{2}, ʃi·^{1} ʃja^2 mi·^{2} ʃja^2,
ʃja·^{2} mi·^{2} ɹo·^{2}, dzɛ^2 bi·^{1} dzɛ^2 ʃja^2, lɛ^2 zə^2 sbi·^{2}
dzɛ^2 ɱa·^{2} dzɛ^2 ʃja·^{2}, lɛ^2 zə^2 ɱa·^{2}, wa·^{2} ð^2 lɛ^2 za^2, bu·^{1} lɛ^2 zə^2,
zu·^{2} Gʌ^2 lɛ^2 zə^2 k'wa·^{2} lɛ^1 zə^2, dʒi·^{2} bɹʌ^1 lɛ^2 zə^2,
ð^2 nʌ^1 sGo·^{2}, zdo·^{2} nʌ^1 ʒ̊ʌ^2, dʒi·^{2} tzu·^{1} lɛ^2 zə^2,
ɹʌ^2 nʌ^1 zɛ^2, zdo·^{2} nʌ^1 sGo·^{2}, zdo^2 na·^{1} bo·^{2}, ʃjei^2 dʒi·^{1} zdo·^{2}
ʃja·^{2} na·^{1} bo·^{2}, ʃjei^2 dʒi·^{1} ʃja·^{2}, o·^{2} bɹa·^{1} lɛ^2 zə^2,
sdʌ^2 nʌ^1 sk'o·^{2}, ʃja·^{2}nʌ^1 zi^2, o·^{2} dzu·^{1} lɛ^2 zə^2, zdʌ^2 nʌ^1 ʒ̊ɛ^2,
ʃja·^{2} nʌ^1 sko·^{2}, zdʌ^2 na·^{1} bo·^{2}, ʃjei^2 zgo·^{1} zdʌ^2,
ʃja·^{2} na·^{1} bo·^{2} ʃjei^2 zbo·^{1} ʃja·^{2},
ʃi·^{1} ts'u·^{1} (or stu·^{1}) ʃy^2, ʃbja·^{2} dʒi·^{1} ʃy^2,
zgʌ^2 ts'o·^{1} ʃy^2, ʃbja·^{2} dʒi·^{1} ʃy·^{2}

Section 7 (lʌ^2 zɛ^2), Fulfilling the vows

mo·^{2} dʒi·^{1} dʒi^2 gu·^{2}, dʒi^1 lɛ^2 zɛ^2, mo·^{2} ɱɛ^1 dʒi^2 gu·^{2}, Ɔɛ^2 lɛ^1 zə^2,
ʃja·^{2} pɹ'ɛ^1 dʒi^2 gu·^{2}, so·^{2} lɛ^1 zɛ^2, zu·^{2} bɛ^1 dʒi^2 gu·^{2}, k'u·^{2} lɛ^1 zə^2,
bɛ^2 sə^2 dʒi^2 gu·^{2}, ja·^{2} lɛ^1 zə^2, dʒu·^{2} gu·^{2} dʒi^2 gu·^{2}, dza·^{2} lɛ^1 zə^2,
zə^2 Tʌ^2 dʒi^2 gu·^{2}, ʒ̊a·^{2} lɛ^1 zə^2, ʃpi·^{1} Tʌ^1 dʒi^2 gu·^{2}, zbo·^{2} lɛ^1 zə^2,
ɹɛ^1 Tʌ^2 dʒi^2 gu·^{2}, dzu·^{2} lɛ^1 zə^2, zə^2 Tʌ^1 dʒi^2 gu·^{2}, ts'a·^{2} lɛ^1 zə^2,
dʒu·^{2} Tɛ^1 dʒi^2 gu·^{2}, stɛ^2 lɛ^1 zə^2,
ʃi·^{1} ts'u·^{1} ʃy^4, ʃpja·^{2} dʒɪ ʃy^4, zgʌ^2 ts'u·^{1} ʃy^4, ʃpya·^{2} dʒi^1 ʃy^4

Section 8 (K'u·^{2}), The Male Owl

gwɛ^2 tzə^1 dzi·^{2} ʃi·^{2}, gwɛ^2 k'u·^{1} ʃi·^{2}, ʃba·^{2} tzə^1 dʒi·^{2} ʃi·^{2},
gwɛ^2 sba·^{1} ʃi·^{2}, k'u·^{1} ɹa·^{1} t'ɛ^2 ɱi^2, zə^2 gy^1 Ɔo·^{2},
spa·^{1} ɹa·^{2} t'ɛ^2 mi·^{2}, To·^{2} lo·^{1} Ɔo·^{2}, ʃi^2 xo·^{1} Ɔõ·^{2} xo·^{1}
k'u·^{2} Xo·^{1} dzo·^{2}; ʃi·^{2} ʃpa·^{1} Ɔo·^{2} ʃpa·^{2}, k'u·^{2} ʃpa·^{2} twʌ^2,
k'u·^{3,1} gʌ^2 dzo·^{2} ɱi·^{2} mo·^{1} ʃi·^{2} bo·^{2} To·^{2}, k'u·^{1} gʌ^2 dɹo·^{2},
k'u·^{1} mi·^{1} tza·^{2} ɱɛ^2, mo·^{1} ʃi·^{2} Ga·^{2} tza·^{2}, k'u·^{1} tza·^{1} dɹo·^{2}
k'u·^{1} mi·^{1} tza·^{2} ɱɛ^2, mo·^{1} ʃi·^{1} Ga·^{2} tza·^{2}, k'u·^{1} tza·^{1} dɹo·^{2}
k'u·^{1} so·^{1} dɹo·^{2} mi·^{2}, ð^2 mo·^{1} ʃi·^{2} Ta·^{2} ɹa·^{2} k'u·^{1} so·^{1} dzwɛ^2,
sə^2 la·^{2} k'wa·^{2}, Ɔo·^{1} la·^{2} k'wa·^{2}

SECTION 9 (sba·^{2}), THE FEMALE OWL

mo·^{2} ɹo·^{2} dʒo·^{2}, ɲa·^{2} dʒo·^{1} lɛ^2, sba·^{2} dʒo·^{1} lɛ^2, mo·^{1} To·^{2} δ^2 sba·^{2},
ks'i·^{2} δ^1 sba^2, sbɛ^1 lʌ^1 Tδ^2 ma·^{2}, ʃjɛ^1 Tδ^2 ma·^{2},
ts'ei^2 mi·^{2} wa·^{2} tzʌ^2, gei^1 ljo·^{2} dʒy^2, mei^2 lʌ^1 so·^{2},
ʒ̊Ti·^{2} lʌ^1 swa·^{2}, k'si·^{2} mi·^{2} wa·^{2} tzə^2, gu·^{1} ljo·^{2} dʒy^4
sbo·^{2} lʌ^1 so·^{2}, dʒi·^{2} lʌ^1 so·^{2}, tʃi·^{2} mi·^{2} wa·^{2} tzə^2,
ts'wa·^{1} ljo·^{2} gy^4, tswa^1 ljo·^{2} so·^{2} ¿a·^{2} ljo·^{1} so·^{2},
ts'a·^{1} so·^{2} ¿a·^{2} so·^{2}, lo·^{2} ʃji^2 so·^{2}, ts'a·^{1} sba·^{1} ɹa·^{2} sba·^{2},
lo·^{2} dzɛ^2 sba·^{2}, ʃi·^{1} ts'u·^{1} ʃy^4, ʃbja·^{2} dʒi^1 ʃy^4,
ʒ̊ʌ^2 ts'o·^{2} ʃy^4, ʃbja·^{2} (or ʃpja·^{2}) dʒi^1 ʃy^2,

SECTIONS 10 AND 11 (dzə^2 and ʃbja·^{2})

gwɛ^2 tzə^1 dzi·^{2} ʃi·^{2}, gwɛ^2 ¿δ^2 ʃi·^{2}, ʃbja·^{2} tzə^1 dzi·^{2} ʃi·^{2},
gwe^2 ʃbja·^{1} ʃi·^{2} li·^{2} sa·^{2} ta·^{1} dʒɛ^2, ¿δ^2 ʃtʌ^2 ljo·^{2},
ʃlo·^{2} pɹɛ^1 ʃi^2 gɛ^2, ¿δ^2 ɹwa·^{1} ljo·^{2}, sgo·^{1} ma·^{2} dzɛ^2 dzɛ^2,
¿δ^2 dzɛ^2 dzɛ^2, xo·^{1} ma·^{2} t'ɛ^2 t'ɛ^2, ¿a·^{2} t'ɛ^2 t'ɛ^2,
¿a·^{2} ljo·^{1} ɱei^2 ẘo·^{2}, ¿δ^2 na·^{1} so·^{2} p'ɹ'ɛ^2, ¿a·^{2} wo·^{1} bo·^{2} ɲa·^{2},
¿a·^{2} ljo·^{2} ji·^{2}, ʃbja·^{2} ljo·^{2} ɱei^2 wo·^{2}, ʃbja·^{2} na·^{1} so·^{2} p'ɹɛ^2,
ʃbja·^{2} wei^1 bo·^{2} ɲa·^{2}, ʃbja·^{2} ljo·^{2} ji^2 mo·^{2}, bo·^{1} tzo·^{2} dʒi·^{2}
dzə^2 zdi·^{2} tʃja·^{2}, zo·^{2} bo·^{1} tzo·^{2} dʒi^2, ɹa·^{2} zdi·^{2} tʃʌ^1,
hwa·^{2} t'u·^{2} dzu·^{2} dzɛ^2, ʃjei^2 zTi·^{2} tʃʌ^2, ʃjei^2 bi·^{2} bo·^{2} li·^{2},
su·^{2} ʒ̊ti·^{2} tʃʌ^2, zə^2 ɹa·^{2} mo·^{2} dʒɛ^2, dʒei^2 δ^2 mo·^{2} tʃʌ^2
zə^2 tsɛ^1 mo·^{2} tsɛ^2, k'si·^{2} ɲa^1 tʃja·^{2}, lʌ^1 ɹa·^{2} ɱae^2 ᗡo·^{2}
ʃi·^{2} mo·^{1} tʃʌ^2, lʌ^1 si·^{1} mi·^{2} ᗡo·^{2}, ʃtu·^{1} ɲa·^{2} tʃʌ^1,
ʃi·^{1} ts'u·^{2} ʃy^4, ʃbja·^{2} dʒi·^{1} ʃy^4, zgʌ^2 sto·^{2} ʃy^4,
ʃbja·^{2} dʒi^1 ʃy^4.

SECTION 12, mʌ^2 tsɛ^1 tzu·^{2} (or dzu^2, or tzo·^{2})

mbo·^{1} ji·^{2} ma·^{2} mi·^{2}, mʌ^2 tsɛ^1 (or tzɛ^1) wei^4,
mbɛ^2 ʒ̊i·^{1} ma·^{2} mei^2,
stu·^{1} xa·^{1} wei^4, mʌ^2 tzɛ^1 tzo·^{2} (or tzu·^{2}) sə^2, zə^2 δ^1 t'ai^2,
stu·^{2} xa·^{2} tzo·^{2} sə^2, ʃi·^{1} δ^2 t'ai^2, mʌ^2 tsɛ^2 tzu·^{2},
zdo·^{2} To·^{2} Ga·^{2} ʃwɛ^2, mi·^{1} Ga·^{2} ʃwɛ^2, zo·^{2} lʌ^1 bɛ^2,
mo·^{1} To·^{2} wɛ^2 gu·^{2}, Ga·^{2} ba^2 mo·^{2} bi·^{1} t'a·^{2} gɛ^2, nTɛ^2 dʒi·^{1} gʌ^2 nʌ^2,
Ga·^{2} ba·^{2} mo·^{2} bi·^{1} t'a^2 sə^2, stu·^{1} xa·^{1} tzu·^{2} To·^{2},
Tɛ^2 zə^2 zda·^{1}, mo·^{1} To·^{1} wɛ^2 gu·^{2}, ɲa·^{1} bo·^{2} ljo·^{2} sə^2,
ts'wei^2 mo·^{1} ljo·^{2} sə, Ga·^{2} ba·^{2} mõ·^{2} bi·^{1}, nTɛ^2 zə^2 zda·^{2},
ts'wei^2 mo·^{1} ljo·^{2} gʌ^2, Ga·^{2} Twei^1 t'u·^{2}, ɱɛ^2 nʌ^2 lɛ^2,
mo·^{2} tzɛ^1 tzo·^{2} To·^{2},
ndzɛ^2 ma·^{1} nʌ^2 dzʌ^2, ʃi·^{2} li·^{1} ʃjei^2 k'u·^{2}, sa·^{1} gʌ^1 tʃɛ^2 nʌ^2,
ʃi·^{2} li·^{1} ʃjei^2 k'u·^{2},
dʒa·^{2} gʌ^1 tʃɛ^2 nʌ^2, go·^{2} ʒ̊i·^{1} ʃjei^2 Ta·^{2}, ʃjei^1 gu·^{2} tʃɛ^2 nʌ^2,
go·^{2} ʒ̊i·^{1} ʃjɛ^2 Ta·^{2},
Tu·^{2} gʌ^1 tʃɛ^2 nʌ^2, stu·^{2} ha·^{1} dzo·^{2} sə^2, Tɛ^2 zə^2 zda·^{1}, go·^{2} ʒ̊i·^{1} ʃjɛ^2 Ta·^{2},
Tu·^{2} nʌ^1 y^2 sa·^{2}, Ga·^{2} ba·^{2} mo·^{2} bi·^{1}, Tɛ^2 zə^2 zda·^{1}, mo·^{2} tzɛ^1 tzo·^{2} To·^{2},
dzɛ^2 ma·^{1} na·^{2}, dzɛ^2 bɹa·^{1} a·^{2} lʌ^2, gi·^{1} gʌ^1 a·^{2} dʒi·^{2}, ʃi·^{1} sta·^{1} bei^2 tʃi^2,
dʒei^2 gu·^{1} a·^{2} lʌ^2, δ^2 zbu·^{1} gu·^{1} a·^{2} dʒi·^{2}, zbo·^{1} sta·^{1} bi·^{2},

dʒei² ʃi·¹ a·² lʌ², mʌ² tsɛ¹ tsu·², dzə² gɛ¹ a·² dʒi·², dzə² sa·¹ bei²,
Ga·² δ² ɲo·¹, k'si·² ŋa·¹ ny·², mo·¹ ts'o·² jɛ² go·², stu·¹ jɛ² go·²,
mo·² (or mʌ²) tsɛ² tzu·², Ga·² To·¹ ʃjei² ʃjei², Ɔu·¹ ʃjei² ʃjei·², li·²swa·¹ δ² dʒi²,
Ɔu·¹ dʒi² dʒi², a·² ʃi·² na·² To·², stu·² xa·¹ dzo², mo·² Tzɛ² tzu·² To·²,
Tɛ² zə² zda·², dzə² ɱɛ¹ sə² tzə², dzə² δ¹ go·², ʃbja·² ɱɛ² sə² tzə²
spja·² δ² go·² na·², spɛ² lʌ² dzə² Tɛ², ɱa·² zgʌ¹ wo·², t'o·² δ² bi·² bi·²,
ɹa·¹ gɛ¹ bɛ², ɲi·² lʌ² dzʌ² Tɛ², ŋʌ² zgʌ² wɛ², tzu·¹ go·¹ bi·² bi·,
ku·² gɛ¹ bɛ², ʃjɛ² lʌ² dzə² Tɛ², ɲa·² zgʌ¹ wo·², tsʌ¹˒² ɹwa·² bi·¹ bi·¹,
gɛ² Ga·² bɛ², dzə² lʌ¹ dzə² Tɛ², pa·² zgʌ¹ wo·², dzə² wa·¹ bi·² bi·²
ni·² la·¹ bɛ², wɛ² lʌ¹ dzə² Tɛ², ɲa·² gzə² wa·², dzə² ¿a·² bi·¹ bi·²,
dzɛ² lʌ² bɛ², dzə² xa·¹ mi·² xa·², a·² xa·¹ bɛ², dzə¹ Go·¹ mi·² Go·²,
a·² Go·¹ bi·², zə¹ ʃji·¹ mi·² ʃji·² a·² ʃji² bɛ², a·¹ bu·¹ δ² ʃji²,
a·² nʌ² lʌ², a·² nʌ¹ zgʌ², a·² lʌ² δ¹ ʃji², ʃji² ʃwɛ¹ δ² a·²,
xa·² ʃji¹ ʃbja·², ʃi·¹ ts'u¹ (or stu·¹) ʃy², ʃbja·² gi¹ ʃy²,
δ² zgʌ² ts'o² ʃy⁴, ʃbja·² dʒi¹ (or gi¹) sy⁴.

Section 13 (mbo·²)

mo·² dʒɛ¹ mo·² ɲa·², ɹo·² dʒɛ² tʃɛ, mo·² dzɛ¹ ɹo·² dʒɛ²,
Twɛ² lja·¹ ʃi·² gɛ², gwɛ² dʒɛ² Ga·², sə² la·¹ ma·² ɲa·²
nTo·² la·¹ tʃjʌ², sə la·¹ To·² la·², ʒ̊ai² pɹɛ¹ wa·² dzə²,
gwɛ² dʒɛ² Gʌ², mo·² dʒo·¹ so·² ɹo·², mo·² bi·¹ dzo·²,
sbo·² ndzo·¹ so·² ɹo·², bo·² ɱa·¹ dzo·², pɹ'ɛ¹ ɹo·² ɹa·² gɛ²,
mbo·² zə¹ ndzu·², li·¹ lo·² ɹa·² gɛ², mbo·² t'a·² ʃp'i·³,
Ga·² zə¹ ɱɛ² zʌ², mbo·² zə¹ dzu·², Ga·² t'a·¹ mi·² t'a·²,
mbo·² t'a·¹ spi·³, k'a·¹ ɹa·² la·² bɛ², mbo·² la·² bɛ²,
dʒu·² gu·¹ la·² tʃɛ², mbo·² la·² tʃɛ², ɹu·² bɛ² dzɛ² gu·²,
a· bɛ¹ bɛ², lo·² ɲi·² dʒɛ² gu·², a·² bɛ¹ bɛ²,
ma·² zdo·² dʒi² gu·², hwei¹ p'o² p'o², ʃpɛ¹ ɹa·² dʒi² go·²
p'o·¹ Ta·² Ta·², δ² zgo·² Ti·¹ ʒ̊i·², mbo·² dʒɛ¹ ʃtʌ²,
mbo·² dʒɛ¹ wu·² dzʌ², nTɛ² t'o² ʃjo·², mbo·² la·¹ Ɔwo·² dzʌ²,
Tɛ² ho·² la·²,

Section 14 (K'o·²)

mo·² bi·¹ ʃi·¹ bi·³, k'o·² ʃi·¹ bi·³, mo·² ¿a·¹ so·² ¿a·²,
k'o·² so·² ¿a·², mo·¹ To·² wɛ· gu·², Ɔa·² ɲa·¹ sga·² sə²,
k'o·² sə² gi·³, t'ʌ¹ wɛ¹ wɛ² gu·², ʃi·² ɲa·¹ wo·² sə²,
k'o·² ʃy² gɛ¹, bu·² ʃbu·² tzu·² li·¹, Twɛ¹ δ² wo·² ɱɛ² lɛ²,
k'o·² tzu·² gi², sə² zə² dzu·² li·², tʃi·¹ δwo·² mɛ² lɛ²,
k'o·² Ti·² gɛ¹, zə² Tʌ¹ dʒi² go·² (or gu·²), ʒ̊a·² sgo·² t'wei³,
ʃbi·¹ Tʌ² dʒi² gu·², δ² zbo·² sgo·² t'wei³, δ² Tʌ² dʒi² go·²,
dzu·² xo·² t'wei³, dzə² Tʌ¹ dʒi² go², ts'a·² xo·² ts'wei³,
ndzu·² Tʌ¹ dʒi² go·², ste² xo·² t'wei³.

Section 15 (dʒɛ²)

dʒɛ² ʃi·¹ ʃto·² mʌ², ʃi·² ʃto·² mʌ², dʒɛ² ʃbɛ¹ ɹa·² mʌ², ʃbɛ² ɹa·² mʌ²,
mo·² ɹo·² nTɛ² ts'o², zdi·² ɹo·¹ ts'o·², zdi·² ɹo·¹ nTɛ² ts'o²,
dzu·² ɹo·¹ ts'o·²,

dzu·^{2} ɹo·^{1} Tɛ^2 ts'o·^{2}, tzu·^{1} tzu·^{2} ʃi·^{2} ɲa·^{2},
swa·^{1} swa·^{3} ts'wei^2
p'ɹɛ^1 lʌ^2 a·^{2} lʌ^2, ʃjɛ^2 tʃi·^{2} gʌ^3, ¿a·^{1} la·^{2} a·^{2} lʌ^2,
ʃjɛ^2 tʃi·^{2} gʌ^3,
go·^{1} la·^{2} a·^{2} lʌ^1, ʃjɛ^2 tʃi·^{2} gʌ^3, ndzə^2 la·^{1} a·^{2} lʌ^2,
ʃjɛ^2 tʃi·^{2} gʌ^3
ʃjɛ^2 sə^1 ɲɛ^2 tʃi·^{2}, ndzə^2 sə^2 tʃi·^{2}, mo·^{2} dʒi·^{1} tzɛ^2 lʌ^2,
ʃjɛ^2 lʌ^2 stɛ^2,
tzu·^{1} p'u·^{3} tzɛ^2 lʌ^2, ¿a·^{2} lʌ^2 stɛ^2, a·^{2} skɛ^2 ji^2 skɛ^2,
ma·^{2} Ta·^{1} skɛ^2,
ɲi·^{2} skɛ^2 jɛ^2 skɛ^2, tzu·^{1} p'u·^{3} skɛ^2, ʃjɛ^1 skɛ^2 jɛ^2 skɛ^2,
pɹɛ^2 ɹo·^{2} wo·^{2} bo·^{2}
ʃjɛ^2 ɲu·^{1} skɛ^2, ndʒu·^{2} ʃji^1 ծ^2 ts'o·^{2}, ʃji^1 ծ^2 ts'o^2,
mo·^{2} To·^{1} zu·^{2} bɛ^2, zə^2 la·^{2} bɛ^2, ni·^{2} sko·^{2} Ta·^{2} ts'wa·^{2}
su·^{1} sko·^{2} zTa·^{2} sko·^{2}, swa·^{1} swa·^{3} tswei^2,
dʒɛ^2 dʒi·^{1} Ꭰwo·^{2} tzə^2,
nTɛ^2 ts'o·^{2} ʃjo·^{2}, dʒei^2 la·^{1} Ꭰwo·^{2} tzə^2, Tɛ^2 xo·^{2} la·^{2}

SECTION 16 (zgu·^{2})

mo·^{2} To·^{2} wɛ^2 gu·^{2}, zgo·^{2} ni·^{2} zgo·^{2} p'ɹɛ^1, ʃjei^2 zgo·^{1} ʃtʌ^2,
zgo·^{2} pɹ'ɛ^1 ma·^{2} tʃjɛ^1, y^2 pɹ'ɛ^1 tʃjɛ^2, y^2 pɹ'ɛ^1 a·^{2} ʒ̊a·^{2},
ʃi·^{1} Gʌ^1 xo·^{2}, zo·^{2} ʃja·^{1} lɛ^2, zgo·^{2} xa·^{1} ma·^{2} tʃjɛ^2,
y^2 xa·^{1} tʃɛ^2, y^2 xa·^{1} tzə^2 sə^2, gwɛ^2 Gʌ^1 xo·^{2},
sto·^{2} ʃja·^{1} li·^{4}, zbo·^{2} ɲi·^{1} ma·^{2} tʃjɛ^2, y^2 ni·^{2} tʃjɛ^2,
y^2 ni·^{1} a·^{2} ʒ̊a·^{2}, ʃwa·^{1} Gʌ^1 xo·^{2}, ʃwa·^{2} dʒi·^{1} tʃju·^{2},
zgo·^{2} dʒi·^{1} Ꭰo·^{2} tsɛ^2, Tɛ^2 ts'o·^{2} ʃjo·^{2}, zgo·^{2} la·^{1} wo·^{2} tzʌ^2,
Tɛ^2 xo·^{2} la·^{1}

SECTION 17 (ts'o·^{2})

dʒi·^{2} ts'o·^{1} bo·^{2} dʒɛ^2, Ga·^{2} ba·^{1} mʌ^2 zə^2, ma·^{2} Ta·^{1} ʃbi·^{3}
ks'ɛ^2 bjɛ^1 Tɛ^2 Gʌ^2, ts'o·^{2} Tʌ^2 ʃi^3, zgo·^{2} bjɛ^1 Tɛ^2 Gʌ^2,
ts'o·^{2} Ta·^{2} ʃjɛ^2, sgo·^{2} xa·^{2} ʃin^2 Tʌ^2, so·^{2} ծzgo·^{1} wɛ^2 sə^2,
ts'o·^{2} zə^2 go·^{1}, ɲa·^{2} wo·^{2} ʃi·^{1} ba·^{1}, gwɛ^2 sko·^{2} ts'wei^2
a·^{2} tʃɛ^1 ɹo·^{2} Go·^{2}, ʒ̊ɛ^2 ծ^2 zbo·^{2} ts'wei^3, za·^{2} wa·^{1} ɹo·^{2} Go·^{2},
bi·^{2} ʃbja·^{2} ts'wei^3, ts'o·^{2} dzi·^{1} Ꭰ·^{2} tzə^2, Tɛ^2 ts'o·^{2} ʃjo·^{2},
ts'o·^{2} la·^{1} Ꭰo·^{2} tsɛ^2, Tɛ^2 ho·^{2} la·^{2}.

SECTION 18 (so·^{2}.)

so·^{2} bi·^{2} ɲa·^{2} ծ^2 mʌ^2, so·^{2} li·^{1} bi·^{2}, so·^{2} ɲa·^{2} ɲa·^{2} ծ^2 ma·^{2},
so·^{2} ʃjɛ^1 ɲa·^{2}, mo·^{1} To·^{2} sə^2 dʒu·^{2}, ʃja·^{1} sə^2 dʒy^2,
ʃja·^{1} mi·^{1} ʒei^2 (or ɹei^2) To·^{2}, zdo·^{1} zə^2 dʒy^2, p'a·^{1} i·^{1} swei^2 gɛ^2,
zgo·^{2} Tɛ^1 ʃtʌ,^{2} zgo·^{2} xo·^{2} mo·^{2} ba·^{1}, su·^{2} jo·^{1} tw'ei^2,
su·^{2} sko·^{2} mo·^{2} ba·^{1}, zTa·^{1} jo·^{2} tw'ei^2, zda·^{1} sko·^{2} mo·^{2} ba·^{2},
p'u·^{2} jo·^{1} ts'wei^2, p'u·^{2} xo·^{2} mo·^{2} ba·^{1}, tʃa·^{2} jo·^{2} ts'wei^2,
tʃja·^{2} xo·^{2} mo·^{2} ba·^{1}, sa·^{2} jo·^{1} ts'wei^2, sa·^{2} xo·^{2} mo·^{2} ba·
ji^2 jo·^{1} ts'wei^2, ʒei^2 (or ɹei^2) xo·^{2} mo·^{2} ba·^{1}, ba·^{2} jo·^{1} tʃ'wei^2,
ba·^{2} xo·^{2} mo·^{2} ba·^{1}, Ꭰgɛ^2 jo·^{1} ts'wei^2, Ꭰgɛ^2 sko·^{2} mo·^{2} ba·^{1}

ts'wa·^{1} jo·^{2} ts'wei^{2}, ts'wa·^{1} xo·^{1} mo·^{2} ba·^{2}, y^{2} jo·^{1} ts'wei^{2}
y^{2} sgo·^{2} Tɛ^{2} ts'ə^{1}, ʃi·^{1} jo·^{2} ts'wei^{2}, y^{2} ʒ̊a·^{2} ʒ̊a·^{2} Tɛ^{2} p'u·^{2},
dzə^{2} jo·^{1} ts'wei^{2}, ʒ̊i·^{2} To·^{1} δ^{2} ljo·^{2}, ts'aƆ^{2} a·^{1} ʃi·^{2},
nTo·^{2} Go·^{2}, ʃi·^{2} dʒja·^{1} ʃi·^{2}, gwɛ^{2} ɲi^{2}, p'u·^{2} bδ^{2} ʃi^{2},
xa·^{2} so·^{1} δ^{2} lju·^{2}, wɛ^{2} bɹa·^{2} ʃi·^{3}
ko·^{1} tzδ^{1} δ^{2} lju·^{2}, to·^{2} dzo·^{2} ʃi·^{2}
p'u·^{2} tzʌ^{2} δ^{2} lju·^{2}, ɹa·^{2} dzu·^{1} ʃi·^{3}
ts'a·^{2} Gɛ^{1} δ^{2} lju·^{2}, swei^{2} ɲa·^{1} ʃi·^{2}
wo·^{2} tzʌ^{2} δ^{2} lju·^{2}, swei^{2} ¿a·^{1} ʃi·^{3},
wa·^{2} tzʌ^{2} δ^{2} lju·^{2}, ts'a·^{2} Ga·^{2} ʃi·^{3},
ja·^{2} ba·^{1} δ^{2} lju^{2}, ɹo·^{2} ba·^{2} ʃi·^{3},
p'o·^{1} so·^{1} δ^{2} lju·^{2}, wɛ, ba·^{2} ʃi·^{2}
sə^{2} Gu·^{1} δ^{2} lju·^{2}, ToƆ ɲi·^{2} ʃi·^{3},
Xɛ^{2} ɲu·^{1} δ^{2} lju·^{2}, wɛ^{2} bɹa·^{2} ʃi·^{3},
bɛ^{2} ʃi·^{1} ɲa·^{2} gɛ^{2}, ts'wo·^{2} dɹo·^{2} ʃi·^{3},
soƆ^{1} p'a·^{1} δ^{2} lju·^{2}, zbu·^{1} ɲi·^{3} ʃi·^{3},
t'ɛ^{2} p'ɛ^{1} ʃjei^{2} tswa·^{2}, ʃjei^{1} zdu·^{2} ʃi·^{3},
mo·^{2} t'o·^{2} δ^{2} lju·^{2}, k'a^{2} bja·^{1} ʃi·^{2},
sə^{1} ma·^{1} dʒɛ^{2} gɛ^{2}, ɹa·^{2} swa·^{1} ʃi·^{3},
δ^{2} zgδ^{2} ɹa·^{2} δ^{2} lju·^{2}, y^{2} ʃja·^{1} ʃi·^{3},
bao^{2} ʃɛ^{1} δ^{2} lju·^{2}, t'o·^{2} tzo·^{2} ʃi·^{3},
δ^{2} ¿u·^{2} mi·^{2} δ^{2} lju·^{2}, ts'a·^{1} k'u·^{2} ʃi·^{3},
ʃtʌ^{1} ʃta·^{1} δ^{2} lju·^{2}, mδ^{2} zgo·^{1} ʃi·^{3},
ma·^{2} lo·^{1} dʒɛ^{2} gɛ^{2}, ʃjei^{1} zdu·^{2} ʃi·^{3}, [40]
ɹo·^{2} mo·^{1} bu·^{2}, a·^{2} dʒo·^{1} lʌ^{2}, zə^{2} wɛ^{1} mi·^{2} δwa·^{2},
dʒi·^{2} dʒo·^{1} ʃi·^{2}, zə^{2} wɛ^{1} ɲɛ^{2} δ^{2} wa·^{2}, δ^{2} zbo·^{1} mo·^{2} ʃi·^{3},
ʃi·^{1} dʒu·^{2} o·^{2} dʒu·^{2}, Tɛ^{2} zgɛ^{2} nʌ^{2}, mu·^{1} dʒu·^{1} ʃgo·^{2} dʒu·^{2},
Tɛ^{2} zgɛ^{2} nʌ^{2}, ʃi·^{1} ku·^{2} mu·^{2} k'u·^{2}, Tʌ^{2} tzu·^{2} nʌ^{2},
ʒ(ɹ)i·^{2} ʃi·^{1} zgo·^{2} Ti·^{2}, Tɛ^{2} zdʌ^{2} nʌ^{2},
gwɛ^{2} ljo·^{2} ma·^{2} stɹo·^{2} ljo·^{1} ma·^{2}, dzɛ^{2} lʌ^{2} dzɛ^{2} wɛ^{2} ʃna·^{1} dzɛ^{2} wɛ^{2},
ka·^{1} ɹa·^{2} bja·^{2} Ga·^{2}, ʃi·^{2} Gʌ^{1} zbo·^{2} stʌ^{1}, bo·^{1} dzʌ^{2} bo·^{2} ʃi^{2},
t'a·^{2} zwei^{2} wɛ^{1},
dʒɛ^{2} Gʌ^{1} Tɛ^{2} ¿ɛ^{1}, Gʌ^{2} Tɛ^{1} ¿ʌ^{1}, a·^{2} p'u·^{2} ljei^{2} p'u·^{2}, zda·^{1} xo·^{1} p'ei^{2},
gwɛ^{2} ljɛ^{2} p'u·^{2}, gwɛ^{2} dʒi·^{1} sə^{3}, p'ɹɛ^{1} zgo^{2} ʃjɛ^{2} dzə^{1} ʒ̊i·^{1} Twei^{2} ɲɛ^{2},
li·^{2} sa·^{2} tzə^{1}, gwɛ^{2} Ta·^{1} t'ɛ^{2}, gwɛ^{2} tzə^{1} tzɛ^{2} ju·^{1}, ʃjɛ^{1}, ʃjɛ^{2} p'jɛ^{1} ʃtʌ^{2},
su·^{1} δ^{2} dzɛ^{2} dzɛ^{2}, sgo·^{2} bo·^{1} ʃji^{2},
sə^{2} Ta·^{1} dʒy^{4}, mi·^{1} Ta·^{1} dʒy^{4},
ʃiɛ^{1} ts'u·^{1} ʃy^{4}, ʃbja·^{2} dʒ·^{1} ʃy^{4}, zgʌ^{2} ts'u·^{1} ʃy^{4},
ʃbja·^{2} dʒɛ^{1} ʃy^{4}.

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[40] The priest stated that if the ceremony is performed in the sacred grove, the 5 great gods are called, but not the 12 lesser gods. If the ceremony is performed on a housetop, in addition to the 5 great gods, the 12 lesser gods are called. He stated that these must not be called unless a real ceremony is being performed. The remainder of the ceremony, the sacred books chanted, varies with each day. The following words are used on a snake, tiger, and possibly on a horse day.

Translation [41] of the Sacred Books or Chants of the Ch'iang Priest at Lo-pu-chai

Section 1

"What is your name, Mr. Wild Mountain Goat" (male demon king)? "My given name is The One With Wild Buffalo Horns." "What is your name, Mrs. Wild Mountain Goat" (the wife of the demon king)? "My given name is The Person With a Chicken's Bill." Wild Mountain Goat goes to a person's kitchen. He goes to the person's home. Wild Mountain Goat drinks warm wine in the home. He goes to the house where bitter things are sold. He eats bitter things. He goes to the lengthwise beams (of the second story). He goes to the crossbeams (across the beams mentioned above). He arrives at the crossbeams. (Fiercely spoken by the priest), "Male Wild Mountain Goat (name of the demon king), what are you doing here? You that injure people (another demon), your given name is Red Demon (demoniacal being).[42] You came over the road that people travel. Red Demon rides the wooden horse with head outstretched, with nine horses, their feet treading along. Take the red demon outside. Invite the white (good) demon to come in and sit down."

Section 2

There is a male deity whose surname is Horse and whose given name is De. The surname of his spouse is Horse and her given name is De. The surname of his oldest son is Du and his given name is Tsha We. There is a carpenter who planes (manufactures) wooden things well. He is an exceedingly good carpenter. He also chisels rocks well, making stone grinders, tops and bottoms, with good wooden bases and snouts. When handfuls of grain are put in, it flows out when well ground to pieces. The god on his shelf, invite him to come. Put three sticks of incense in the ashes of the incense burner. Invite the deity Dwe Tzu to come. "Can you build the house for worshiping gods?" "I can build it." The god will build the temple (home for worship). Can you build it? I can build a (fine) house.

Section 3, Calling the God Ma

Call the god Ma here. We will erect a new god-house for worship. Call Ma to erect a building. (Arrange) for the god a seat to sit on. Call the servants, for it is dawn (the rooster has crowed). Call the apprentices to bring tools,

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[41] In making the following translation, every word and every phrase was written down in the International Phonetic Script, the meanings studied and written down in English, and the final translation made in consultation with and the approval of the Ch'iang priest.

The phrase translated "he repeats three words" in section 6 probably refers to a magic formula, incantation, or chant.

The sickle with nine teeth mentioned in section 17 reminds one of the neolithic sickle with a number of small, sharp teeth to do the cutting.

[42] This section is really an incantation. When asked why he spoke so fiercely near the end of the section, the priest replied that you must act gruffly toward the demons or they will act overbearingly toward you.

efficient masons, efficient plasterers. White walls, opposite walls alike white. A man Beh, his given name Ma Beh, a scholar to divine the lucky days of the month. The worker, Ma Beh, with his hammer shapes stones, digs a ditch, and takes out the dirt with a basket. A hundred upright (wooden) pillars are erected firmly and perpendicularly. The main horizontal beams, a pair, erected level and parallel. The hundred crossbeams are fixed soundly, the hundred poles are nailed firmly, one thousand bamboo sticks woven together firmly, a hundred small-leafed bamboo twigs compactly laid down in order, a hundred loads of clay made smooth and firm with a hoe, one hundred black stones securely laid into place, the outer walls of the roof made firm above and below. The shrine (god-house) is built firmly, awaiting the time when sacrifice is provided properly. The house for the sacrificial goat is ready for the goat, and the soul of the goat is provided for.

Section 4, Calling the God Ro

(God)Ro, will you chant the sacred books or not? If you do not chant the sacred books, how will you be able to perform the ceremony of paying the vows? If you do not pay the vows you should perform the vows for both the sky god and the earth god (goddess?). Perform the ceremony of paying the vows to the gods in the house. When people perform the ceremony of paying the vows, it should be with sincere hearts. We will certainly pay the vows. Chinese pay their vows, Ch'iang also pay their vows. Both (ceremonially) pay their vows. Eat the (sacrificial) meat properly. Let the paying of the vows be correctly performed. At dawn finish the vow ceremony. Complete it when it is bright (daylight). When the sun is white, finish the vows, lead the male goat. The leader who carries the rooster shares in the ceremony. The cock and the goat will both be sacrified. Wood will be used for the ceremony, the split ginko wood white. The god flag is arranged properly. To the string we have tied the three hairs (from the goat's ear). The horns are placed securely at the opening of the shrine. The ear of the goat is fastened onto the drum.

Section 5, The Gods Receive

The gods having received the offerings have returned home. They have seen the vows performed. The gods have accepted the offerings. The people have received the hide and the hairs from the necks of the goats. The gods have received these offerings. The people are inside the house. The sacred books have been (or are being) chanted. The women are in the house. The ceremonial objects have been set down. The Taoist priest is in the house. The brass gongs are set down. The starlike (lamps or candles) are in the house. They have been blown out. The water ditch beside the house is dammed up. The magistrate has arrived in the house. The magistrate's seal has been set down. The Ch'iang priest is in the house. His drum has been set down. The wealthy guests and relatives are in the house. Their ceremonial gifts have been laid down. The servants are in the house. Their tools have been laid down. The inner home is inside the open front door, where the household utensils are laid down. The gods have finished properly. We have completed the payment of vows. The goats have been rightly received by the gods, and they have the hairs from the goats' necks.

Section 6, Shi

Shall we repeat the divine book or not? If not, how can we fulfill the vows? Shall we chant the words of the sacred books? If not, we cannot perform the vows. The divine ancient priest will repeat the words one by one. He is a very able priest. The (divine) woman priest will chant the words one by one. She is very efficient in working in the fields and in carrying loads on her back. It is difficult to write large characters, hard to write, but easy to chant. It is easy to write small characters. They are easy to write, hard to chant. The person chants the words, he repeats three words. Large stones can be easily brought. They are hard to push along, easy to build with. Small stones are easy to fetch. They are easy to push along, but hard to build with. The stones are plastered with clay firmly. The laborers have put into place three stones. The masons have built into the wall three stones. The house of the god is erected well. The house is plastered well with clay. The workers have built it correctly. They have plastered it with clay.

Section 7

The god Gi is in his house. A message is sent up to him. The goddess is in her house. A message is sent up to her. The cypress tree near the house—a letter is hung up on it. The stars (regarded as deities) are in their houses. Flying up, the message is delivered. The scholar who chants the sacred books is in his house. The words are delivered to him. The deity named water is in his house. Smilingly the message is presented. The magistrate is in his house. The seal is presented. The priest Stu is in his house. The ceremonial drum is delivered to him. The house of the sky-lamp-post. The incense has been lighted and sent up. The simple (common) man is in his house, which is built and given. The house of the door braced with pillars is finished properly for the god. The goats and the flags are in order, the sacred books have been chanted correctly, the goats and the flags are arranged correctly.

Section 8, The Male Owl

A male goat is necessary to perform the vows. The goat is at hand, the owl bears the message. Flags of bamboo and paper are necessary to perform the vows. The goat and the ceremonial platter are ready. Who speaks for the skin of the owl (with the idea of eating the flesh)? It is the pine squirrel that speaks for it. A lonely traveler on the road speaks for it. The leopard with the hairy mouth wants to eat the male owl. The male owl measures his head in a peck measure. The owl's head is so big that he measures it in an imperial peck measure. The eyes of the male owl are measured with a ruler. The eyes of the owl are as big as the imperial tea bowl. The tail of the owl is as big as the emperor's broom. You could sweep the floor with the tail of the male owl. It sweeps the seats of the gods. We will sweep the place (before the gods) where the priest performs his ceremonies.

Section 9, The Female Owl

Feathers and claws on the feet, there are four feet, the female owl has four feet. In the sky are birdlets, offspring of the female owl, one hundred children of the female owl. During the first lunar month draw a picture, a pretty picture. (There is) a vine-circled sacred stick, walking correctly in front. A rolling-pin is called (to make bread). A good encircled stick came (or was brought) properly inside the house which they call an upright bamboo stick, a vine-encircled cane.[43] They say, "Since this has come we will (ceremonially) sweep the village (free of demons), and the grass plot (near the village)." The village and the grassy plot are important. Fir twigs and their butts are needed (as a ceremonial broom). The female owl whose nest is at the village, with a handful of fir twigs chase this mother owl away. The sacred books have been chanted properly, the goats and the flags have been arranged properly, incense and candles and the divine horse have been arranged properly. The goats and the flags are properly arranged.

Sections 10 and 11

The selling price has been fixed by the owner of the goats. The leader has paid the earnest money.[44] The shepherd herds the goats on the mountains. The thirsty goats are led to water. The arm of the caretaker is very long. The keeper leads the goats to graze. Their white teeth chew the grass. When they have eaten enough, the keeper leads them home. The mouth of the owner asks, "Why do you come back so early?" The caretaker replies, "They have finished eating." They tend the goats with white cords. The leader has come. Has the unleavened bread been prepared? The cake of unleavened bread has not been prepared. When the cake of bread is ready, tie it with a white cord. When the cake of bread is cooked, place it in front of the god's shrine. The cake of bread has come. A person fills the peck measure with grain. Buckwheat and peas are wanted. Pure water should be poured from the bowl onto the (red-hot) plowshare. We must pick up the plowshare with tongs. A good-looking round stick is used for the spindlewhorl. Join the threads together with your teeth. The three hairs from the neck of the goat are tied to the string of the bow. We must have the ceremonial sword. The bow is held ready in the

[43] Some of the sacred canes used by the Ch'iang priests are sticks around which a vine grew and wrapped itself so as to leave a deep impression around the stick. Some of them have on top what looks like a carved human head. This is regarded as the head of the demon king. Sometimes at the top of the encircling vine mark a snake's head is carved. It then looks as though a snake were encircling the cane. The king of demons helps the priest control and exorcise demons, and the snake helps frighten the demons. The one purpose of this sacred cane is to control or exorcise demons. Sometimes the sides of the cane are ornamented by knots that grew there naturally when the cane was a live limb or small tree. This scared cane reminds one of the sacred cane used by the Taoist priest in China, which is also used exclusively for the exorcism of demons. It is very likely that the Ch'iang priest has borrowed this from the Taoist priest, and made some adaptations.

[44] When two people make a bargain as to the price of some object, the purchaser often pays a part of the purchase price as "earnest money." This is regarded as a guarantee that he will complete the payment, and the acceptance of this earnest money is a guarantee on the part of the owner that he will not fail to sell at the price agreed upon.

hands (to shoot). One hundred bows are needed. Unless the quivers are leather, they are not desirable. All the bows and all the arrows in the quivers are needed. Without spear points the spears are undesirable. One thousand spears are needed.

The gods have been finished (worshiped) properly, the goats and the flags are arranged properly.

Section 12, The Goddess Mu-tseh-tsu

Above there was one who was sorrowful, called Mu Tseh. Below was one who was sorrowful, called Stu Ha. Mu Tseh considered in her mind, and called from above the person below. Stu Ha considered in his mind, and called to the goddess above. Mu-tseh-tsu combed the hair of her head. After it is combed, she can get married. (She said), "In the sky is a house. Speak to my father Mo-bi-da about it, to see if he is willing or not." Her father, Mo-bi-da, replied, "You child Stu Ha, what have you come here to do? In the sky we have a house. What have you come here for?" "I have come to seek a wife." Father Mo Bi answered, "You have come to seek a wife. You are not a match for me. My daughter, Mu-tseh-tsu, if you want to get her, the mountain trees in three gulches (or canyons) you must go and cut down. The mountain trees in three gulches, you must go and burn them. Thirty bushels of rape (mustard) you must sow in the fields. Thirty bushels of rape, you must go and reap." Stu Ha replied and said to him, "Thirty bushels of rape I have sowed and brought home." "My daughter Mu Tseh I will marry to you. One oldest daughter is married to a god and cares for the house of the god. The second daughter is married to the Dragon King and cares for his home. The third one, Mu-tseh-tsu, is to be married to a common man. In front drive a hundred domestic animals. Behind a thousand will go back home. The hair of the head should be combed beautifully, the finger rings worn properly, beaten of silver. Await a lucky day."

Stu Ha, the groom said to the daughter, Mu-tseh-tsu, "My home is not good." He told her to return home. "Thirsty and without food, go back home to eat." "If I go back," she said, "during the first moon (lunar month), what things have you to give me?" "The (jasmine) flower that welcomes the spring." "If I return during the second moon, what have you to give me?" "The Shui Tang (water pool) flower that blossoms on the edges of wells." "If I return during the third moon, what have you to give me?" "Roses which bloom on the edges of terraced fields." "If I return during the fourth moon, what have you to give me?" "Buckwheat flowers that blossom in the fields." "If I return during the fifth moon, what have you to give me?" "Wheat and barley which bloom in the fields." "Has the barley ripened?" "All has turned yellow and ripened." "Has the barley been reaped with a sickle?" "All has been reaped." "Has the beard grown on the wheat?" "All (the wheat) has blossomed beards." "One complete year, 1 month, 12 months, 12 flowers. One month, 30 days." Three wheat biscuits have been cooked, the sacred books have been chanted properly, the goats and flags have been arranged properly, incense and candles have been arranged properly, the goats and flags have been properly arranged.

Section 13

A person has no house. He wants a house. He wants a house and land. He wants tools, firewood, and water. Goats and dogs are mine, and chickens and cats. I want also geese and ducks. Using a cane covered with white pewter, drive the goat ahead. The person sits down and winds yarn on the spindle. The aged father, yes, a woman sewing. The aged mother, yes, white mountains and cliffs. The sacred book is like a magistrate in his chair. On a low mountain is a perpendicular cliff. The sacred book (or chant) is like a priest. There is a pass over a mountain. A flower blooms on a cliff on a mountain pass. The sacred book has bloomed like a flower. A fir tree in full blossom has been brought here. It is brought home. I brought it. Lights in the home are like stars. They blossom like a flower. A fir tree in full blossom has been brought here. Cedar twigs from the high mountains have been brought home. A dull white, the stone is here. The sacred book has been put down in the home. This house belongs to the sacred book, Ceremonially sweep (free of demons) the house. The sacred book can fly. We will chant the sacred book that has flown here. (Sacred book), you seem to me to be alive.

Section 14

An old person named Wood (or an old god?), a parent of this sacred book. A person makes a straw image and binds it with a cord. The sacred book binds the straw image. In the sky there is a house. There is a phoenix with feathers bright as silver. The phoenix went and saw the sacrificial goat. They have a home. A dog and a person went to look at it. They released the goat in the field. A cord of cotton. A weak cord that will break is undesirable. Tie the goat with a rope made of palm fiber. One circle and one knot are not enough. Lead the goat over here. The magistrate has a house. He takes the seal in his hand and presses down. The priest has a house. The ceremonial drum is in his hand ready to be beaten. The wealthy man has a house. Cedar twigs from the high mountains are taken in the hand and burned. The common people have houses. The red-hot plowshare is in the basin (for the leaders to purify themselves by the steam). The second (inner) door has a house. The leaders are holding the goats and the white paper flags.

Section 15

There is a goddess whose name is Sto Mu. A priestess named Ra Mu. The priestess is efficient in chanting the sacred books. A hairy horse was lost. The horse fell off a cliff and was killed. The horse was lost by falling to death over a cliff. The knife cuts up the horse flesh (to eat). With a knife skin the horse and cut off its flesh. Carry water on the back and bring firewood. The fire ignites and heats the cooking vessel. One white person (there is). Drive the wild goat out of the woods. The wild goat could not be driven out. The (wild) man was driven out. (There was) one man with a rifle and a spear grasped in his hands. There was a palm tree. One stabbed the (wild) man with the spear. One prod, two prods. He prodded the palm tree. Three prods—again he prods. The wild man sat on the white pavement slab. He hacks the wild man with an ax, and prods (with his spear). He opens the main door of his house. (In the door) he was good to see (to those inside). The lights in the house were like stars in the sky shining down. The second watch in the night. (By and by) the mountains and the clouds were lightened with the break of dawn. When it is broad daylight we will return home. He is the sacred book Je Ji. Drive out the demons, go. The sacred book makes the demons fly away. Fly very quickly.[45]

Section 16

In the sky in a circle are a black and a white stone. There are three stones there. The white stone is not wanted. One white chicken. With the chicken cleanse the throne of the god. Cleanse the lower places so the people will be happy. The yellow stone is not wanted. The yellow chicken is wanted, a yellow hen. Cleanse the sacrificial goat from head to foot. Cut off the three hairs from the goat's neck and tie them to the large flag. The black stone is not wanted. We need a black chicken. One black chicken. Purify it from head to foot with the smoke of cedar twigs. Cleanse the cedar twigs while cleansing the sacred books. This is the stone that can fly. Quickly fly away.

Section 17

The priest's apprentice teaches (or is taught). The aged father, the priest, is very good. Climb up eight mountain ridges. Take cedar twigs in the hands and scatter them. Climb up nine mountain ridges. The cedar twigs grow up. There is a golden yellow sickle. In all it has nine teeth (like a saw). Twigs of the crow bush, purify the goat's mouth. Eighteen skin bags, purify with the smoke of cedar twigs the goat's mouth. Eighteen skin bags, purify with the smoke of cedar twigs the barley and wheat. There are skin bags to hold buckwheat. Purify with smoke the peck measure and the pint measure. Call the apprentice to ceremonially sweep the thrones of the gods. Let the apprentice take burning cedar twigs in his hands and with the smoke cleanse the thrones of the gods. The apprentice makes the demons fly away more quickly. Fly away quickly.

Section 18, The God So

"God So,[46] what is your name?" "My name is Mr. Sifter." "What is the name of So's wife?" "It is Mrs. Sifter." There came out of the sky, a light came forth. Behind the light in the road a tiger came. Into the pool of water a stone fell (displaced by the tiger?). With its lips the rock blew a wind, and the wind awakened the mountain. The mountain with its lips blew a wind, and the wind awakened the clouds. The clouds with their lips blew a wind, and the wind awakened the trees. The trees with their lips blew a wind, and the wind awakened the leaves. The leaves with their lips blew a wind, and the wind awakened the road. The road with its lips blew a wind, which awakened the resting place beside the road. The resting place beside the road with its lips blew a wind, which awakened the terraces. The terraces blew a wind which awakened the village. The village with its lips blew a wind, which awakened

[45] This section has the flavor of an incantation to exorcise demons.

[46] The word *so* means sifter.

the chickens. The chickens flapped with their wings (before crowing), and the people were awakened.

(Calling to the local gods)

Come, God of Chengtu, Ts'ang-a-shi (Liu Pi);
God of Kuan-hsien, Hsi-jia-shi (Kuan Shen Yen);
God of Yang-tzŭ-lin, P'u-ber-shi, big tree god;
God of Wen-ch'uan, We-bra-shi, city wall god;
Come God of Wei-chou, T'o-dzo-shi (Tu-ti);
Come God of Yen-men, Ra-dzu-shi, or god of the pointed cliff;
Come God of So-ch'iao ruler of water (Shui Kuan);
Come God of Hsiao-chai-tzŭ, Shui-ga-shi;
Come God of Lo-pu-chai, god of the mountains;
Come God of Ch'ing-p'o, the lord of earth;
Come God of Wen-ch'eng, big city wall god;
Come God of Sugoo, Tong-nyi-shi;
Come God of Hong-(Mung)-hsien (Mou Chow), big city wall god;
Come God of T'u-ti-lin, the lord of the earth;
Come God of Sung-P'an, the black yak god;
Come God of Three Villages, the god of the three cliffs;
Come God of Mo-t'o, the big cliff god;
Come God of P'u-wa, the white cliff god;
Come God of Mu-shang-chai, the phoenix god;
Come God of Li-fan, the lord of earth;
Come God of Er-go-mi, the thorn tree god;
Come God of T'ung-hua, the thunder god;
Come God of T'ung-li-shan, the god of the three mountain peaks.[47]

This is the horse year and the tenth moon. Is it or not the first day of the month? It is the day of the Dragon God. Open the front door and the inner door, the silver door, the golden door. They are opened. The male and the female dogs are tied up. Push away the stones in the roads. The goat has come, and the three hairs are ready. Any sins the goats have (are that) the hills and ranges are used as pastures, and they eat all kinds of bushes, biting and chewing them—they have this sin. With the dipper pour water on the goat's head. One tremble, two trembles, the goat has trembled. The gods have accepted the goat. The three leaders dressed in white take the flags and hold them in their hands and fingers. They pick up the goat and kill it with the knife. There are three (knives, or leaders who do the killing?). The time has come for killing the goat. The *huen* and the *p'e* souls of the goat have been led away correctly, the ears are properly stuck upon the flags, the gods have returned properly, the incense and the candles are rightly arranged, the doors are properly closed, the incense and the candles are properly arranged.

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[47] At Lo-pu-chai barley seeds are burned after calling each god. If this ceremony is performed in a sacred grove, the 5 great gods are called. If this ceremony is performed on a housetop, the 5 great gods and the 12 lesser gods are called. This can be done only in an actual ceremony, so it was omitted here. The remainder of the chant varies with each day.

The romanization of the names of the gods and of the places of which the Chinese characters were not known are according to the pronunciations in Szechwan Province.

The Ch'iang regard each section of the sacred chants as a sacred book. It is evident that the division between sacred books and incantations is not very distinct, for some of the sections of the sacred chants that are regarded as sacred books are definitely incantations.

9. INCANTATIONS AND EXORCISM OF DEMONS

Belief in and fear of demons as the source of diseases and other calamities and simple or elaborate methods of exorcising them are widespread in central Asia. The writer does not know of one ethnic group among whom they are not to be found. It is also assumed that priests or shamans who have the right techniques can control and exorcise demons.

The minds of the Ch'iang are simply saturated with belief in and fear of demons. Diseases and all other calamities are caused or may be caused by demons. Priests, by their ceremonies, control, protect from, and exorcise demons. People avoid traveling at night as much as possible, for demons are regarded as more likely to be about at night than in the daytime. Demons fear and avoid light, and love dark places.

There are many methods of controlling, protecting from, and exorcising demons, and some of these methods are so widespread in West China that they are found among the Miao and the Lolos of Kueichow, Yunnan, and Szechwan Provinces, as well as among Tibetans, the *Jung,* and the Ch'iang. There are charms and incantations for practically every purpose, from the healing of a boil to the curing of a stomachache.

Among the Ch'uan Miao the *tusn kung* or *do nun* exorcises demons, and the *mo* or priest conducts funerals and performs memorial ceremonies. Among the Ch'iang the same priest generally performs both kinds of ceremonies.

The ceremonies of exorcism among the Ch'iang are sometimes long and elaborate and must be performed solemnly, reverently, and correctly. To perform these ceremonies special priests or shamans are required. The writer has witnessed a number of the ceremonies of exorcism among the Ch'iang, and has been requested by the priest not to laugh, for that would spoil the spirit of reverence appropriate for such ceremonies.

The following ceremony, witnessed by the writer at Mu-shang-chai, was performed by the local priest, Mr. Kou. A man had had bowel trouble for more than 20 days and requested the priest to exorcise the demon that was causing it.

A fire was made of corn cobs and cedar twigs, and a plowshare was placed on the fire. The priest began repeating incantations under his breath. Then he picked up some cedar twigs and moved them around above the plowshare. He then burned some paper or spirit money, repeating more incantations and occasionally saying loudly "phit." Often the incantations were repeated under the breath so that they could not be heard. Repeating more incantations, he threw some grains of barley onto the plowshare. Still repeating incantations, he picked up the red-hot plowshare with a pair of tongs and put his tongue against it so that one could hear a frying sound. He moved the plowshare over and around near the abdomen of the patient but without touching the abdomen, then placed the plowshare back into the fire. Then he trod on the plowshare with his bare foot, brushed the sparks off his bare foot, then trod with this bare foot on the man's abdomen and chest. Again he lifted the red-hot plowshare out of the fire with the tongs, waved it back and forth over the man's back, and put it back into the fire. With his bare foot he again trod on the red-hot plowshare and then on the man's back. All this time he was repeating incantations. He then put the plowshare into water, and the man leaned over so that the steam rose onto his abdomen, chest, and face. Then the priest gave the man some of the water and he drank it.

The priest would not tell the meanings of his incantations, saying that if he did they would not be efficacious. He told the writer that he had been paid one dollar for performing this ceremony. Next day the sick man admitted that he had not been cured.

On August 16, 1942, a similar ceremony was performed at Lo-pu-chai by the priest, Mr. Chang. The ceremony was called *sung mien ren* in Chinese and *nga mi shi* in the Ch'iang language. The ceremony was performed to heal a woman who had a pain in the abdomen.

After smoking some tobacco, the priest burned some paper spirit money. Then he poured two small cups of wine and lighted two candles and three sticks of incense. At this point he requested the writer not to laugh during the ceremony. He began chanting incantations which continued through most of the ceremony. First he chanted under his breath, then audibly, in phrases of three or four syllables, which later grew longer. He now held his sacred cane upright in his right hand, the bottom or point of the cane resting on the ground. There was on this cane the imprint of a vine which had grown around it, and at the top a snake head had been carved, so that the cane looked as though a snake were coiled around it. The priest said that this made the cane more efficacious in frightening away demons.

The chanting continued—now in a low talking tone, now very rapidly. On the table is a peck measure full of buckwheat. Stuck upright in this buckwheat are the two lighted candles and the three lighted sticks of incense. On the table in front of the peck measure are two small cups of wine, some paper spirit money, and a wheat biscuit on which there is some pork. The priest goes to another room, where he burns incense to and worships the family gods. Then he sits down, chats with the spectators, and takes a long smoke.

Again the priest begins to chant his sacred books and incantations, at first in three-syllable phrases. It is evident that the efficacy of the ceremony depends very much on these incantations.

The priest pauses and drinks some tea, then he and all the spectators drink some wine. Then he takes the iron plowshare and places it in the fire. Then he continues the incantations—*teh tzu do, he tzu bo,* three syllable phrases followed by longer phrases. In this ceremony the priest does not wear his ceremonial hat or beat his drum, but he uses his sacred cane. After some time he again stops to rest and smoke. A man now kneads some dough, and the priest in his incantations changes to a scolding tone. The priest now kneads the dough into five objects, a man, an incense vessel, a chicken, an object with one point, and an object with three points. He puts these inside a bamboo husk which he has made into the shape of a plowshare.

After another pause and a smoke, the priest puts some incense twigs and three sticks of lighted incense on the edge of the fireplace as an offering to the fire god. A live chicken is brought, later to be sacrificed. On the uncooked buckwheat is placed five dollars from the family of the patient for his services. The priest puts lighted cedar twigs in the dough incense burner. Before the fire as an offering to the fire god he pours out two cups of wine and lights two candles. He burns spirit money before the fire and waves the chicken as an offering. He pours some wine on the fire and throws some buckwheat into the fire. He continues to chant, waves the hen toward the fire, and burns more paper or spirit money.

The patient, a woman, now comes into the room and sits down. The priest continues his incantations as they cut off the lower part of her long gown, and she puts on the upper part. Always chanting, the priest waves the dough objects and later the chicken around her head and body. She blows her breath on the face of the chicken, which is a hen. The hen is taken out toward the front of the house. The priest waves a dagger over and around the woman's head and body. She takes off her upper gown and her shoes. The priest waves a coal of fire around the dagger, and sticks the dagger into the buckwheat. He lights more incense, then brings a bowl of water and a bowl of tea and places them on the table. The priest prepares a long string, burns cedar twigs, chants under his breath, waves the cedar twigs over the water, puts the string on the back of the table, burns spirit money, waves burning incense sticks over the water, stamps his foot several times, claps his hands, blows on the water, then takes iron tongs and picks up the red-hot plowshare. He picks up the bowl of water with one hand and waves the plowshare over it with the other. He yells "phit" and spurts water from his mouth on her abdomen and feet—water from the bowl.

Now, speaking in Chinese, he treads with his bare foot on the red-hot plowshare, then on her naked abdomen—this he does several times, pressing down with his foot on her abdomen as if pressing something out—they said it was the demon. Then he spurts water, and with his hands presses down on her abdomen to press out the demon. He scolds the demon and orders him to go. He continues this procedure for some time, now shouting "phit" and spurting water on her, now treading downward on her abdomen. He places the plowshare in the water, and she bends over, allowing the stream to cover her head and body. Then she inhales some of the steam. The priest then puts the plowshare on the ground and burns spirit money by placing it on the red-hot plowshare. The lips of the priest move, but there is no sound as he repeats his incantations; then he stamps with his feet and claps his hands. Then he waves his finger over the bowl of water, apparently to write charms on it, and gives the bowl of water to the woman, who drinks it all. He puts a little dough on the dagger and again burns incense. He picks up the string. Repeating incantations, he sits down on a stool beside her. She holds three sticks of lighted incense in her hands. Repeating incantations over the string which he holds in his hands, he ties the string around her neck, then cuts the string. He ties part of the string around her right wrist, then around her right ankle. Then, he touches her forehead, her hands, knees, and feet. When he arises, all express their thanks to him.

The priest goes outside the house, and before the front door he burns incense to his patron deity. Then there is a sumptuous feast, with wine and pork and other edibles. After the feast he again lights candles and incense, burns spirit money, and continues to chant, swaying back and forth. At the corner of the house he lights and sticks into the ground candles and incense, calling loudly to his patron deity. They bring to him the woman's cloth turban and the piece of her garment that was cut off. He now waves burning spirit money over her face and hands and acts as if he were taking something out of her (the demon) and putting it in the flat, round sifting basket called in Chinese a *bo gi.* In Chinese he calls upon the Pearly Emperor, then loudly commands the demon to depart one thousand, two thousand, and three thousand *li,* then calls out "gone." "Yes," reply the spectators. He throws a broom out of the door. In respect for the fire god, four men march around the fire carrying the dough objects, the chicken, a torch, incense, candles, and spirit money.

They and others pass outside the door to the road and march on to the crossroads, where they put down beside the road the candles, incense, sifting basket, the woman's clothing and shoes, the chicken, and the dough objects. The chicken's throat is cut, its blood is splashed on the dough objects, and the chicken's feet and the ends of its wings are cut off and tied to a string over the front door of the patient's home. The chicken is placed on the ground, and the sifting basket, the clothing and shoes of the woman, the dough objects, and the candles and incense are burned to the god of the crossroads. For a time the sacred cane is stuck into the ground. The priest picks up the hen, and they all depart. The priest takes the chicken home as part of his reward, which includes money, pork, two candles, three sticks of incense, and spirit money to his gods.

This was a long ceremony beginning at about 8:30 p. m. and ending finally in the home of the priest at 3:15 a. m. After that the priest took a long smoke before going to bed.

Another method of exorcising demons is to tread on a red-hot *ko* or iron cooking vessel with ceremonies and incantations similar to those we have just described. A manlike image is made of straw. This is stabbed with small bamboo knives or daggers, which are left sticking into the straw image. A cockerel is killed and offered to the gods and spirits, and the straw image is escorted outside the village and left beside the road.

The sacred cane is used exclusively for the exorcism of demons. The priest at Ho-p'ing-chai told the writer that if, when traveling at night he met a demon, he would prod the cane into the ground so that it stood upright, and repeat an incantation, the demon would certainly depart. The priest at Lo-pu-chai said that if when traveling at night he met a demon, he would prod the sacred cane into the ground in the same way, but would not repeat an incantation. The following is the incantation used by the priest at Ho-p'ing-chai with the sacred cane at night to exorcise demons, as given to the writer and translated by the priest:

a·^{3} ba·^{2} mʌ^{2} la·^{2} bi·^{2} bu·^{2} ntzɛ^{2} mi·^{1} mʌ^{2} la·^{2}
mbu·^{3} tzu·^{2} la·^{2} sa·^{1} mʌ^{2} la·^{2}
sti·^{1} To·^{2} bɛ^{2} k'wei^{1} mʌ^{2} la·^{2}

mʌ^{1} Ta·^{2} Ↄa·^{1} tju·^{2} mʌ^{2} la·^{2}
t'a^{1} Ti·^{5} si·^{2} dju·^{1} mʌ^{2} la·^{2}
zε^{2} dju·^{2} bi·^{1} dju·^{2} mʌ^{2} la·^{2}
o·^{1} gε^{2} ʃta·^{2} bi·^{2} mʌ^{2} la·^{2}
o·^{1} Ti·^{2} sta·^{2} mja·^{2} mʌ^{2} la·^{2}

TRANSLATION

Abba Mula (the patron deity of the priest), I, the priest,
invite you to come (and eat and drink), O god Mula.
I carry the drum and ceremonial objects, Mula.
The master of ceremonies and all the people have come, Mula.
My eyes see, all the ceremonial objects are here, Mula.
The aged leaders and the priest have come, Mula.
The leaders among the men have come, Mula.
We call the women, Mula.

One method of exorcism is to *hua shui,* or to transform water. The priest repeats incantations and with his fingers draws charms above the water. Then the water is drunk by the patient. This method may be a part of a longer ceremony of exorcism such as that of treading the red-hot plowshare.

Another method is to entice the demon into a jug, cover the jug with red paper, tie the paper on the jug with silk thread, and bury the jug upside down at the crossroads where many passers-by will walk over it. It is said that after the demon is imprisoned in the jug, he moves about so that he causes the red paper to move.

Sometimes the demons are "swept" out of the house. A fire is built in one corner of the room, and the priest, after repeating incantations, takes hot oil into his mouth and spurts it onto the fire, causing the fire to blaze up. It is asserted that the fire never sets the house afire, even if the house has a straw roof.

Sometimes a straw image of the mysterious nine-headed bird is made, incantations are repeated, a cockerel is killed, and the straw image is ceremonially carried out and deposited by the roadside.

The following explanation of the ceremony of using the straw image of a nine-headed bird to exorcise demons was given the writer by the Ch'iang priest at Lo-pu-chai:

If you see two snakes hooked together (copulating), or a bird flies over you and his droppings fall on you, or a hen crows, or a hen lays a very small egg, or a rat chews your clothes, or you dream that your teeth are falling out, or you dream that you are getting wood on the mountains, or a crow lights on your house and caws, or a frog or a toad gets into your house and croaks, or a female goat gives birth to three kids, all these are unlucky. You may become ill, or somebody may die, or you may get into a quarrel.

To exorcise the demon that is troubling you, the priest makes a straw image, called an *erga,* of a nine-headed bird. A rooster is killed and skinned, and his skin is used as a garment of the straw image. A five-colored (many-colored) paper flag is made and hung up on top of the house. The drum is beaten, the sacred books are chanted in the Chinese language. During the ceremony small, sharp pieces of bamboo are stabbed into the body of the straw image. The image is left with the flag on top of the house, on the wall. A fir branch is also stuck up on the wall near the straw image and the flag. They are left on the houses for at least half a year. If the image falls off, it is left there, but if it does not, it is thrown anywhere away from the house. Sections 1 to 5 of the sacred books are chanted during this ceremony.

Chinese door gods pasted on the front door prevent demons from entering a house. Sometimes a wall is built in front of this door, and a sacred white stone placed on top of it for the same purpose. A sacred white stone on top of a grave keeps demons away.

Charms are used to protect from demons. A red cross or a red cloth image of a monkey is sometimes sewn onto the shoulder of a child's garment as a charm. Small brass mirrors, old cowry shells, and Chinese coin charms are sewn onto the hats of children or onto their garments to protect them from demons. Most priests have stamps or seals by which they stamp charms on paper. These charms consist of Chinese characters formed in strange shapes. The priest at Ho-p'ing-chai had four such charms. One used the name and power of Kwan-yin, the goddess of mercy, one the god of thunder, one the efficacious Taoist god Lin Kuan, and one Li Lao Chün, the founder of Taoism.

Incantations are often secret, and sometimes are pronounced under the breath. They should not be taught or explained to anybody who is not a priest or a geomancer. They should be used only in solemn sacred ceremonies, which are often of exorcism. They may be in the Ch'iang or in any other language, and the priest and the bystanders may or may not understand them. They may have an apparent and definite relation in their wording to the exorcism of a particular demon, or to demons in general, or they may be merely the relating of a legend or story. They are believed to be efficacious, some of them very much so, in producing desired results, including the exorcism of demons.

The following incantations are given as illustrations. The first two are in the Chinese language and are so used by the Ch'iang priests. The third is used in the Ch'iang language. The International Phonetic Script and the explanations are such as were given the writer by the Ch'iang priest.

化水咒

雪花開　雪花長　雪花童子下房來
一根下來冷如雪　二根下來冷如霜
冷冷如霜　冷冷如雪
太上老君勅勅如律令

TRANSLATION

Snow flowers bloom (it snows), snow flowers grow
(the snow becomes thicker on the ground).
The snow baby comes down (it snows).
One comes down cold like snow, the second comes down
cold like frost.
Cold, cold like frost, cold, cold like snow.
The orders of the most high Lao Chün are like law.

東方土地，南方土地，西方土地，北方土地，橋樑土地，廟門土地，燈桿土地，廿四個路旁土地。死得不名的陰死鬼，陽死鬼，挨打樹不鬼，抹頸跳河鬼，兇死血光鬼，端公遊尸，道士遊尸，木匠遊尸鬼，鐵匠遊尸鬼，某人，撞住你的碼頭，靠住你的馬尾，實送金帛銀錢，實送花盤，水窖錢飯，東方來，東方去，南方來，南方去，西方來，西方去，北方來，北方去，一來不要誤弟子，二來不要誤來染，吾奉太上老君，勅勅如律令巫師弟子，口含三十六牙，手提二十八劍，遠看三千里，近看八百里，閻王老爺看着我是黑頭堂，判官小鬼看着眼溜溜，巫司弟子，手頭拿摟千根白玉棍，一不打天，二不打地，端端打你邪魔妖鬼，天煞歸天，地煞歸地，年煞月煞，日煞時煞，一百二十個兇神惡煞，姜太公到此，諸神會備，一送一千里，二送二千里，三送三千里，四送四千里，五送五千里，一送送在天羅地網，再也不得翻身，吾奉太上老君，勅勅如律令。

Translation

The T'u-ti in the east, the T'u-ti in the south, the T'u-ti in the west, the T'u-ti in the north, the T'u-ti of the bridge beams, the T'u-tis at the gate of the temple, the T'u-ti of the sky lamp post, the twenty-four T'u-tis beside the roads, the demons of the people who have died at night, the demons of the people who have died in daytime, the demons of the tree stumps, the demons of people who have committed suicide by cutting their throats, the demons of people who have drowned in rivers, the demons of those who have died violent deaths or have bled to death, the demons of exorcists whose souls are wandering, the wandering demons of carpenters, the wandering demons of blacksmiths; Sir, I have bumped against the head of the horse you are riding, and against the tail of the horse you are riding (to prevent your departure). I will give you money of gold, silver, and brass (or bronze). I will present you a tray of flowers. There is little water, but the money and the rice are plentiful. Come from the east and return to the east, come from the south and return to the south, come from the west and return to the west, come from the north and return to the north. When you come, do not deceive me, this apprentice magician, or the others who have come (to look on). I have received the strict orders of the Most High Lao Chün, like a legal command. I the apprentice magician, having in my mouth thirty-six teeth, carrying twenty-eight swords in my hands, can see three thousand *li* distant and eight hundred *li* near. Master Nien Wang and the official recorder in hell, the small demons in hell, you see that my eyes are large and bright (with fierceness) ; I, the apprentice magician, holding in my hands one thousand clubs as white as jade:—first, I will not strike the sky, second, I will not strike the earth. I will strike straight at you demoniacal spooks and demons. Let the poisonous breath of the sky return to the sky, and the poisonous air of the earth return to the earth, also the poisonous year air, the poisonous month air, the poisonous day air, and the poisonous hour air, and the evil breath of one hundred and twenty fierce gods. Kiang T'ai Kung has arrived here. All the gods have assembled here. First, I will escort you one thousand *li;* second, I will escort you two thousand *li;* third, I will escort you three thousand *li;* fourth, I will escort you four thousand *li;* fifth, I will escort you five thousand *li.* Escorting you once, I will escort you to the nets of the sky and of the earth (where you will be caught) so you cannot return again. I am acting in accordance with the orders of the Most High Lao Chün, which are like law.

sʌ^{2} Gʌ^{2} gʌ^{2} ʃi·^{2}, xo·^{1} mi·^{1} δ^{2} mʌ^{2}
xo·^{1} gʌ^{1} gʌ^{2} ʃi·^{2}, sδ^{2} mi·^{1} δ^{2} mʌ^{2}
sʌ^{2} δ^{4} la·^{2} zo·^{2}, ɲa·^{2} ljo·^{1} zo·^{2} (or ʒo·^{2})
δ^{2} mo·^{2} lji·^{1} zo·^{2}, δ^{2} mo·^{2} mi·^{1} lɛ^{2}
δ^{2} mo·^{2} dzə^{1} dzo·^{2}, δ^{2} mo·^{2} mi·^{1} lɛ^{2}
δ^{2} mo·^{2} ku·^{1} kwɛ^{1}, δ^{2} mo·^{2} bi·^{1} ɲae^{2} δ^{2} mo·^{2}
xa·^{2} o·^{2} δ^{2} mo·^{2}, δ^{2} mo·^{2} ɱa·^{1} ɲae^{2} δ^{2} mo·^{2}
wɛ^{2} kwa·^{1} δ^{2} mo·^{2}, δ^{2} mo·^{2} ʃi·^{2} ɲae^{2} δ^{2} mo·^{3}
Tu·^{2} lju·^{1} δ^{2} mo·^{2}, δ^{2} mo·^{2} tsei^{1} ɲae^{2} δ^{2} mo·^{2}
sa·^{1} ts'ə^{1} δ^{2} mo·^{2}, dʒi·^{3} ji·^{3} zda·^{2} tsei^{1} δ^{2} mo·^{2}
ʒo·^{2} ɲi·^{2} dʒa·^{2} tʃei^{1} δ^{2} mo·^{2}; lo·^{2} ɲi·^{2} ka·^{2} zdδ^{1} mo·^{2}
xa·^{3} dʒi·^{1} ha·^{3} lja·^{2}, ha·^{2} tsei^{1} tso·^{2}, δ^{2} mo·^{2} tsei^{1} tso·^{2},
xa·^{3} dʒi·^{1} ha·^{2} lja·^{2}, ha·^{2} tsei^{1} bja·^{3}, δ^{2} mo·^{2} tsei^{1} bja·^{3},

so·^{3} dʒi·^{3} To·^{2} sə^2 dzu·^{1} To·^{2} sə^2, δ^2 mo·^{2} To·^{1} zə^2
mo·^{2} ɱa·^{1} ʃi·^{2} tso·^{2}, dzu·^{1} sə^1 bo·^{2}, mo· gɛ^1 zə^2,
sə^2 δ^1 ɲo·^{2}, δ^2 mo·^{2} δ^1 ɲo·^{2} δ^2 ʃi·^{1} wei^3 ʃi·^{3}
δ^2 mo·^{2} δ^1 ɲo·^{2},
mba·^{2} ʃi·^{1} wei^2 ʃi·^{2}, δ^2 mo·^{2} δ^1 ɲo·^{2}, dzɛ^2 wo·^{2} wɛ^1 ʃi·^{3},
δ^2 mo·^{2} δ^1 ts'a·^{2}, Twa·^{1} tʃu·^{3} wei^3 ʃi·^{3}, δ^2 mo·^{2} δ^1 tʃwi·^{3}
sə^2 δ^1 ɲo·^{2}, δ^2 ¿a·^{2} δ^1 ɲo·^{2}, a·^{2} dzɛ^1 dzɛ^1 zsgo·^{1} ɲo·^{2},
a·^{2} wɛ^2 wɛ^2 zsgo·^{1} ɲo·^{2}, a·^{2} ts'wa·^{1} ts'wa·^{1} zsgo·^{2} ɲo·^{2}

TRANSLATION (as approved by the Ch'iang priest)

"I have not forgotten you, Er Mo, nor have you forgotten me, Er Mo. Since the demons injure people, for whom shall be wait to help us? Wait for Er Mo, the King of Demons. Er Mo has not arrived. It is necessary to wait for Er Mo. Er Mo has arrived." "What is your name, King of demons?" "My name is Er Mo." "What is the name of your wife?" "Her name is We Kwa Er Mo." "What is your oldest son's name, Er Mo?" "His name is Du Lyu Er Mo." "What is the name of your oldest daughter, Er Mo?" "Her name is Sa Tzu Er Mo." "How many sons and daughters have you, Er Mo? How many fields have you, Er Mo? How many fir trees have you, Er Mo?" "My home is very large, my implements are many, I have many pigs. They go to the mountains to get my wood. With iron hook and rope they drag to the home of Er Mo. Women gathering good roll it down, then carry it on their backs to my home."

"I will drive the demons away, I will even drive away Er Mo. I'll escort Er Mo to the crossroads, to the level resting place I will drive Er Mo. At the grindingstone I will press Er Mo down into the mortar. I will shut Er Mo in it. I will drive you quickly away. Paper (spirit) money I will give you as road money (to pay the expenses of travel). Do not injure this family. Injure nobody in this region. Injure nobody in this fortified village." [48]

10. THE TRADITION OF HEBREW ORIGIN

Before the establishment of the Chinese Republic in 1911, there was no tradition of a Hebrew origin of the Ch'iang people. It was approximately 1915 when Rev. Thomas Torrance began to work among the Ch'iang. He sincerely loved them and tried to help them by teaching them the Christian religion, by opening schools (which he was prevented from doing), and by giving them good bulls and cockerels with which to improve their stock. The Ch'iang also loved and respected Mr. Torrance. They told him that they were monotheists,

[48] This incantation is repeated in the Ch'iang language, after which another incantation is repeated in Chinese. It is used to exorcise the Hsueh Kuang Kuei, a demon of a person who is beaten to death, or fell off a cliff and was killed, or was stabbed or shot to death so that there was much bleeding. The demon is escorted to the crossroads, where a *bo chi* or bamboo sifter or winnower and spirit money are burned and water is poured out onto the ground. Er Mo is the king of demons, who is also a deity. Here he seems to be identified with the Hsueh Kuang Kuei.

and he believed them. This deception was comparatively easy because the Ch'iang do not make images of their gods.

Mr. Torrance thought that he saw physical resemblances between the Ch'iang and the Hebrews, and also that he found numerous parallels in their social and religious customs. Both Mr. Torrance and Mr. Kou P'in-shan, his leading convert and probably his best friend among the Ch'iang, became convinced that the Ch'iang of western Szechwan are of Jewish descent. Mr. Kou wrote and published a pamphlet in which he stated this belief. Mr. Torrance stated in every one of his writings about the Ch'iang [49] that they are monotheists and finally in his book, "China's First Missionaries," he asserted that the Ch'iang are descendants of the ancient Israelites. They found some real parallels such as the flat-roofed house and the marriage of a widow to her deceased husband's brother, but some of their parallels are far-fetched.

For instance, Mr. Torrance mentions the sacrifice of a lamb among the Ch'iang.[50] The Ch'iang never sacrifice a lamb, but always a full-grown goat. Among the ancient Hebrews the lamb was often sacrificed as a sin offering, a propitiation for sins. Among the Ch'iang the goat is sacrificed or offered in payment of vows or promises made when praying to the gods for favors. Mr. Torrance mentions the sacred cane of the Ch'iang as evidence that the Ch'iang are Israelies.[51] It is more likely that the Ch'iang have borrowed the sacred cane from the Taoists, who are very strong in the vicinity of Kwanhsien and in the Ch'iang region, for both the Taoist and the Ch'iang priests use the sacred cane for the same purpose, the exorcism of demons. Incidentally, the cane shown opposite page 98 in "China's First Missionaries" is not a Ch'iang sacred cane at all, but a Mount Omei pilgrim's walking stick, made on Mount Omei and used by Chinese and other pilgrims to Mount Omei, but not used at all among the Ch'iang. Mr. Kou P'in-shan mentioned the fact that the Chinese history of Li-fan calls the Ch'iang in that region Pai (pronounced bei) Lan Ch'iang

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[49] Rev. Thomas Torrance was a Fellow of the Royal Geographical Society. His mastery of the Chinese written and spoken language was excellent. He was recognized by his fellow missionaries as an authority on some phases of Chinese art and archeology, including pottery, porcelain, and bronzes. He sent a number of valuable objects to the British Museum and collected a goodly number for the West China Union University Museum. He was the first Westerner to discover and to prove that the so-called Mantzu caves of Szechwan are not, as everybody had believed, ancient dwellings of pre-Chinese aborigines, but Chinese Han dynasty cave-tombs.

[50] Torrance, Thomas, China's first missionaries, pp. 35, 87. London, 1937.

[51] Ibid., pp. 96-102.

and insists that this is a transliteration of the word Abram.[52] The Chinese word for Abraham is pronounced in Szechwan Ya Bei (or Beh) La Han (亞伯拉罕), and shortened to Ya Bei (or Beh) Lun, but never to Bei (or Beh) Lun. The Chinese word for Orchid Ch'iang, the term in question, in Szechwan is pronounced bei lan 白蘭. In an article published in The Southwestern Frontier 西南邊疆 in 1944, Mr. Ting Su discusses this name and shows that there is an Orchid Mountain north of the Ch'iang region, and that the Ch'iang living near that mountain were given the name Orchid Ch'iang.[53] Mr. Torrance mentions a Ch'iang cry of distress, "ya-wei," believing that it means Yaweh or Jehovah. "Ai-yah" and "ai-o-wei" are cries of distress widely used in Szechwan and the China-Tibetan border, which in this case is shortened to "ya-wei."[54] *Aba* or *Abba* for "father" is used by the Ch'iang, but it is also used by the Chinese in the Ch'iang region, by the Wa-ssŭ just south of the Ch'iang, by the Chia-jung just west of the Ch'iang, by the Chinese in northern Szechwan and in parts of Yunnan, and in several other provinces of China. The flat-roofed house and the high stone watch tower are widespread among the peoples of the China-Tibetan border. The sacred grove, similar even in the fact that the oak is one of the most common sacred trees, has existed in past ages in regions as far apart as Germany and eastern Asia.

The writer reiterates that in all his contacts with the Ch'iang, not one of them ever told him that they are monotheists. Many of them willingly gave him lists of the gods they worship and explained their functions. Some of the Ch'iang, however, through the influence of Mr. Torrance and of Kou P'in-shan, became convinced that the Ch'iang are descendants of the ancient Israelites. The following is the writer's translation of Mr. Kou's tract in which he expresses his belief that the Ch'iang are descendants of the Hebrews.

An Open Letter to the Ta Ch'iang People Concerning the Origin and End of Paying Vows

By Kou P'in-shan, of Mu-shang-chai

Ch'iang brothers and friends of every place and fortified village, we live in between the borders of the Chinese and the Tibetans, adjacent to the Rung on the west, and bordering on the Chinese territory on the east. If we wish to

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[52] Ibid., p. 46.

[53] Ting Su, The Orchid Ch'iang and the Orchid Mountain, *in* The Southwestern Frontier, published by the Chengtu Southwest Border Research Society, pp. 6-7, 1942.

丁驌 白蘭羌與白蘭山 西南邊疆 第十四期.

[54] Torrance, Thomas, ibid., p. 122.

communicate with the Jung, the language is different. We cannot read the Tibetan literature, and we do not believe in the religion of the Lamas. Although we have intercourse with the Chinese, there are inconveniences. There are two reasons. First, our religious customs are different. We have to offer sacrifices and pay our vows in forests. Second, our place is very cold and our products not abundant. We wear linen (hemp) clothing. Few of our children can read. Therefore they do not understand the good points of the Ch'iang, and we live generation after generation in our locality. We converse with and help each other, do our duties, and let it go at that. There is no place where the source of our sacrifices can be investigated. We only know that they have been inherited from our ancestors. Now, Mr. Torrance of the American Bible Society has toured Wen-ch'uan, Li-fan, and Mao-chou, and found out that the sacrifices of every fortified village correspond to those of the Book of Exodus in the Bible, and he sent especially the preacher Ch'en Pin-Ling of the Bible Society to sell books in every village, and to preach and exhort people.

I got a copy of Genesis, Exodus, and the Four Gospels, and studied them, then understood that our sacrifices which worship the God of Heaven have the same roots as those methods of sacrifice of ancient Israel. Israel had a sacrificial altar on which to sacrifice lambs which must be without blemish. While killing the lamb, they scattered the blood with straw for remission of sins and the paying of vows, and to pray to the God of Heaven, and they prepared unleavened bread and mutton, which they all divided and ate, which corresponds to our custom of paying vows. Generation after generation the Israelites had this ceremony. Then Jesus Christ came to earth to be the Lamb of God, and to bear the sins for the people of all nations. This was because the blood of the sheep could not remove sins, and it was necessary for Jesus Christ to do the work of redemption on the cross before people could be truly saved. He died for sinners and after three days became alive again, to cause all who believe in Him to be free from sin and to be saved. According to this, the sacrifices of our Ch'iang ancestors were really excellent, but could not completely save people. Alas, at that time they had not heard about the coming of Jesus Christ, fulfilling the ancient ceremonies. Jesus' way of redemption is certainly dependable. Because he was human, he could do the work of redemption for men. Because he was divine, he could bear the sins of all men, and become the Savior of the people of all nations.

From ancient times we have regarded white as righteous, black as evil. We set up a white stone to symbolize the holiness and purity of the God of Heaven. We took a sheet of white paper and before it stuck a white flag to indicate our good purpose of worshiping God. If we study the Christian Bible, we know that God is most holy and pure, and exceedingly just, and most kind and righteous. If we wish to worship Him, we must deeply repent of our former sins, and depending on His redeeming merit, sincerely pray before we can be well-pleasing to Him. In ancient times our ancestors observed the custom of sacrificing and killing sheep. Now on the flats by the rivers many have forgotten and have deserted the old religion of our ancestors, and worship idols of clay and wood. Those images of dead people certainly cannot save people. The only real god is the Father of Heaven, who is the Ma-bei-ch'i that we worship. The coming to earth of Jesus Christ fulfilled our ancient ceremonies of sacrifice. We must trust Him for salvation.

This life is the living forever of the soul, which enjoys this happiness of heaven. Therefore the Bible says, "The wages of sin is death, but the gift of

God through our Lord Jesus Christ is everlasting life." All who are led by God's Holy Spirit are children of God. The Gospel (Christian) church, when it worships God, often calls God Heavenly Father, and calls heaven the kingdom of God. As a human father loves his sons and daughters, the Heavenly Father even more loves us as His sons and daughters, and prepares the paradise of His kingdom to reward our sufferings on earth. My Ch'iang friends, please think carefully. We understand that the fact that Jesus fulfilled our ancient sacrificial ceremonies is a matter of great joy. I urge you all to quickly study the Bible and understand clearly the doctrine. We live in a bitterly cold land and wear hemp clothing, regard white as superior and do not dye them; in all these ways the former generations imitated the kingdom of heaven and regarded white as pure. From this you can see that we are their descendants and ought to follow the high and pure teaching, sincerely repenting, trusting in the saving grace of Christ, and with pure white hearts worshiping God, forever becoming His sons and enjoying happiness. Let those who wish to understand this doctrine please talk about it with Mr. Ch'en Pin-ling and me.

The following are important facts:

1. The Ch'iang are not monotheists. They worship 5 great gods, 12 lesser gods, many local gods, and even some trees and rocks as living deities. Moreover, they regard the Chinese gods as real gods, and gladly worship any that they consider to be important and advantageous for them.

2. While there are parallels in their cultural traits to those of the Hebrews, there is none that cannot be very satisfactorily explained without reference to Jewish customs.

3. The Ch'iang have no taboo against the eating of pork.

4. There is no evidence of Hebrew origin in the Ch'iang tradition. Mr. Kou P'in-shan and others have told the writer that Gula is the Ch'iang people, and Chïla the Chinese. Many have said that the Ch'iang have probably come from eastern China.

5. The Chinese are a very historically-minded people. They have written hundreds if not thousands of histories and gazetteers, and several of these historians are among the greatest the world has known. It would be practically impossible for a large group of Israelites to migrate into China without this being noted in Chinese histories. There is no such reference in Chinese histories, but many that indicate that the Ch'iang migrated westward from their early home in northeast China.

6. There is not one physical characteristic of the Ch'iang that would convince a physical anthropologist that they are of Jewish descent. They are a dark-eyed, dark-haired, and dark-skinned race, with hair that is generally straight or with long waves.

7. The evidence of history, language, customs, and physical char-

acteristics indicates that these people are members of the Burma-Tibetan branch of the yellow race.

The writer had intimate contacts with the Ch'iang, including Mr. Kou P'in-shan, and with Mr. Torrance in the summer of 1933. At that time none of the Ch'iang had any idea that they were descendants of the ancient Hebrews and had migrated from the west. Indeed, Mr. Kou suggested to the writer that the war with the Chinese probably occurred in the northeast of China. Mr. Torrance then believed that the Ch'iang were monotheists and had begun to suspect that they had migrated from the west. Later Mr. Torrance came to believe that the Ch'iang are descendants of the ancient Israelites and convinced his Ch'iang friends and followers. Thus the tradition was born and developed. A Ch'iang Christian at T'ao-tzŭ-p'ing told the writer that the Ch'iang purposely deceived Mr. Torrance into the belief that the Ch'iang were monotheists because of Mr. Torrance's very strong disapproval of polytheism and idolatry.

VI. CONCLUSION

This book is the result of several years of first-hand contact with and study of the Ch'iang people, and of research in Chinese histories and the writings of Chinese and Oriental scholars.

The task of studying and interpreting as accurately as possible the lives and customs of these people is not an easy one. The natural reticence of the people, their willingness to give illusive and inaccurate answers that they believe will satisfy the inquirer, and the great variation in different localities in language and customs, make the work a very difficult one. The researcher cannot always tell when he is being deceived, and he needs to be extremely careful, checking and rechecking the information he is given.[55]

[55] In the summer of 1942 the writer spent a few days in P'u-ch'i-chai. The night before, he stayed in the home of a farmer near P'u-ch'i-kou, a few miles away. The farmer was very friendly and gave much valuable and interesting information. At P'u-ch'i-chai the writer mentioned the information the farmer had given. "Who gave you such accurate information?" they asked in astonishment. The writer gave the farmer's name. On the way back to Li-fan, the writer again stayed overnight in the home of the farmer. Apparently our host had been rebuked for giving us so much accurate information, for he was much less friendly and refused to tell us anything more.

The same summer the writer stayed a few days in Lung-ch'i-chai. The aged priest repeated some of his sacred chants, which the writer wrote down in the International Phonetic Script, with such explanations as the priest chose to give. By-and-by the priest came to the phrase, *"ha nu ch'i."* *Ha nu* means 12, and *ch'i* means god or gods. The phrase refers to the 12 lesser gods. With a cunning look in his eyes, the priest said that it meant the 12 tribes of Israel.

The Ch'iang are being gradually absorbed by the Chinese. There is cultural absorption by social and commercial contacts, and there is intermarriage. In recent years Chinese schools have been established by the Chinese Government in the Ch'iang villages. In these schools the Chinese language and culture are taught. A normal school has been established in Wei-chou, to which both Chinese and Ch'iang students are admitted.

There are families of Ch'iang descent that no longer call themselves Ch'iang. There are localities where the people are Ch'iang but speak the Chinese language and have adopted Chinese dress and customs. At P'u-wa the headman is a Ch'iang who has married a Chinese wife, and in 1942 only two or three of the oldest people could speak the Ch'iang language.

The Ch'iang are not monotheists, but worship many Ch'iang gods and many Chinese gods. The Ch'iang gods have no images, with the exception of Abba Mula, the patron deity of the priest, and the King of Demons, whose head is carved on some of the sacred canes. There are 5 great gods, among which the supreme god is generally Mu-bya-sei, the sky god. He seems to closely resemble T'ien 天, or Heaven, the supreme god of the Chou people with whom the Ch'iang united in 1121 B. C. to overthrow the Shang dynasty. There are 12 lesser deities, many local and special gods, and some trees and stones are actually worshiped as gods. Chinese gods with or without images are regarded and worshiped as real and living deities. Mu-bya-sei is identified by many with the Taoist Jade Emperor, and in recent years he has been identified with the god of the Jews and Christians.

Sacrifices are gifts or offerings to the gods to secure their favors, in payment of vows or fulfilment of promises. In the spring there is a ceremony in which the gods are asked for good crops, rain, and a prosperous year, and promised that in return there will be gifts or offerings later in the year, generally in the fall. These offerings are on the housetops or in the sacred groves. Worship on the housetops is a family affair, but that in the sacred grove is participated in by the whole community, there being one or more representatives from every family. Only men can participate in or witness the ceremonies on the housetops or in the sacred groves, for women are believed to be impure and unworthy. In the homes the ceremonies may be conducted by members of the family, but on important occasions the priest is called in to officiate. The ceremonies in the sacred groves are always conducted by the priest, assisted by laymen who are called masters of ceremonies. The priest has the sacred implements and knows the sacred chants, the incantations, and the methods of performing the ceremonies.

In the sacred groves one of the most common sacred trees is the oak, but there are other kinds also. The sacred white stone is considered to be holy, and a likely and appropriate object or place near which one can worship his gods and enjoy actual communion with them. These white stones generally cap the shrines in the sacred groves, in the Ch'iang temples, and on the housetops. They are also placed on the tops of graves and on walls built before the main doors of houses to keep away demons.

Formerly cremation was the only way to dispose of the dead. Increasingly this method is being reserved for those who have died violent or unusual deaths and might become demons; people who die normal deaths are buried in graves.

There is no written language. The "sacred books" include a kind of book consisting entirely of pictures and used only in divination, and religious chants that are memorized by priests and taught by one priest to another. The priesthood seems to be gradually dying out.

There are many ceremonies to exorcise demons, who are believed to be the cause of sickness, death, and many other calamities. These ceremonies include "sweeping the house," treading a red-hot plowshare, transforming water, and shutting a demon in a jug which is buried upside down at the crossroads. These ceremonies are performed by the priests.

The priest is highly respected. He, his ceremonies, his sacred implements, and the gods are believed to possess a mysterious potency so that he can perform wonders for the benefit of the people. There are also taboos, for this strange power is dangerous if it is wrongly used.

The Ch'iang are a comparatively primitive people, and in their religious ceremonies they seek food, rain, good crops, long life, numerous descendants, increase of domestic animals, protection, social prestige or honor, and a successful and satisfying life. There is evidence that many of them regard the sacred books as living beings and believe that the ceremonial hat is able to see and to hear. Even trees and stones are worshiped as deities. To understand and interpret these people as correctly as possible, the student should learn as much as he can about the cultures and history of the Chinese, the Tibetans, and other ethnic groups in central Asia. He should also have a knowledge of primitive religion and of primitive peoples. He should study what others have written about the Ch'iang and should have an intimate and first-hand knowledge of the Ch'iang people.

There is no evidence that the Ch'iang are descendants of the Hebrews. All the evidence is to the contrary. Their language, customs, and physical characteristics indicate that they belong to the Burma-Tibetan branch of the yellow race. According to Chinese history, they came centuries ago from northeast China and were pushed westward by the Chinese. Some of them went into Kansu and possibly farther west, and others turned southward into Szechwan. Formerly they extended beyond Sungpan into Kansu in the north and into the Ya-chou Prefecture and near Yüeh-sui in the south, but now they extend only from Tieh-ch'i on the north to So-ch'iao on the south, and from a few miles east of Wen-ch'uan, Wei-chou, and Mao-chou on the east to the village and creek called P'u-ch'i-kou and about 20 *li* up T'o or Tsa-ku-nao River from Li-fan, on the west.

As to the future of the Ch'iang of western Szechwan, one can only conjecture. Will they be completely absorbed by the Chinese, or will a goodly number of them cling to their old customs, traditions, and religion? Only time can tell.

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Explanation of Plate 3

1. A small wooden jug or vial. It is apparently an imitation in wood of the bronze vial shown in figure 3.
2. Bronze bell. Length 47 mm., width 45 mm., thickness 27 mm.
3. Small bronze vial or jug. Smooth and bright except where patinated. Length 53 mm., maximum diameter of body 28 mm.
4. Bronze ornament with holes through sides for sewing onto shields or armor. They vary in size. Length of this one 74 mm., maximum width 34 mm.
5. Bronze pendant. Length 61 mm., width 33 mm.
6. Bronze handle of sword or dagger, about one-fifth natural size.
7. Hollow circular bronze pendant.
8. Hollow rectangular bronze pendant.
9. Brass cooking vessel. Height 138 mm., maximum diameter 160 mm.
10. Two-handled earthenware jug with ornamental circles on the sides and two rows of vertical lines around the neck. They are made of gray clay and sometimes polished black. We know of no specimens of this kind found in ancient tombs anywhere else in the world, although some slightly resembling them have been found with neolithic painted pottery in Kansu. They vary greatly in size. There is a simpler kind without the ornamental circles on the sides.

11, 12, 13. Ornamental bronze bars with two, three, and four bulbs.

14. A *pan liang* or half-tael coin. About nine-tenths of the coins in the slate-slab tombs are Chinese *pan liang,* the remainder being *wu chu.* This is one evidence that the tombs were made near the end of the Chou or during the early Han dynasty.

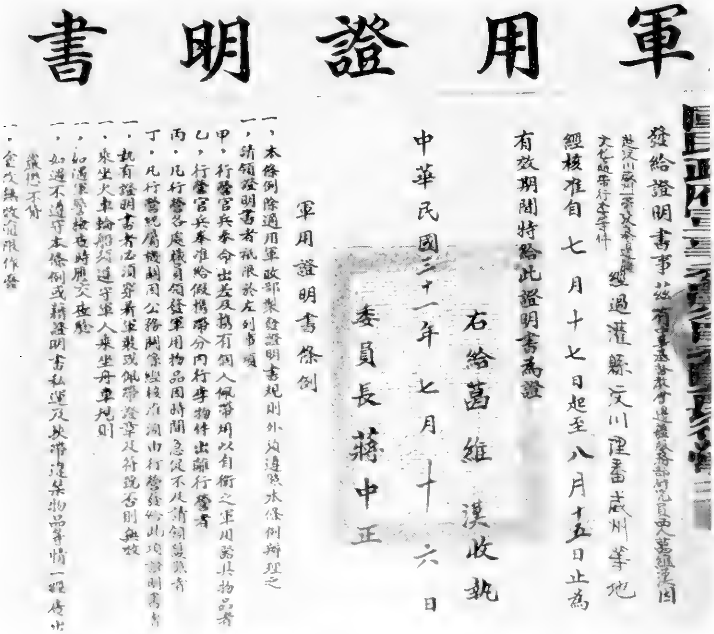
15, 16. Disklike bronze buttons or ornaments.

17. Small bronze button or ornament.
18. A bronze ring ornamented with birds. Diameter of the ring 41 mm.

Aside from the two-handled jug shown in figure 10, the pottery of the slate tombs corresponds to that found in Chinese Han dynasty tombs. The slate-tomb culture is dated by archeologists between 500 and 100 B.C.

Illustrations and information are reprinted from an article by the writer in the Journal of the West China Border Research Society, vol. XV, Ser. A.

PLATES



軍用證明書

發給證明書事茲有……葛維漢因

經過灌縣汶川理番威州等地

經核准自七月十七日起至八月十五日止為

有效期間特給此證明書為證

右給葛維漢收執

中華民國三十一年七月十六日

委員長蔣中正

軍用證明書條例

一、本條例除適用軍政部製發證明書規則外均遵照本條例辦理之

一、請領證明書者祇限於左列事項

甲、行營官兵奉命出差及携有個人佩帶用以自衛之軍用器具物品者

乙、行營官兵奉准給假携帶分內行李物件出離行營者

丙、凡行營各處機關領發軍用物品因時間急促不及請領護照者

丁、凡行營所屬機關因公務關係經核准由行營發給此項證明書者

一、執有證明書者必須穿着軍裝或佩帶證章及符號否則無效

一、乘坐火車輪船須遵守軍人乘坐舟車規則

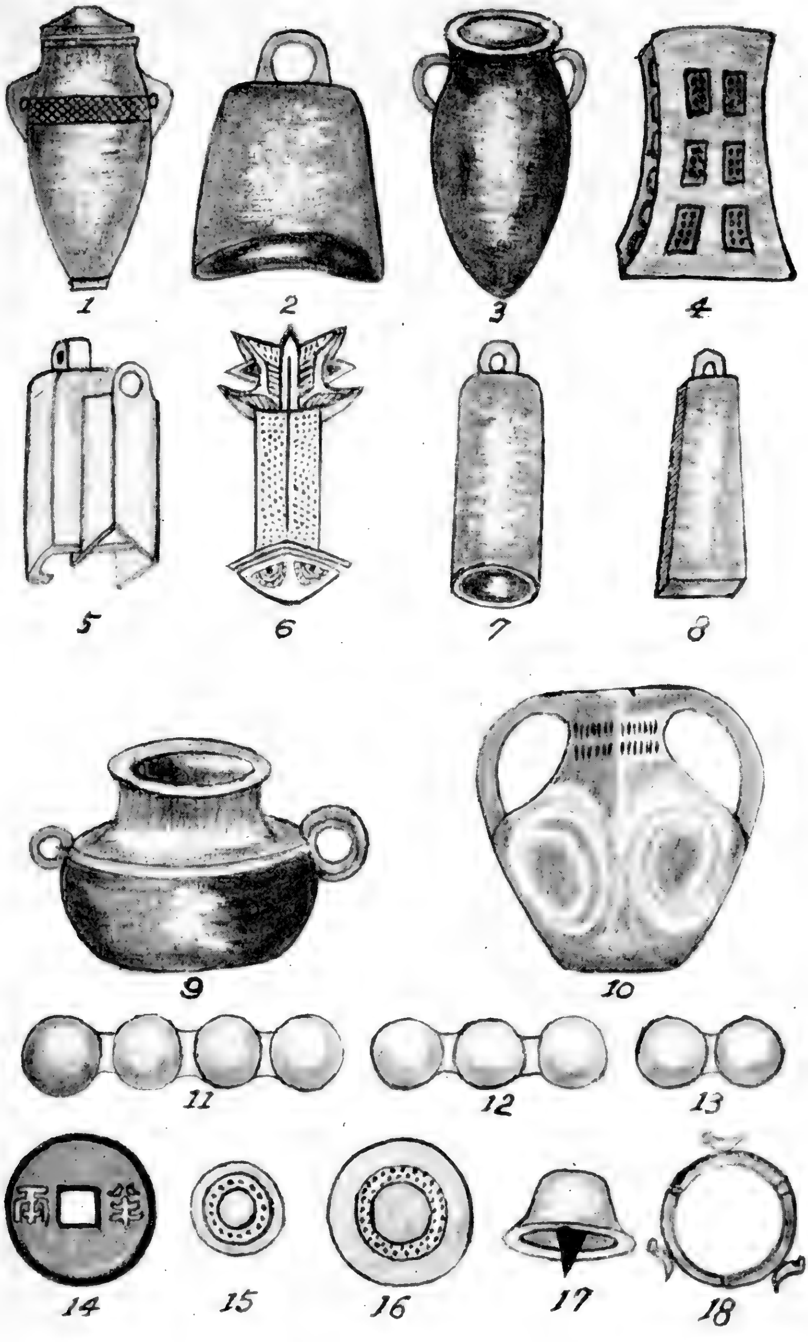
一、如遇軍警檢查時應交查驗

一、如遇不遵守本條例或藉證明書私運及挾帶違禁物品等情一經……嚴懲不貸

一、塗改無效……作廢

Upper, Picture of a passport issued to the writer by Generalissimo Chiang K'ai-shek in the summer of 1941 for research among the Ch'iang. *Lower*, Governors of four Chinese provinces looking at a white panda. D. C. Graham second from the right. Pandas are found in the Ch'iang region.

Upper, A slate-slab tomb on the side of a terrace in the Ch'iang region.
Lower, A Ch'iang farmer at Tung-men-wai 羌民老農.



Objects found in slate-slab tombs in the Ch'iang region near Li-fan, Wei-chou, and Wen-ch'uan. (For explanation, see p. 110.)

Upper, Mr. Kou, a Ch'iang of Mu-shang-chai, with his wife and child. *Lower*, A Ch'iang headman and family near Wen-ch'uan. Note the belts worn by the women.

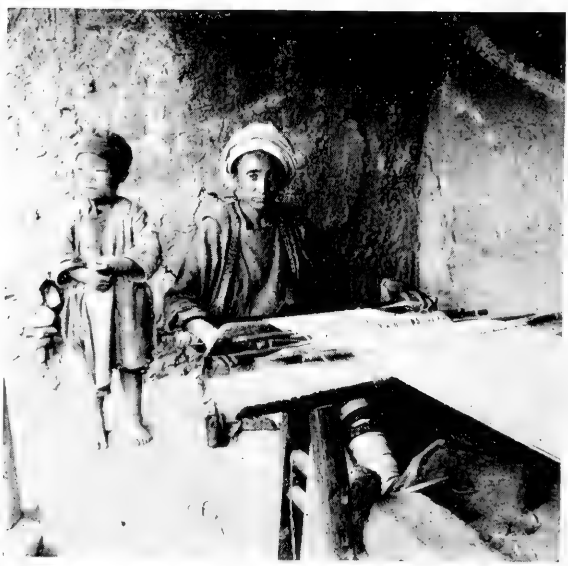
Upper, Ch'iang woman and girl wearing woven belts. *Lower,* The rope bridge consisting of bamboo cables and boards across the Min River at So-ch'iao. The weight of this bridge sometimes breaks the bamboo cables.

Upper, A perilous bridge called a *p'ien ch'iao* in western Szechwan. It is built on the side of a perpendicular cliff over a swift mountain stream. Holes are chiseled into the side of the cliff and poles are stuck horizontally into the holes. Such bridges are dangerous because the poles gradually slip out of the holes and the bridge finally falls into the stream. *Lower,* A man with baggage crossing a bridge consisting of a single bamboo cable over a turbulent mountain stream.

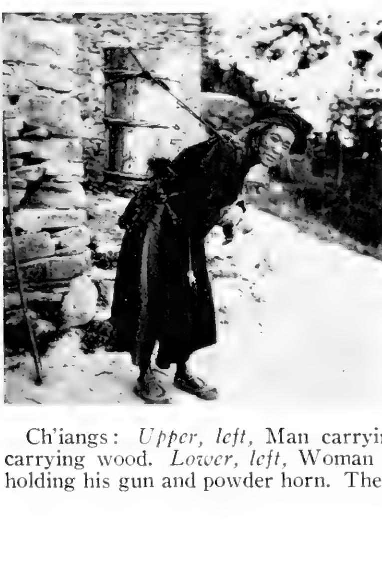
Upper, A cobalt bridge near Wei-kuan in the Ch'iang region.
Lower, Ch'iang road built over a cliff.

Upper, The village of Ts'a-to-kou showing flat-roofed Ch'iang houses and Chinese temple and house with sloping roof. *Lower,* A village showing flat-roofed stone houses and watch towers.

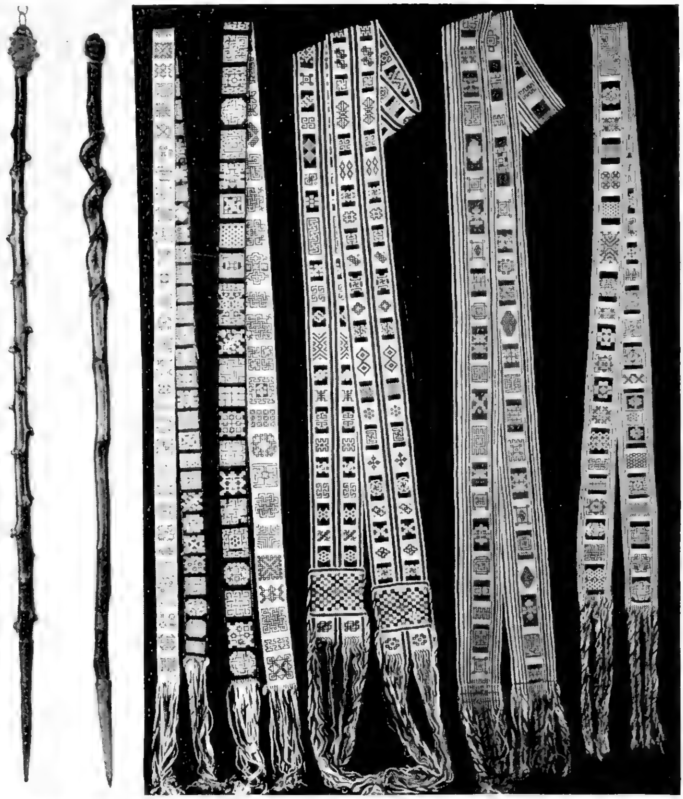
Upper, The village of Mu-shang-chai, showing the tower and houses beyond. Note the terraced hillside in the background. *Lower,* A street between two stone houses, with a tall stone tower beyond the houses.

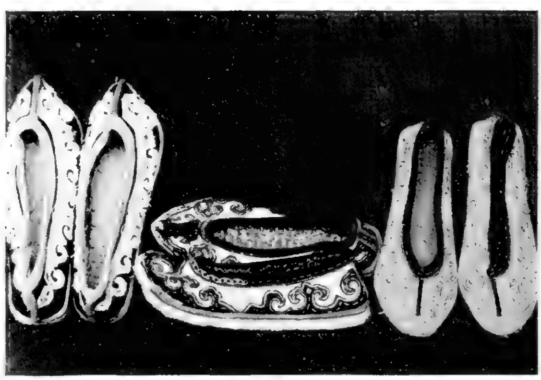


Upper, Stone towers at P'u-wa, with tops broken off.
Lower, A Ch'iang woman weaving cloth.



Ch'iangs: *Upper, left,* Man carrying home a basket of ripe corn; *right,* woman carrying wood. *Lower, left,* Woman carrying water in a wooden tub; *right,* hunter holding his gun and powder horn. The gun is a muzzle loader.



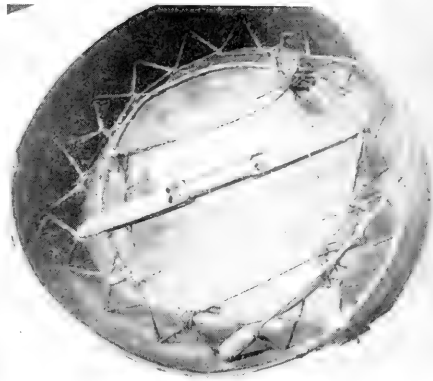


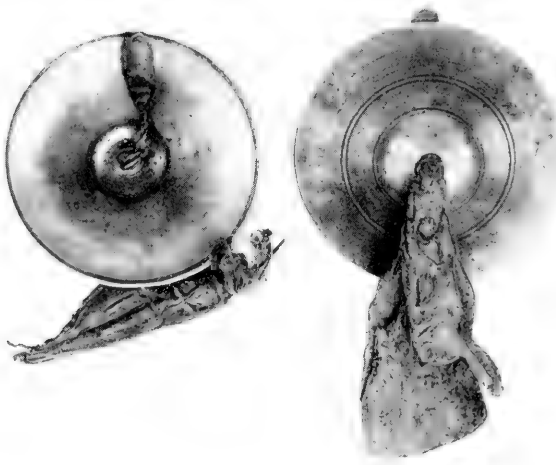
Upper, Two sacred canes (on the left), and embroidered belts. *Lower, left,* Woman's homespun gown or cloak made of undyed hemp; *right,* Woman's embroidered shoes. (Canes, belts, and gown, courtesy of American Museum of Natural History.)

Upper, left, A house with five shrines, one for each of the five great gods; *right,* temple or sacred shelter near a sacred grove. *Center,* The Ch'iang priest at Lung-ch'i-chai, standing in front of the shrine on his housetop. The shrine has a hole for burning incense, and is capped by a sacred white stone. There are twelve small stones around the base of the large one for the twelve lesser gods. *Lower,* A house used in cremating the dead.

Upper, left, A sacred grove near Wei-chou; *right,* a shrine in a sacred grove near Lo-pu-chai, with five places to burn incense to each of the five great gods. The usual sacred white stone is missing, it's place marked by the writer's white hat. *Lower, left,* Priest dressed in white hemp cloth with ceremonial hat, drum and drumstick, and a farmer dressed in dark blue cotton cloth and wearing a white cotton turban; *right,* the priest at Mu-shang-chai, wearing his ceremonial hat and sword and holding his ceremonial drum, with a lay helper dressed in white hemp cloth.

Upper, A boy sitting by a fireplace in a Ch'iang temple. The fireplace is composed of three stones chipped to form right angles. Each stone is a god—the fire god, the female ancestor, the male ancestor. *Center,* A stove consisting of an iron circle and three iron legs which are worshiped as gods. *Lower,* Men walking to the sacred grove to pay vows by offering sacrifices to the five great gods. As usual they are dressed in homespun white hemp garments and are walking in single file. The man in front is carrying a white rooster to be offered.





Upper, left, The patron deity of a Ch'iang priest, called abba mula or ndjei chu. It consists of the skull and other parts of a golden-haired monkey wrapped in white rice paper; *right,* a priest's sacred drum with ornamented handle. *Center,* Ceremonial brass gong used by priests. *Lower,* Antelope horns used by priests to exorcise demons. (Gong and horns courtesy of American Museum of Natural History.)

INDEX

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 135, NUMBER 2

Charles D. and Mary Vaux Walcott
Research Fund

MORPHOLOGY AND TAXONOMY OF THE FORAMINIFERAL GENUS PARAROTALIA LE CALVEZ, 1949

(With Five Plates)

By
ALFRED R. LOEBLICH, JR.
California Research Corporation
La Habra, Calif.

AND

HELEN TAPPAN
U. S. Geological Survey

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MORPHOLOGY AND TAXONOMY OF THE FORAMINIFERAL GENUS PARAROTALIA LE CALVEZ, 1949 [1]

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INTRODUCTION

Material collected by the writers from the Paleocene and lower Eocene of the Atlantic and Gulf Coastal Plains was found to contain foraminiferal species with distinctive apertural characters. A comparison of this material with some collected by the authors in England and France in 1953-1954 showed the presence of related species in somewhat younger Eocene and Oligocene strata, and proved that these species belong to the genus *Pararotalia* Le Calvez.

The earlier and more primitive species show better the ontogenetic apertural development of this genus; they made possible the later recognition of these same apertural characters in the type species. The generic definition is therefore here emended and the type species, *Pararotalia inermis* (Terquem), is redescribed.

Other new species are here described from the Paleocene and Eocene of the Atlantic and Gulf Coastal Plains and the Oligocene of England and France.

Certain species previously described as *Rotalia* or *Globorotalia* are also shown to belong to *Pararotalia*. These include *Rotalia armata* d'Orbigny from the Miocene, *R. byramensis* Cushman (and *R. incisura* Todd, here shown to be a synonym of *byramensis*) from the

[1] Publication authorized by the Director, U. S. Geological Survey.
[2] Mrs. Helen N. Loeblich.

Oligocene, *R. parva* Cushman from the Oligocene, *R. canui* Cushman (part, from the Oligocene of France; not including *Rotalia stellata Reuss,* 1856, from the German Oligocene, for which *canui* was proposed as a new name), and *Globorotalia spinigera* Le Calvez from the middle Eocene, Lutetian, of France.

In addition to the type species, *Pararotalia inermis* (Terquem), only *P. subinermis* Bhatia from the Oligocene has been previously placed in this genus. This latter species is also here described and figured.

One additional specimen, from the Miocene of France, is figured as *Pararotalia* species. The lack of sufficient material makes specific identification impossible, but it is here recorded for its stratigraphic interest.

GEOLOGIC OCCURRENCE

Previously reported from the middle Eocene and Oligocene, the genus is now known to range from the Paleocene (Landenian) to Miocene (Burdigalian) (see fig. 1). The oldest species known, *P. macneili,* new species, is from the Matthews Landing marl member of the Porters Creek clay (Midway group) of Alabama, equivalent to a part of the Landenian stage of the European section. The other Paleocene species, *P. ishamae,* new species, also occurs in the lower Eocene. The lower Eocene (Ypresian) of Europe contains *P. calvezae,* new species, and the middle Eocene (Lutetian) contains *P. inermis* (Terquem) and *P. spinigera* (Le Calvez). Reaching its climax in the Oligocene, *Pararotalia* is represented by *P. subinermis* Bhatia, *P. curryi,* new species, *P. parva* (Cushman), and *P. byramensis* (Cushman). From the Miocene, only *P. armata* (d'Orbigny) has been described, although a single specimen of an undetermined species is also here figured.

Although no species are yet reported from the upper Eocene or lower Miocene, further search will undoubtedly show their presence.

In addition to the above-mentioned species, which are here illustrated and described, the specimen figured by Kaasschieter (1955, pl. 9, fig. 2) as *Rotalia rimosa* Reuss from the lower Aquitanian-upper Burdigalian of the Aquitaine Basin of France, also appears to be a *Pararotalia*. The species was originally described from the Oligocene of southern France (Gaas), and although the original figure does not show the true apertural character, it seems to represent the same species as that of Kaasschieter. As no material of this species was at present available to the writers, this species cannot here be definitely allocated.

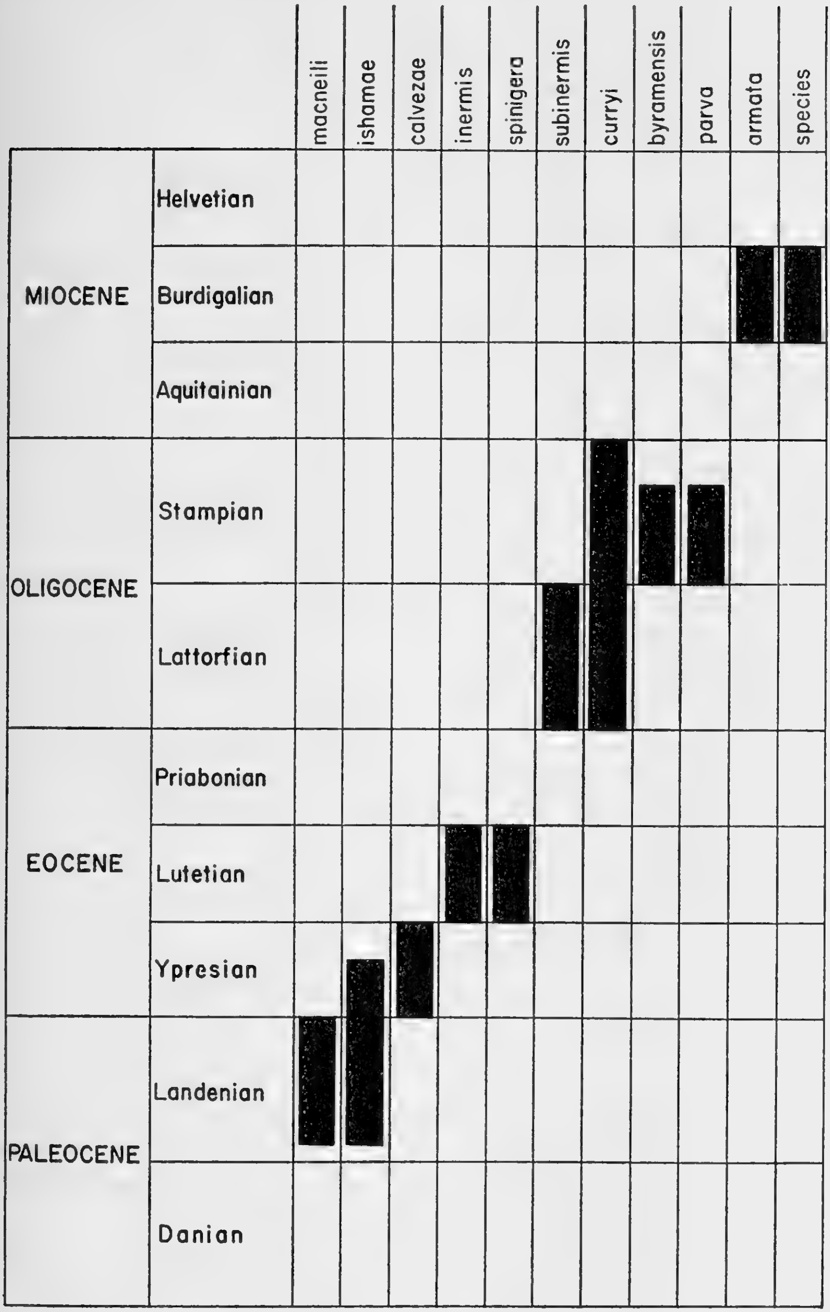


FIG. 1.—Geologic occurrence of known species of *Pararotalia*.

MORPHOLOGY

The character of the aperture of *Pararotalia* is discussed in detail in the generic diagnosis which follows. Only general comments on its relationship to the taxonomy are here included.

Pararotalia was originally separated from *Rotalia* Lamarck because of the areal aperture, which was first observed in *P. inermis* (Terquem). Le Calvez (1949, p. 33) noted that other species which she considered as *Rotalia* were otherwise similar (e.g., *Rotalia armata, R. audouini*) but that they had an "ouverture typique de *Rotalia*."

Kaasschieter (1955, p. 86) considered *Pararotalia* to be only a subgenus of *Rotalia*, regardless of the apertural character. He added that specimens of *R. audouini* "were observed which are in this respect identical with *R. inermis,* but other individuals show typical *Rotalia*-apertures or a position in between the two extremes. Unfortunately most of our specimens are too badly damaged for a clear analysis of this important characteristic." He also added that "*R. byramensis* Cushman is entirely within the range of variation of our specimens of *R. audouini*."

Examination of *R. audouini* shows that this species always has a completely basal aperture, dissections showing no earlier chambers that have developed the umbilical apertural plate characteristic of *Pararotalia* which leaves an areal opening in the face of the chamber. *Rotalia byramensis* is, however, a true *Pararotalia,* the areal aperture being well developed. Dissection of specimens of *Pararotalia* always shows this areal aperture in earlier chambers, as here shown in *P. inermis,* even in specimens in which it is absent from the final chamber. Such dissections show that the margin of the next chamber is added so as to curve around the areal opening, and the later umbilical plate is only secondarily attached at its lower margin, expanding anteriorly to cover the umbilical portion of the previously extraumbilical-umbilical interiomarginal opening. Thus, in a large suite of specimens of any species, one may observe both those specimens with basal aperture exposed and those with areal aperture and umbilical plate. In those species with relatively open umbilicus, such as the *P. ishamae–spinigera* group, this plate may also be secondarily broken out. This character has undoubtedly led to some taxonomic confusion, and specimens of the same species may have been variously placed in one or the other genus, or the genera regarded as transitional (Kaasschieter, 1955, p. 86).

A comparison of the various species here illustrated suggests that two lineages developed within the genus. The simplest and geologically oldest species, *Pararotalia macneili,* new species, and *P. ishamae,* new species, are simple discorbidlike forms with rounded and inflated chambers, without peripheral spines, and without a strongly angled umbilical shoulder. The umbilicus is relatively open and the umbilical apertural plate can be easily observed. Later species show a progressive development of angularity of chambers, the development of nodes at the more acute umbilical shoulders, and the appearance of peripheral spines and keels. Young specimens of the lower Eocene *P. calvezae* show the ancestral type, with nonspinose rounded chambers, whereas the adult test becomes more angled with peripheral spines. This lineage becomes more ornate with the development of the umbonal thickening and pustules on the spiral sides, nodes at the umbilical shoulder on the opposite side, the peripheral keel, and the more prominent spines of *P. spinigera* (Le Calvez). This group continues into the Oligocene, as represented by *P. curryi,* new species, and *P. parva* (Cushman), and in the Miocene by *P. armata* (d'Orbigny).

A second and more specialized group branched off in the middle Eocene and Oligocene with the development of a more lenticular test, limbate sutures and peripheral keel, and characterized in particular by a very sharply angled umbilical shoulder, which together with the prominent umbilical plug serve to close the umbilicus and obscure the umbilical apertural plate, although the areal aperture is distinct and prominent. This group is represented by *P. inermis* (Terquem) in the middle Eocene, *P. byramensis* (Cushman) and *P. subinermis* Bhatia in the Oligocene.

RELATIONSHIPS OF THE GENUS

Although many of these species have been regarded by earlier workers as *Rotalia,* and the genus *Pararotalia* has even been considered as a subgenus of *Rotalia,* there is actually no close relationship between these genera. As recently revised by Smout (1954, 1955) the present genus would not even belong to the same family (Rotaliidae) or superfamily (Rotaliidea) as the genus *Rotalia.*

Smout restricted the superfamily Rotaliidea to include forms having the test built of radial, laminated calcite and (1955, p. 202) "canaliculate with no aperture, or pores on the apertural face, or pores elsewhere, sometimes with interiomarginal intercameral foramina, or showing derivation from such a form." All genera of the Rotaliidae "have radial canals or fissures or umbilical cavities and intraseptal and subsutural canals are common if not universal." *Rotalia* s. s. is typical of this group.

The superfamily Discorbidea, according to Smout (1955, p. 202), includes genera that are "noncanaliculate with an interiomarginal aperture, areal aperture, or showing derivation from such a form." Furthermore (Smout, 1954, p. 10), "perforation of the intercameral foramen as an aperture seems universal in the Discorbidea." Smout (1954, p. 10) included in the superfamily the families "Discorbidae, Amphisteginidae, Cymbaloporidae, Planorbulinidae, and perhaps, the Globorotaliidae."

Pararotalia does not have radial canals or fissures, nor does it have intraseptal and subsutural canals and thus does not belong to the Rotaliidae. It does have an interiomarginal aperture (originally) and areal aperture (derived from the basal aperture, by the addition of the umbilical apertural plate) and thus belongs to the superfamily Discorbidea and most probably to the family Discorbidae.

Furthermore, as many of the species of *"Rotalia"* which have been confused with species of *Pararotalia* also have a basal aperture, although lacking the later umbilical apertural plate and consequent secondarily areal aperture, they do not belong to true *Rotalia,* but possibly also should be referred to the Discorbidea. Additional study of these forms is necessary for generic placement.

ACKNOWLEDGMENTS

The writers wish to acknowledge the field assistance of M. Henri Tintant, Université de Dijon, France, who accompanied us in the collecting at Grignon, France; of Mr. Dennis Curry, Pinner, Middlesex, England, and Mr. A. G. Davis, London, England, in the collecting of the Oligocene Middle Headon beds of southern England; and of Mr. Richard Page, Smithsonian Institution, in the collecting of the Aquia formation of Virginia. Illustrations of the various species are camera lucida drawings prepared by Patricia Isham, scientific illustrator, U. S. National Museum.

SYSTEMATIC DESCRIPTIONS

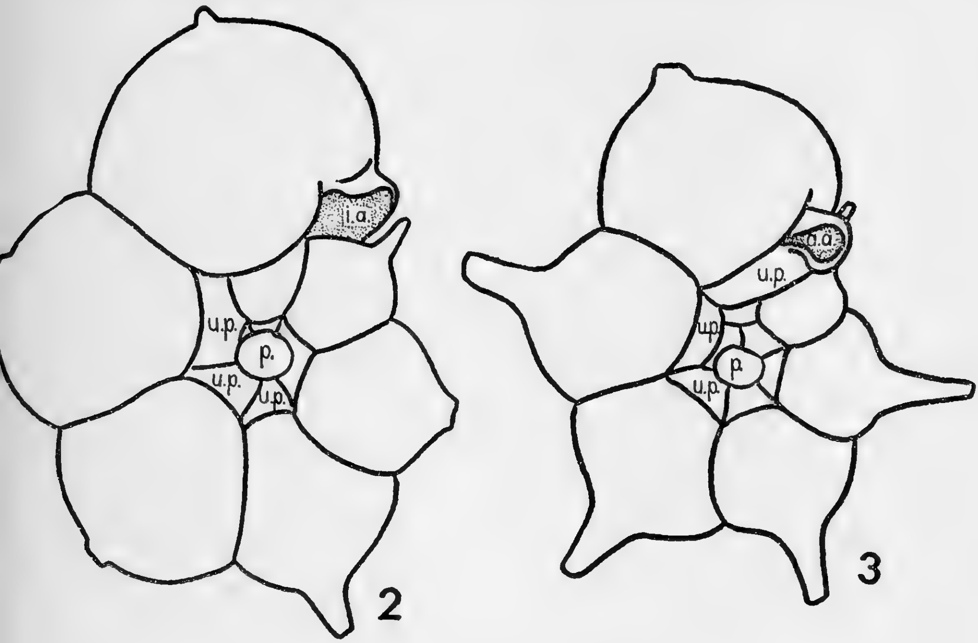
Family DISCORBIDAE Cushman, 1927

Genus PARAROTALIA Le Calvez, 1949, emended

Pararotalia Le Calvez, Mém. Expl. Carte Géol. Dét. France, Rev. Foram. Lutétiens. II Rotaliidae, p. 32, 1949.

Type species.—Rotalina inermis Terquem, 1882. Fixed by original designation and monotypy.

Test free, trochospiral, planoconvex to biconvex, umbilicus filled with a plug which may be broken out in preservation, chambers rounded to ovate in plan, may have smoothly rounded periphery or may develop a short, blunt peripheral spine on each chamber, umbilical



FIGS. 2, 3.—*Pararotalia parva* (Cushman).

2. Outline drawing of specimen, showing protruding lip above an open interiomarginal aperture (i.a.) with umbilical apertural plates (u.p.) present on earlier chambers around the umbilical plug (p.), but not on final chamber.

3. Outline drawing of specimen with umbilical apertural plate (u.p.) covering umbilical margin of final chamber, and partially closing the primary aperture, leaving open only the areal aperture (a.a.) typical of the genus *Pararotalia*. Early chambers also show umbilical apertural plates (u.p.) around the umbilical plug (p.).

region of each chamber partially covered by secondary umbilical plates; sutures flush to moderately depressed, straight to gently curved; wall calcareous, perforate, radial in structure, smooth or variously ornamented with large, solid spines or fine scattered spines or nodes; aperture on the umbilical side, originally interiomarginal and extraumbilical-umbilical (see text figs. 2, 4), with a lip above; a thin and delicate secondary umbilical plate is then formed before the development of the next chamber (text figs. 3, 5), covering the umbilical portion of the aperture and leaving visible only a narrow, elongate, comma-shaped or slitlike areal portion of the aperture roughly paralleling the base of the apertural face, an internal septum being formed at the junction of the umbilical plate and the chamber wall, and the septum may be reflected at the surface by a more or less distinct suture; this thin umbilical plate may be very narrow and almost unnoticeable or relatively large and commonly broken away after development, showing only the interiomarginal aperture.

Remarks.—Pararotalia Le Calvez differs from *Globorotalia* Cushman in having an areal aperture, formed by a secondary umbilical plate which partially covers the umbilical portion of the aperture, and leaving open only a slitlike portion of the aperture.

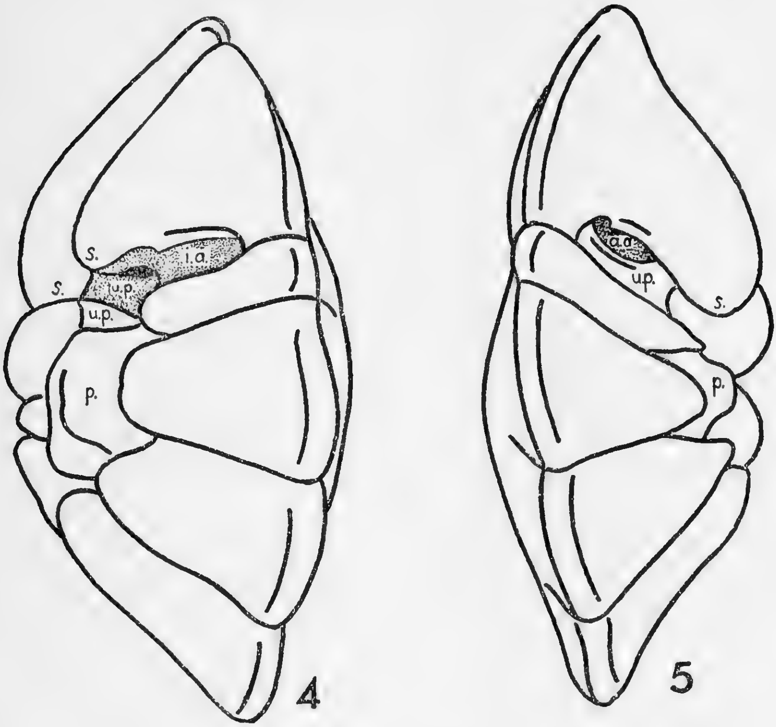
Eponidella Cushman and Hedberg superficially resembles the present genus in having chamberlets on the umbilical side (similar in appearance to the umbilical plates of *Pararotalia*) and an areal aperture, but the aperture of *Eponidella* is restricted to the face of the final chamber and does not have the morphologic relationship to the secondary umbilical plates that is found in the present genus.

This genus was originally described as having a simple areal aperture, which is strongly suggested in the type species. The observation of the secondary plate in other species and strong similarity in final appearance of the areal apertures led the writers to examine carefully at high magnifications a large suite of specimens of the type species from Grignon, France. Although the external suture is almost invisible (text figs. 4, 5), dissected specimens proved the presence of this secondary umbilical plate in the type species also (see pl. 1, figs. 3a, b), hence the generic diagnosis is herewith emended.

The species thus far studied show an evolutionary trend from a biconvex test with lobulate periphery and rounded chambers to a nearly lenticular or planoconvex test with angular chambers and a keeled, spinose, or stellate periphery.

The secondary umbilical plates are more prominent in the early species, with a well-marked suture at the junction of this plate and the chamber wall, and the fragile nature of the plates coupled with their later development allows for a greater frequency of specimens in which it has not yet been developed in the final chamber or has been secondarily destroyed. Younger species show a much narrower series of plates restricted to the area below the umbilical shoulder and commonly obscured by a combination of elevated umbilical shoulder and protruding umbilical plug. They also seem to be formed almost simultaneously with the original chambers, as very few of the specimens show the early marginal aperture either before its development or by later breakage.

Range.—Paleocene (Landenian) to Miocene (Burdigalian).



FIGS. 4, 5.—*Pararotalia inermis* (Terquem).

4. Outline drawing of specimen, showing narrow lip above the open interiomarginal aperture (i.a.) in the final chamber through which can be seen the areal aperture of the penultimate chamber and its umbilical apertural plate (u.p.). Plate of earlier chambers nearly hidden beneath the overhanging umbilical shoulder (s.) of the chambers, and further protected by the extremely large umbilical plug (p.).

5. Outline drawing of specimen with umbilical apertural plate (u.p.) covering umbilical margin of final chamber, partially closing the primary aperture, leaving open only the areal aperture (a.a.), typical of the genus. Umbilical plates are more difficult to see and are better protected in these angular and sharply keeled species.

PARAROTALIA ARMATA (d'Orbigny), emended

Plate 5, figures 2a-c

Rotalia (*Rotalie*) *armata* D'ORBIGNY, Ann. Sci. Nat., sér. 1, vol. 7, p. 273, 1826.

Test free, trochospiral, biconvex, periphery acute, peripheral outline stellate, spiral side evenly convex, umbilical side with chambers strongly inflated near the umbilical shoulder, tending to form a circle of umbilical nodes, umbilicus filled by a large rounded and greatly elevated plug; chambers in 2 whorls, 6 to 7 in the final whorl, each with a short, blunt spine at the peripheral chamber angle; sutures limbate, nearly flush and gently curved on the spiral side, depressed and radial on the umbilical side; wall calcareous, smooth except for the umbilical plug, the umbilical node on each chamber and the peripheral spines, the peripheral border nonperforate and keel-like; aperture interiomarginal, on the umbilical side, the lower portion secondarily closed by an umbilical plate, leaving only a small areal opening.

Figured hypotype 0.33 mm. in diameter.

Remarks.—*Pararotalia armata* is characterized by the stellate outline, depressed sutures on the umbilical side, elevated plug, and the nodes formed on each chamber at the umbilical shoulder. It is similar to *P. byramensis* (Cushman) in general appearance, differing in the stellate outline, more compressed test, and the more regularly convex spiral side.

Types and occurrence.—Figured hypotype (U.S.N.M. P5807) from the Miocene (probably Burdigalian) at Dax, Dept. Landes, France.

PARAROTALIA BYRAMENSIS (Cushman), emended

Plate 1, figures 1a-c

Rotalia byramensis Cushman, U. S. Geol. Surv. Prof. Pap. 129-E, p. 99, pl. 23, fig. 1, 1922; Prof. Pap. 129-F, p. 138, 1922.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 22, p. 100, pl. 16, fig. 23, 1946.

Rotalia dentata Parker and Jones? Cushman, U. S. Geol. Surv. Prof. Pap. 129-E, p. 100, pl. 23, fig. 2, 1922.

Rotalia incisura Todd, U. S. Geol. Surv. Prof. Pap. 241, p. 39, pl. 5, fig. 25a-c, 1952.

Test free, relatively large, trochospiral, planoconvex to biconvex, periphery angular to keeled, peripheral outline angularly lobulate; all of the 1½ to 2½ whorls visible on the flat to gently convex spiral side, only the 7 (rarely 6 to 9) chambers of the final whorl visible on the elevated umbilical side, chambers radially elevated on the umbilical side, forming a nodelike projection at the umbilical shoulder, then dropping sharply into the deep umbilicus, which is completely filled with an umbilical plug in small specimens, but in large specimens a deep and narrow umbilical depression remains around the umbilical plug, each chamber with a single short peripheral spine at the dorsal angle, the rate of increase in chamber size and resultant overlap of the preceding chamber resulting in a slight variation in apparent position of these spines in earlier chambers from near the midpoint of the chamber to near the following suture, this variation occurring from chamber to chamber in the same specimen; sutures gently curved, distinct, limbate, and may be elevated on the spiral side, deeply incised and radial on the umbilical side; wall calcareous, finely perforate, surface smooth or more rarely somewhat wrinkled in large or gerontic specimens, ornamented by the raised sutures and peripheral keel and spines; aperture interiomarginal, extraumbilical-umbilical, secondarily filled at the umbilical margin with an umbilical plate which leaves only a small rounded or ovate areal aperture completely surrounded by a narrow lip.

Greatest diameter of figured hypotype 0.40 mm.

Remarks.—*Pararotalia byramensis* resembles most closely *P. inermis* (Terquem) from the Eocene (Lutetian) of France, but the chambers increase more rapidly in height, the peripheral outline is more angularly lobulate and the chambers more strongly spinose, and the sutures are more limbate and elevated on the spiral side.

The holotype of *P. byramensis* is a somewhat atypical specimen, as it is a gerontic form which is unusually large, with more than the usual number of chambers per whorl. It has 9 in the final whorl, but earlier whorls show the more common number of 7 per whorl, similar to the average specimen at that size. Noting the differences of the type *byramensis,* the smaller specimens were later placed in a separate species, *Rotalia incisura* Todd (1952), which was said to differ from *R. byramensis* in having "shorter spines, which originate from the sutural angle rather than the central part of the chamber, and project tangentially forward rather than radially, and in the lesser protrusion of the chambers, such that except for the spines the periphery would be only very slightly lobulated. This species also differs in its strongly limbate dorsal sutures and the presence of a blunt keel on the periphery, and in its lack of surface ornamentation." These differences, however, vary considerably from specimen to specimen, and from chamber to chamber of even the "holotypes" of the two species. The type of *R. byramensis* has more limbate sutures than that of *R. incisura,* in contrast to their descriptions, and both are distinctly keeled. Examination of a large suite of specimens from the type locality of the Byram formation collected by the writers, shows all gradations between these two "species," hence they are here considered synonymous.

Types and occurrence.—Holotype (Cushman Coll. 25563) from the Byram formation, Pearl River at bridge, Byram, Miss.

Figured hypotype (U.S.N.M. P5697) from the Byram formation, west bank of Pearl River, just north of suspension bridge east of Byram, Hinds County, Miss. Collected by A. R. Loeblich, Jr., October 11, 1941.

PARAROTALIA CALVEZAE Loeblich and Tappan, new species

Plate 2, figures 3a-7c

Test free, trochospiral, biconvex, umbilicus filled with a protruding plug, periphery subacute to rounded, peripheral outline gently lobulate to stellate, chambers in 2 whorls, 5 to 6 in the final whorl, more commonly 5, one or more may have a single peripheral spine, chambers gently convex on the spiral side, with a subangular umbilical shoulder on the opposite side, umbilical portion partially covered by an elongate secondary umbilical plate; sutures distinct, depressed, radial on the umbilical side, gently curved on the spiral side; wall calcareous, distinctly perforate, ornamented with the peripheral spines; aperture on the umbilical side, interiomarginal and extraumbilical-umbilical, with a narrow lip on the forward margin parallelling the outer periphery of the test, the very narrow secondary umbilical plate covering the umbilical portion of the aperture, but largely within the angle formed by the umbilical shoulder so that only those of the latest chambers can be well seen.

Greatest diameter of holotype 0.35 mm. Paratypes range from 0.23 to 0.35 mm. in diameter.

Remarks.—This species differs from *P. spinigera* (Le Calvez) in being more biconvex, in possessing a more rounded rather than keeled periphery, more depressed sutures on the spiral side, in being smaller and with more commonly 5 rather than 6 chambers in the final whorl. It is probably ancestral to *P. spinigera,* which is larger, more highly ornamented, and has a more angular periphery, chambers, and umbilical shoulders.

This species is named in honor of Mme. Yolande Le Calvez, Bureau des Recherches Géologiques et Géophysiques, Paris, France, in recognition of her excellent work on the Foraminifera of the Lutetian of the Paris Basin.

Types and occurrence.—Holotype (U.S.N.M. P5686) and figured paratypes (U.S.N.M. P5687a-d) from the lower Eocene, Ypresian, about 8 feet above the base of the exposure in the brick pit at Gan, about 8 kilometers south of Pau, Dept. Basses Pyrénées, France. Collected by H. T. and A. R. Loeblich, Jr., April 1954.

PARAROTALIA CURRYI Loeblich and Tappan, new species

Plate 3, figures 5a-7c

Rotalia canui CUSHMAN (part; not *Rotalia stellata* Reuss, 1856), Bull. Soc. Sci. Seine-et-Oise, sér. 2, vol. 9, No. 4, p. 55, pl. 3, figs. 2a-c, 1928.—BHATIA, Journ. Paleontol., vol. 29, No. 4, p. 684, pl. 66, figs. 32a-c, 1955.

Test free, small, biconvex, periphery subacute, peripheral outline lobulate to stellate, spiral side strongly convex, umbilical side with a large umbilical plug; chambers sightly inflated on both sides with 2 whorls, commonly 6 chambers in the final whorl, but young specimens may have only 4 or 5 chambers per whorl, adult chambers commonly each with a single short, blunt peripheral spine; sutures depressed and gently curved; wall calcareous, finely perforate, surface of early whorl somewhat nodose on the spiral side, a peripheral spine is commonly developed on some of the chambers of adult tests, but may not be present in young tests or on the final chambers of adult tests; aperture interiomarginal, with a distinct lip at the upper forward margin, the lower portion of the aperture secondarily closed by an umbilical plate which leaves only a small areal opening.

Holotype 0.23 mm. in diameter. Paratypes range from 0.15 to 0.38 mm. in diameter.

Remarks.—This species is very similar in appearance to *P. parva* (Cushman) but is somewhat thicker and more robust, with a more closed umbilicus.

Cushman (1928, p. 55) proposed *Rotalia canui* as a new name for *Rotalia stellata* Reuss, 1856, not *R. stellata* Ehrenberg, 1840. Inasmuch as Cushman proposed a new name for the homonym of Reuss, the type specimen must be that of Reuss and cannot be "Jeurs (holotype)" as Cushman erroneously stated (1928, p. 55). The species of Reuss is from the Oligocene, Casseler Schichten, of Luithorst, Germany, and is a larger planoconvex species with more angular chambers, similar to *Pararotalia armata* (d'Orbigny), although an areal aperture was not noted and Reuss's species may not belong to the present genus. However, Cushman figured as *R. canui* from the French Oligocene a specimen with more gently lobulate peripheral outline, less acutely angled periphery, and a typical *Pararotalia* aperture. One of the French specimens of Cushman is here figured (pl. 3, fig. 7). Bhatia (1955, p. 684) also recorded the present species as *Rotalia canui* from the Middle Headon, Brockenhurst beds of England. His figured specimen lacks the umbilical apertural plate on the final chamber and thus shows only an interiomarginal aperture. The French and English species is thus quite distinct from that of Reuss, and this species is here named for Mr. Dennis Curry of Pinner, Middlesex, England, in recognition of his work on the English Tertiary stratigraphy and paleontology. Mr. Curry accompanied the writers in 1953 while collecting from the Tertiary of southern England and the Isle of Wight.

Types and occurrence.—Holotype (U.S.N.M. P5808) and figured paratype (U.S.N.M. P5809) from the Oligocene (Lattorfian), Middle Headon, Brockenhurst beds, at White Cliff Bay, east coast Isle of Wight, England. Collected by H. T. and A. R. Loeblich, Jr., with Dennis Curry and A. G. Davis.

Figured paratype (U.S.N.M. P5810) from the Oligocene, Stampian, at Jeurs, Dept. Seine-et-Oise, France.

PARAROTALIA INERMIS (Terquem), emended

Plate 1, figures 2a-3b

Rotalina inermis Terquem, Mém. Soc. Géol. France, sér. 3, vol. 2, p. 68, pl. 6, fig. 1a-c, 1882.

Pararotalia inermis (Terquem) Le Calvez, Mém. Expl. Carte Géol. Dét. France. Rév. Foram. Lutétiens. II Rotaliidae, p. 32, pl. 3, figs. 54-56, 1949.

Test free, trochospiral, lenticular, biconvex, periphery sharply acute and strongly keeled, all whorls visible on the convex spiral side, only the 7 to 8 chambers of the last whorl visible on the deeply umbilicate opposite side around the prominent umbilical plug; chambers much inflated near the umbilicus, forming nodelike elevations at the umbilical shoulders; sutures curved, limbate, but flush on the spiral side, radial and deeply depressed and slitlike on the umbilical side; wall calcareous, finely perforate, surface smooth, except for the nodose umbilical elevations of the chambers, the umbilical plug, peripheral keel, and rare short peripheral spines of solid nonporous calcite; aperture an areal ovate opening surrounded by a slight lip, and may have as a minor toothlike projection from the upper margin the remnant of an earlier upper lip of the marginal aperture, the final areal opening due to secondary constriction by very narrow umbilical plates developed below the umbilical shoulder and closely joined to the lower chamber margin, the presence as a distinct structure being evident internally in dissected specimens.

Hypotypes range from 0.28 to 0.50 mm. in diameter.

Types and occurrence.—Hypotypes (U.S.N.M. P5693a-b) from the middle Eocene, Lutetian, Calcaire grossier (Zone IV of Abrard), in the sand pit at Grignon, now in the Parc d'Ecole Nationale d'Agriculture, Grignon, Dept. Seine-et-Oise, France. Collected by H. T. and A. R. Loeblich, Jr., with Henri Tintant, April 1954.

PARAROTALIA ISHAMAE Loeblich and Tappan, new species

Plate 3, figures 1a-4

Test free, tiny, trochospiral, periphery rounded, peripheral outline gently lobulate, about 2 whorls visible on the spiral side, final whorl composed of 5 chambers, umbilical side deeply umbilicate, with a protruding umbilical plug; sutures gently arcuate, somewhat thickened and those of final whorl very slightly depressed on the spiral side, less thickened and more depressed on the umbilical side; wall calcareous, finely perforate, surface smooth and unornamented; aperture interiomarginal, extraumbilical-umbilical, a relatively high open arch, with a narrow lip above, but with the umbilical portion commonly secondarily covered by an umbilical plate which leaves open only the narrow ovate or slitlike areal remnant of the aperture nearest the peripheral margin of the test, the portion of the plate adjacent to the aperture somewhat thickened to resemble a lower lip.

Greatest diameter of holotype 0.20 mm. Paratypes range from 0.13 to 0.28 mm. in diameter.

Remarks.—This more primitive-appearing species is smaller and does not develop the peripheral spines of *P. calvezae,* new species, and *P. spinigera* (Le Calvez), lacks the nodose ornamentation of the early spire, and is more nearly biconvex, without a keel or angular periphery. A few small specimens of *P. calvezae* approach the characteristics of this species, suggesting that these later and more ornate species may have developed from such an ancestral type.

Types and occurrence.—Holotype (U.S.N.M. P5689) and figured paratype (U.S.N.M. P5690) from the Aquia formation, 3-foot shell bed between two 1-foot indurated layers 10 to 13 feet above the base of the exposure, west bank of the Potomac River near mouth of Aquia Creek, S. 10° E. of Brent Point, Va. Collected by A. R. Loeblich, Jr., and Richard Page, 1956.

Paratype (U.S.N.M. P5691) from the Nanafalia formation, at the type locality of the formation, Nanafalia Landing, Tombigbee River, Marengo County, Ala. Collected by A. R. Loeblich, Jr., July 1956.

Paratype (U.S.N.M. P5692) from the Matthews Landing marl member of the Porters Creek clay, Naheola Landing, Tombigbee River, SE$\frac{1}{4}$ sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Ala. Collected by A. R. Loeblich, Jr., July 1956.

PARAROTALIA MACNEILI Loeblich and Tappan, new species

Plate 2, figures 1a-2b

Test free, small, trochospiral, biconvex, periphery subacute, peripheral outline lobulate; chambers arranged in about 2 whorls, all visible on the spiral side, only the 6 or 7 of the final whorl visible around the large, protruding umbilical plug on the opposite side; inflated chambers of nearly equal breadth and height; sutures gently curved, slightly depressed on the spiral side, those of earlier whorl somewhat obscured by the nodose surface ornamentation, sutures nearly radial and depressed on the umbilical side; wall calcareous, finely perforate, surface hirsute with numerous short, blunt spines; aperture originally interiomarginal, extraumbilical-umbilical but secondarily closed by a narrow umbilical plate which leaves only the small ovate areal opening typical of the genus.

Greatest diameter of holotype 0.20 mm. Paratypes range from 0.13 to 0.25 mm. in diameter.

Remarks.—*Pararotalia macneili,* new species, differs from *P. ishamae,* new species, in having a strongly hirsute wall, and more globular-appearing chambers. *Pararotalia spinigera* (Le Calvez) differs in having angular chambers and a peripheral keel, a nodose umbilical shoulder around the umbilical plug, and in having a more coarsely perforate wall, a single peripheral spine per chamber instead of the completely hirsute wall.

The species is named in honor of F. Stearns MacNeil, U. S. Geological Survey, in recognition of his contributions to the stratigraphy of the Paleocene of Alabama.

Types and occurrence.—Holotype (U.S.N.M. P5694) and figured paratype (U.S.N.M. P5695) from the Matthews Landing marl member of the Porters Creek clay, Naheola Landing, Tombigbee River, SE$\frac{1}{4}$ sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Ala. Collected by A. R. Loeblich, Jr., July 1956.

PARAROTALIA PARVA (Cushman), emended

Plate 4, figures 4-5c

Rotalia dentata Parker and Jones var. *parva* CUSHMAN, U. S. Geol. Surv. Prof. Pap. 129-F, p. 139, pl. 35, figs. 1, 2, 1922; U. S. Geol. Surv. Prof. Pap. 133, p. 47, 1923.

Rotalia parva Cushman, CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 22, p. 100, pl. 16, figs. 24, 25, 1946; TODD, U. S. Geol. Surv. Prof. Pap. 241, p. 40, pl. 5, fig. 26, 1952.

Test free, trochospiral, periphery rounded, peripheral outline lobulate to stellate, umbilicus filled with broad umbilical plug; chambers of nearly equal breadth and height, commonly 6 in the final whorl, more rarely 5 to 5½, early whorls nodose on the spiral side; sutures radial, slightly depressed in the final whorl, those of earlier whorls obscured on the spiral side by the nodose ornamentation; wall calcareous, finely perforate, smooth except for the umbonal nodes, and a single solid imperforate spine at the peripheral margin of each chamber; the spines may, however, be lacking in some of the later chambers or in rare specimens may be absent from all chambers; aperture interiomarginal, extraumbilical-umbilical, later filled with a secondary umbilical plate which leaves open only a small areal opening at the end nearest the test periphery, this areal opening surrounded by a lip, formed partially by the secondary plate and partially by the upper lip of the original opening.

Hypotypes range from 0.18 to 0.38 mm. in diameter.

Remarks.—Originally described as *Rotalia,* this species has little in common with that genus, completely lacking the internal canal system of true *Rotalia.* The very distinctive areal aperture, visible even on the holotype, has never been accurately described. Early descriptions mentioned only the number of chambers and size of peripheral spines, and did not discuss the aperture (Cushman, 1922, 1923; Cushman and Todd, 1946). Todd (1952, p. 40) described the aperture as "a rather large arched opening under the ventral edge of the last formed chamber." Specimens do occur that show the open arched marginal aperture (one of the two specimens figured by Cushman and Todd [1946] shows this, although they figured only the spiral side). The other specimen figured by Cushman and Todd (1946), the holotype selected by Cushman (1922), and many other specimens in the Cushman collection show the typical areal aperture of *Pararotalia.* In other specimens, however, extraneous matter obscures the aperture and umbilical region because of inadequate preparation of material.

Pararotalia parva is very similar to *P. spinigera* (Le Calvez) in appearance, but has less angular and more globular chambers, and a more gently rounded umbilical shoulder and relatively larger umbilical plug, which leaves open very little of the umbilical depression. *Pararotalia parva* differs from *P. ishamae* in possessing peripheral spines and in being about twice as large.

Types and occurrence.—Holotype (Cushman Coll. 59665) from the type locality of the Mint Spring marl member of the Marianna limestone, shell and sand bed at foot of high waterfall, Mint Spring Bayou, Vicksburg, Miss. Collected by C. W. Cooke and E. N. Lowe.

Paratype (Cushman Coll. 59664) from same horizon, foot of high waterfall in Glass Bayou, near Vicksburg, Miss.

Figured hypotypes (U.S.N.M. P5696a, b) from the Byram formation, west bank of Pearl River, just north of suspension bridge east of Byram, Hinds County, Miss. Collected October 11, 1941, by A. R. Loeblich, Jr.

PARAROTALIA SPINIGERA (Le Calvez), emended

Plate 4, figures 1a-3

Globorotalia spinigera (Terquem) Le Calvez (not *Rosalina spinigera* Terquem, 1882), Mém. Expl. Carte Géol. Dét. France. Rév. Foram. Lutétiens. II Rotaliidae, p. 39, pl. 6, figs. 97-99, 1949.

Globorotalia spinigera Le Calvez, ibid., IV Valvulinidae, Peneroplidae, Ophthalmidiidae, Lagenidae, p. 48, 1952.

"Rotalia" spinigera Terquem, Gullentops, Mém. Inst. Géol. Univ. de Louvain, vol. 20, p. 17, pl. 1, figs. 15a-c, 1956.

Test free, trochospiral, planoconvex, spiral side gently to strongly convex, umbilical side flattened and umbilicate with an umbilical plug, periphery angled, peripheral margin lobulate to stellate; chambers in about 2 whorls, 5 to 6 in the final whorl with a single short, blunt spine arising from the periphery of each chamber or the spines may be reduced or absent in the later 1 or 2 chambers; early chambers appear nodose on spiral side, later portion gently convex and of nearly equal breadth and height, chambers with a rather abrupt umbilical shoulder on the umbilical side which may become sufficiently pronounced as to suggest a node at the umbilical shoulder, umbilical portion of chambers covered by a secondary plate which reaches from the umbilicus over the umbilical portion of the aperture, flaring outward to form a lower lip to the thus constricted areal remnant of the aperture; sutures radial, distinct, and deeply depressed on the umbilical side, gently curved and somewhat depressed in the later whorl on the spiral side, those of earlier whorls being obscured by the nodose surface of the early whorl; wall calcareous, relatively coarsely perforate, the umbonal knobs, peripheral spines, umbilical plug, and the nodes at the umbilical shoulder appearing solid and imperforate, secondary umbilical plates relatively thin and delicate and appear less coarsely perforate; aperture on the umbilical side, interiomarginal and extraumbilical-umbilical with a short spatulate lip covering the forward one-third of its upper margin, the secondary umbilical plate later covering the umbilical portion of the aperture to the lower margin of the spatulate upper lip, leaving visible only a narrow comma-shaped areal opening and flaring to form a protruding lower lip to the aperture, which is roughly parallel to the lower margin of the chamber.

Hypotypes range from 0.30 to 0.55 mm. in diameter.

Remarks.—This species was described by Le Calvez (1949, p. 39) as *Globorotalia spinigera* (Terquem). She stated that the original type of Terquem had disappeared, but on the basis of the original figures, she identified as Terquem's species this form which was stated to be frequent at Grignon and Septeuil. In the addenda to this publication Le Calvez (1952, p. 48) later stated that types of additional species had been found, including a slide of *Rosalina spinigera* Terquem. The two individuals contained therein were not the same as the present species, but Le Calvez identified one as a badly preserved *Rotalia septifera* (Terquem) and the other as a good specimen of *Rotalia armata* d'Orbigny. She therefore placed *Rosalina spinigera* in the synonymy of *Rotalia armata* and the present species was considered as a distinct species, *Globorotalia spinigera* Le Calvez.

The specimen figured by Le Calvez and the description given represent forms in which the delicate secondary umbilical plate of this species has been broken away, giving the erroneous appearance of a simple interiomarginal aperture.

Gullentops (1956) recently suggested that *Rotalia spinigera* might belong to *Pararotalia* or to *Neorotalia* Bermudez, 1952, stating (p. 19) that among some hundreds of specimens of *R. spinigera* there were some with an areal aperture. He believed that only the aperture of the final chamber was marginal, and that all earlier ones were wholly areal. The present writers have also observed and figured (pl. 4, fig. 1) a complete specimen with an areal aperture on the final chamber. Gullentops referred the species *spinigera* to the genus *"Rotalia,"* in the sense of Cushman, although he stated (p. 19) that it had not the least resemblance to the group of *R. trochidiformis*. He also commented that the genus *Pararotalia* had not yet been completely defined. Gullentops (1956, p. 18) placed both *Rotalia dentata* var. *parva* Cushman and *R. canui* Cushman in the synonymy of *R. spinigera,* thus implying that they also have areal apertures, and could belong to *Pararotalia*. We agree to their congeneric status, but believe the younger species can be separated from *P. spinigera,* as discussed under their respective descriptions above.

Types and occurrence.—Hypotypes (U.S.N.M. P5688a-c) from the middle Eocene, Lutetian, Calcaire grossier (Zone IV of Abrard), in the sand pit at Grignon, now in the Parc d'Ecole Nationale d'Agriculture, Grignon, Dept. Seine-et-Oise, France. Collected by H. T. and A. R. Loeblich, Jr., with Henri Tintant, April 1954.

In the description given by Le Calvez (1949, p. 39), this species was recorded as frequent at Grignon and Septeuil, but no locality was given for the specimen figured, nor was a holotype mentioned in either publication of Le Calvez. The specimens here figured are from the Grignon locality and may thus be topotypes.

PARAROTALIA SUBINERMIS Bhatia, emended

Plate 5, figures 1a-c

Pararotalia subinermis Bhatia, Journ. Paleontol., vol. 29, No. 4, p. 683, pl. 67, figs. 3a-c, 1955.

Test free, relatively large, periphery keeled and sharply angled, peripheral outline subangular; about 2 whorls visible on the flat spiral side, only the 7 chambers of the final whorl visible on the strongly elevated umbilical side, chambers about twice as high as broad, wedge-shaped in outline, much elevated around the umbilicus and with acutely angled umbilical shoulders, umbilicus with a large and strongly protruding plug; sutures flush, straight but oblique on the spiral side, deeply incised and radial on the umbilical side; wall calcareous, finely perforate, surface minutely granular in appearance; aperture appearing to be a narrow areal slit as the umbilical apertural plate is obscured at the surface by the strongly protruding chambers with acutely angled umbilical shoulders.

Diameter of figured topotype 0.50 mm.

Remarks.—This species differs from *Pararotalia inermis* (Terquem) in the more angled peripheral outline, the flatter spiral side with straight and oblique rather than curved sutures, and the more elevated umbilical side with large umbilical plug which nearly completely fills the umbilicus.

Types and occurrence.—Figured topotype (U.S.N.M. P5811) from the Oligocene (Lattorfian), Middle Headon, Brockenhurst beds, at White Cliff Bay, east coast of Isle of Wight, England. Collected by H. T. and A. R. Loeblich, Jr., with Dennis Curry and A. G. Davis, September 24, 1953.

PARAROTALIA species

Plate 5, figures 3a-c

A single specimen of a *Pararotalia* was obtained from the Miocene (Burdigalian) near Dax. It somewhat resembles *P. curryi,* new species, but is more strongly keeled, more compressed, and has relatively higher chambers. The umbilical side lacks a plug, but as only a single specimen is available, it is not certain whether or not this is an accidental feature. The elevated chambers around the umbilicus somewhat resemble *P. spinigera* (Le Calvez) but the spiral side is less convex and the peripheral spines less prominent.

Diameter of figured specimen 0.35 mm.

Types and occurrence.—Figured specimen (U.S.N.M. P5812) from the Miocene, Burdigalian, at Mont de Marson, near St. Avit, region of Dax, Dept. Landes, France.

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EXPLANATION OF PLATES

Plate 1. *Pararotalia byramensis, P. inermis*

Fig. 3b × 255, all other figures × 146.

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Fig. 1. *Pararotalia byramensis* (Cushman) 10

1a, Spiral view of hypotype (U.S.N.M. P5697) from the Byram formation (Oligocene) of Mississippi, showing low convexity and thickened sutures. 1b, Umbilical view, showing thickened sutures and umbilical plug. 1c, Edge view, showing much elevated umbilical side, angular umbilical shoulder, and areal aperture.

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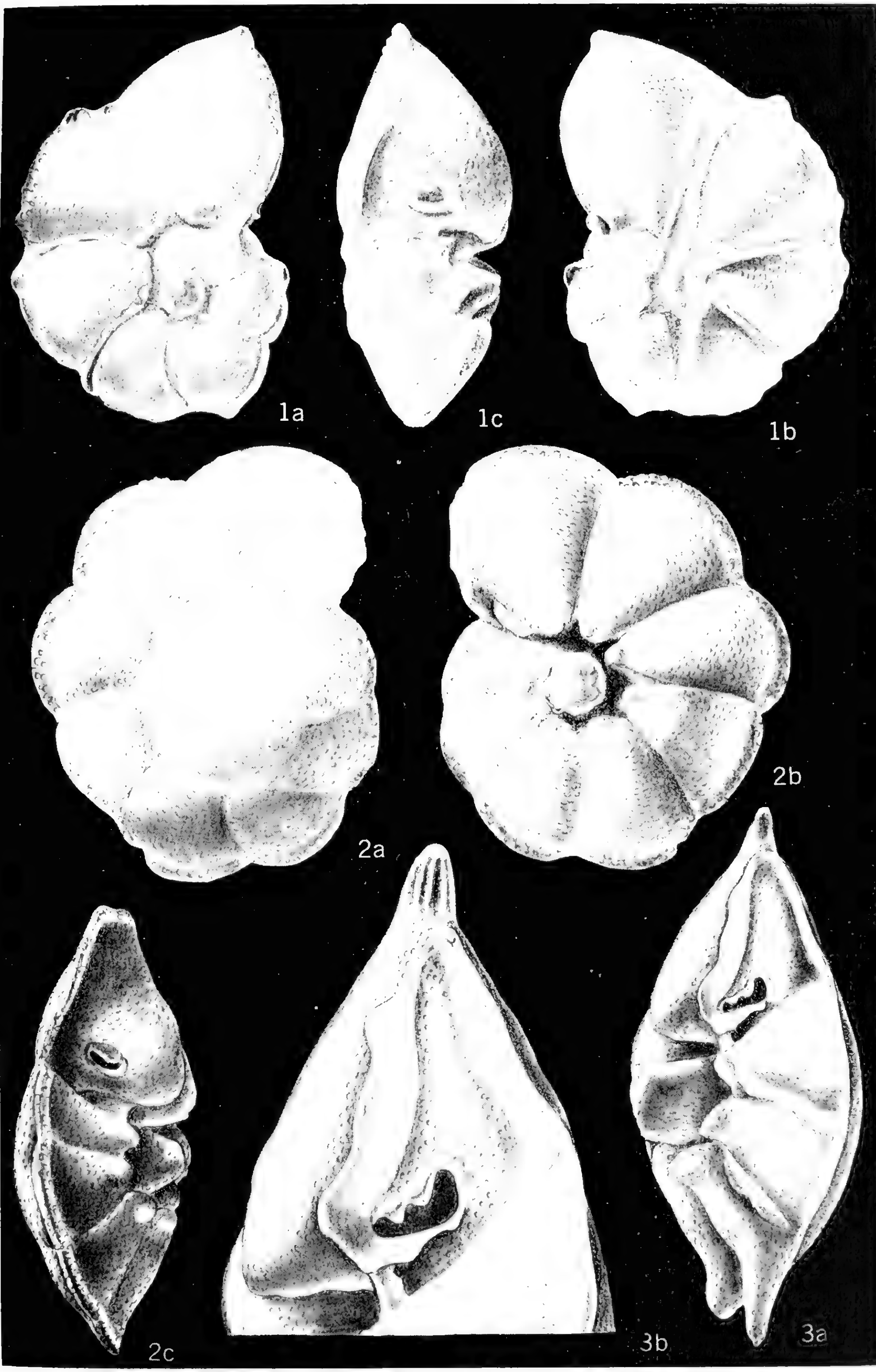

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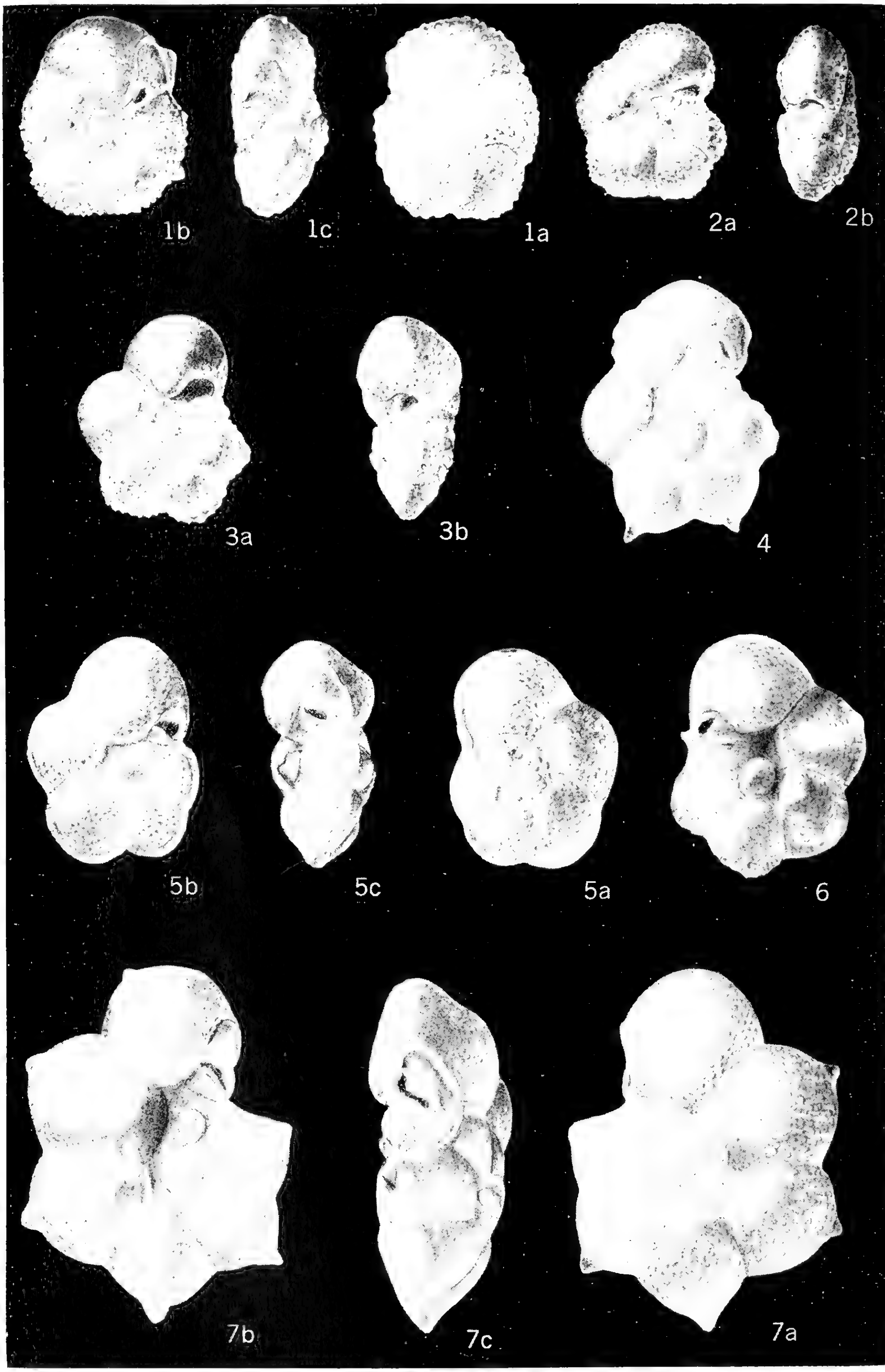

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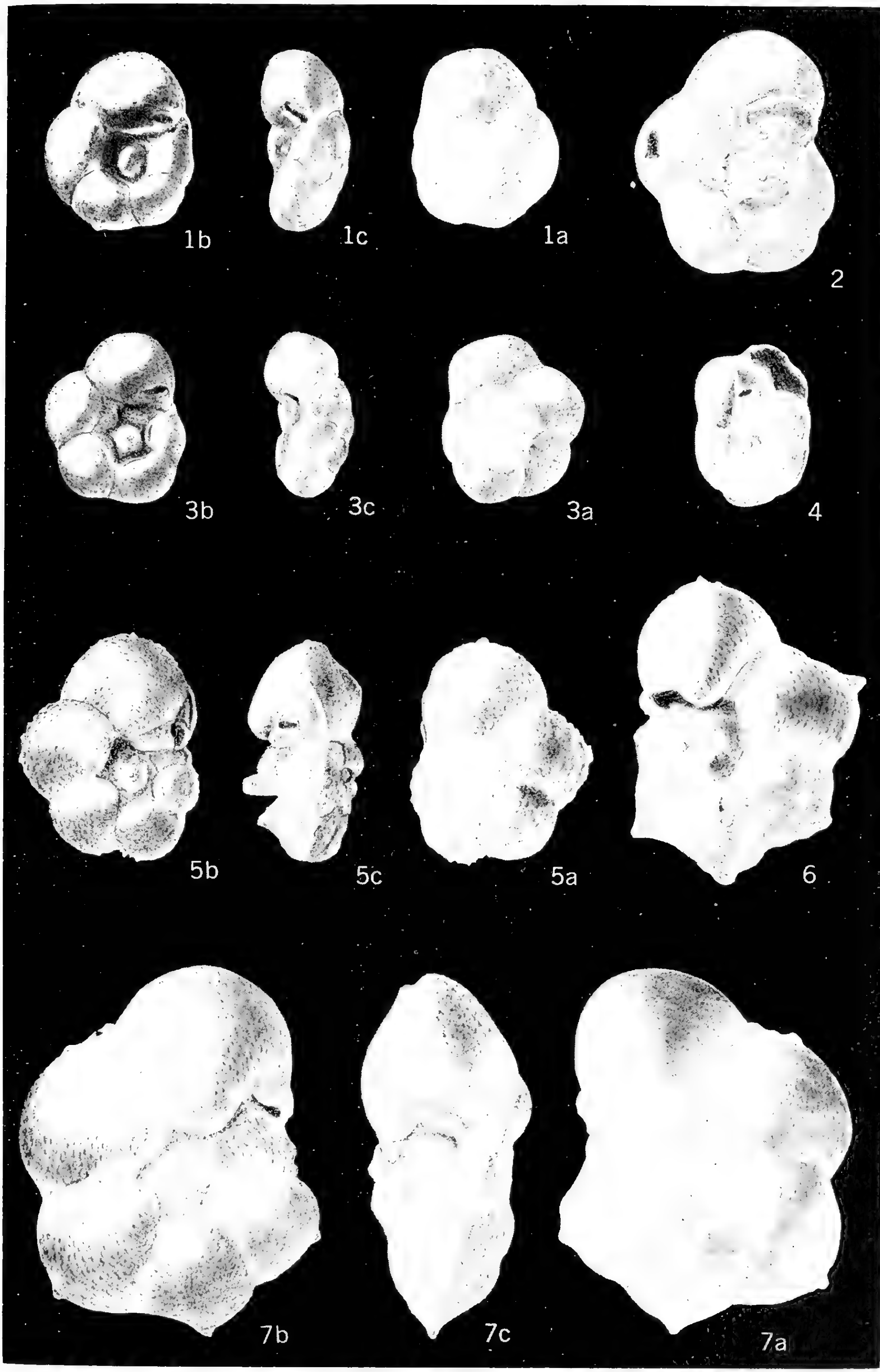

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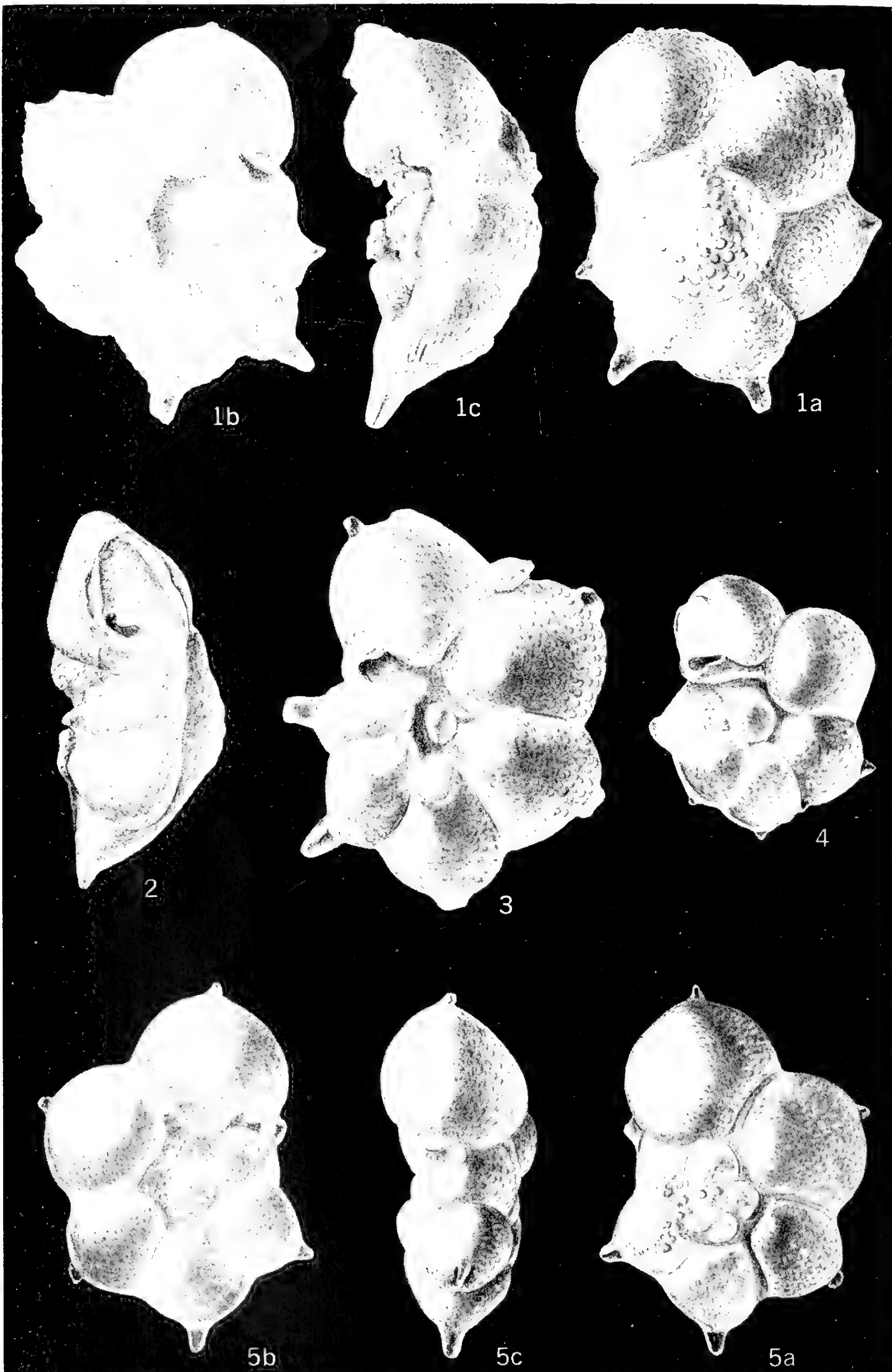

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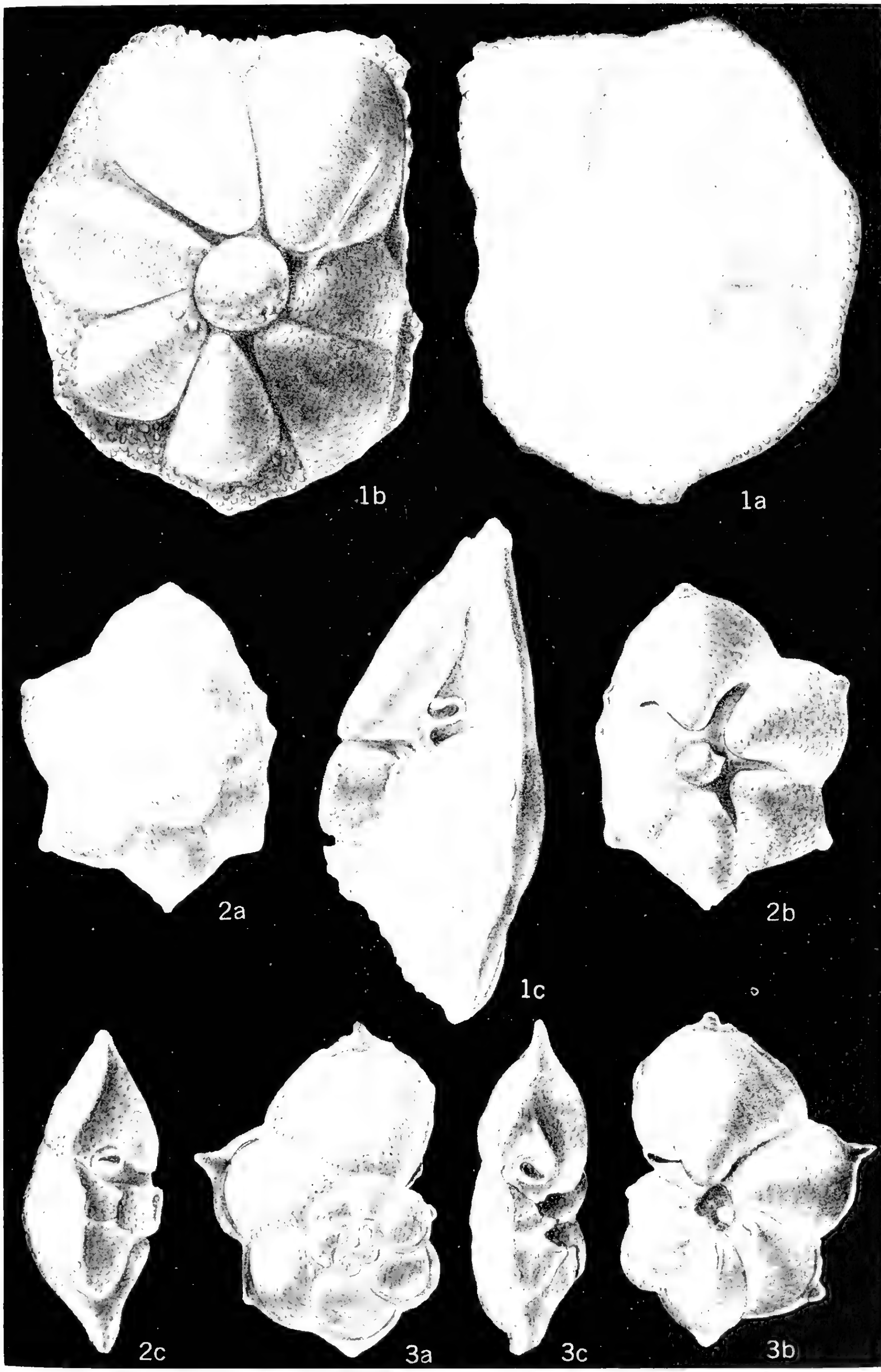

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(See explanation at end of text.)

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Charles D. and Mary Vaux Walcott Research Fund

GEOLOGY OF BARRO COLORADO ISLAND, CANAL ZONE

(With Three Plates)

By
W. P. WOODRING
Geologist, United States Geological Survey

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GEOLOGY OF BARRO COLORADO ISLAND, CANAL ZONE[1]

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Geologist, United States Geological Survey

(With Three Plates)

INTRODUCTION

Barro Colorado Island has been a wildlife reservation since 1923, at first as the Institute for Tropical Research in America under the direction of the National Research Council, and since 1946 as the Canal Zone Biological Area, administered by the Smithsonian Institution. Though hundreds of papers and books have been published on research conducted on the island, only a few sentences on the geology have appeared. One of these sentences deserves special mention, for it was written by a mammalogist: "There are many outcrops of rock, chiefly Bohio conglomerate" (Enders, 1935, p. 387). No geologist could write a more pertinent one-sentence statement concerning the geology of the island. The present account is intended primarily for visitors who may be interested in the geologic background and what it means in terms of geologic history, particularly the geologic history of the Panamá land bridge. For that reason it includes matter that is elementary to geologists. An additional purpose is to show that geological fieldwork is rewarding in a superficially unpromising forested area, provided sufficient time and facilities are available.

During six weeks in January and February (two of the four dry-season months), 1954, Mrs. Woodring and I were granted residence privileges on the island, while I studied its geology and that of nearby areas accessible by launch and cayuca (dugout).

Fieldwork on Barro Colorado was a memorable experience. It was like working in an unfenced combined zoological park and botanical garden. Agouti, coati, howling monkey, and white-faced monkey were seen every day; three-toed anteater, collared peccary, and iguana

[1] Publication authorized by the Director, U. S. Geological Survey. For summary see page 36.

frequently; the elusive little squirrel monkey, three-toed sloth, nine-banded armadillo, white-tailed deer, nutria, and crocodile occasionally. While I was writing notes near the mouth of the first stream south of Fuertes House, 13 collared peccaries, adults and young, slowly filed across the stream not more than 15 meters [2] upwind, unaware of my presence. Spoor of big cats and tapir was the only indication of those animals, the largest on the island. A pair of semidomesticated young tapirs frequently appeared in the clearing during the evening. To our surprise the male one evening chased a tame deer all over the clearing. He probably was resentful because the deer had just been fed. From the vantage point of the laboratory veranda, where so much could be seen, we watched white-faced monkeys making their tremendous leaps in the forest canopy, some of them pausing in a balsa tree to bury their heads deeply in the vaselike flowers, exactly as shown in Chapman's photograph (1938, pl. 5).

Parrot, parakeet, toucan, and antbird were ever present in the forest, and brilliant little honeycreepers were seen every evening in a leafless tree in front of the laboratory veranda. Great tinamou, whose haunting flutelike whistle will always be associated with memories of dawn and dusk, and crested guan (both game birds elsewhere) were common. Black-throated trogon, rufous motmot, and oropéndola were not unusual in the forest. A colony of oropéndolas, which returns to the clearing year after year to build its long pendent nests in a tall sandbox tree near the Chapman Cottage, was engaged in that task.

The big trees—cedro espinosa (*Bombacopsis fendleri*)—plotted on plate 1 are not exceptional but are located along trails, where their towering height and massively buttressed trunks are well displayed. The scarlet-flowered passionflower vine and the purple-flowered jacaranda were in bloom in the forest. It was too early for the guayacán, which in March brightens the forest with clouds of bright yellow blossoms.

Interesting as the animals and plants may be, they have no bearing on the geology, except their effects on a geologist, who may be unable to resist the temptation to spend more time on nongeologic observations than he is accustomed to.

There was only one drawback to fieldwork and that was due to a personal susceptibility. I found no effective way to keep off my body the minute ticks that are prevalent during the dry season, and their

[2] Metric units are used in this paper, not only because Barro Colorado is in the midst of metric-using countries, but also to conform with the system of marking trails on the island.

slightest bite raised a blister. I envied the young people, from schools in the Canal Zone and Panamá, who were attired in shorts for a day-length visit and evidently were not bothered. They, however, were not much exposed to ticks on the well-traveled trails near the laboratory.

For an introduction to the island and its unusual opportunities and beauty, a prospective visitor could do no better than to read Chapman's two delightful books (Chapman, 1929, 1938).

HISTORICAL BACKGROUND

The flooding of Gatun Lake, through the construction of Gatun Dam on Río Chagres, began in 1911 and was completed in 1913-14. Before the damming, the site of Barro Colorado was the high northeastern part of a ridge between the valley of Río Gigante (part of which now is Gigante Bay) and Laguna de Peña Blanca (now Peña Blanca Bay). The ridge was designated Loma de Palenquilla (fig. 1). The high part of Loma de Palenquilla owed its altitude to a thick cap of basalt, although that was not then known. (The name Palenquilla, displaced westward to the west side of Peña Blanca Bay, survives as the name for a point.) Loma de Palenquilla is labeled on a French map prepared in 1844 and published in 1845 (Garella, 1845). Varro Colorado, presumably named for a bluff of red clay, also appears on the map as the name of a settlement of Río Chagres near the northeast end of Loma de Palenquilla. On a French map dated 1886 Varro Colorado Arriba is on the north side of the Chagres and Varro Colorado Abajo a little downstream on the south side, and the ridge is labeled "Lomas de Palenquillo" (Wyse, 1886). The outline of what was to become Barro Colorado Island is well shown by two 10-meter contours on the last of the French maps, which was published in 1899 and was used in the drafting of figure 1 (Etienne and others, 1899). The outline of the island in figure 1 and slight modifications of minor drainage features are taken from a modern map of the same scale, but the contours on the French map agree remarkably well with the outline. The only serious error on the French map is the drawing of a stream practically along the crest of the present Bohio Peninsula. The French map was prepared under the auspices of a Commission of the second French canal company, a member of which was the French geologist Marcel Bertrand, well known for his early work on overthrusting in the complexly deformed subsurface coal fields of northern France and on recumbent thrust sheets (nappes) in the Alps. Bertrand collaborated with a resident Swiss engineer, Philippe Zürcher, in preparation of the most satisfactory of the early accounts of

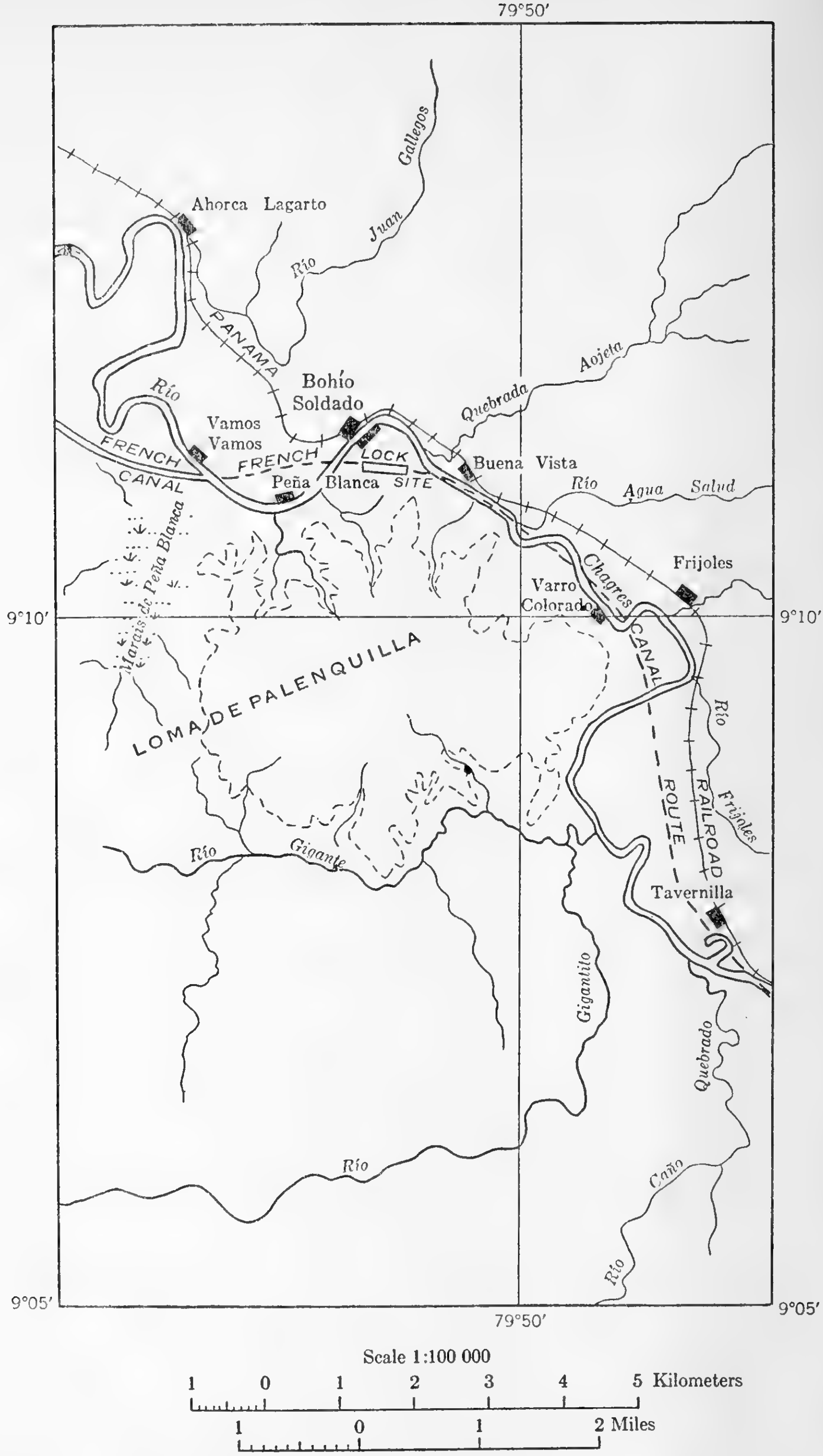


FIG. 1.—Map showing site of Barro Colorado Island before damming of Río Chagres to form Gatun Lake. Outline of island shown by broken line. Modified from map in report of Commission of second French canal company (Etienne and others, 1899).

the geology of the proposed canal route (Bertrand and Zürcher, 1899). Two famous French geologists were involved in the early work: Marcel Bertrand and the paleontologist Henri Douvillé. With few exceptions, Douvillé's (1891, 1898, 1915) age assignments have stood the test of time.

In its lower course Río Chagres was a wide stream, and under the drive of the trade winds during the dry season tidewater extended upstream almost to Loma de Palenquilla (Kirkpatrick, *in* Chapman, 1938, p. 206). In the early 1850's, before completion of the Panama Railroad in 1855, small iron-hulled steamers plied the river up to Gorgona, 12 kilometers in a direct line above Varro Colorado, to supplement the fleet of smaller vessels in accommodating the swarm of California-bound gold-rush travelers. From Gorgona, bongos (large dugouts) ascended the river to Las Cruces, a short distance upstream from the present site of Gamboa, where passengers disembarked for the arduous trip by muleback or on foot to Panamá City.

During the French construction periods (1881-89, 1895-99) or later, Loma de Palenquilla was used for an unexpected purpose. This episode, revealed by countless bottles of assorted design and a French iron dump car set up as a boiler—all near the summit of Barro Colorado—was discussed by Enders (1935, p. 388) and Chapman (1938, pp. 207-209). They concluded that this remote spot was the scene of illicit rum-distilling operations and surmised that the summit area, now sparsely forested, was cultivated to supply sugarcane. As suggested by Chapman, archeological excavations doubtless would throw light on this chapter of the island's history.

GEOGRAPHIC AND GEOMORPHIC SETTING

Barro Colorado, the largest and highest island in Gatun Lake, is 25 kilometers in a direct line south-southeast of Colón and about the same distance north of the continental divide (fig. 2). It is roughly circular and roughly dome-shaped, and reaches an altitude of 164 meters above sea level, or 138 meters above the normal level of Gatun Lake. The greatest diameter is 5½ kilometers and the area 15 square kilometers. Though the island is small, it is so deeply indented that the length of the shoreline is about 50 kilometers. The Panama Canal channel extends north and east of the island. The closest approach is at Salud Point, a view of which is shown on plate 3.

With the exception of the laboratory clearing of 2½ hectares and a few insignificant clearings elsewhere, the entire island is forested, but not all the forest is primary. Plate 2 shows the laboratory clearing and the surrounding forest. A network of well-kept trails extends

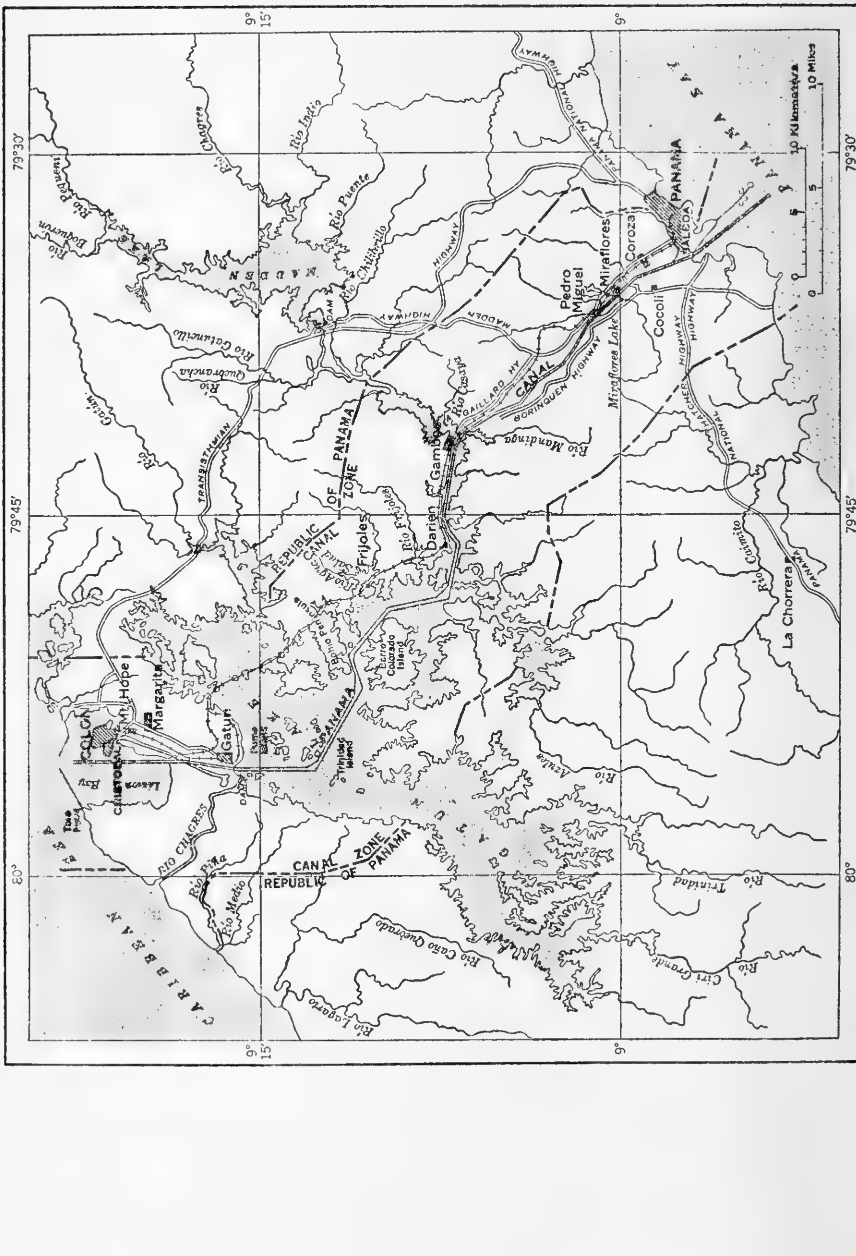


Fig. 2.—Map of Canal Zone and adjoining parts of Panamá showing location of Barro Colorado Island. Adapted from U. S. Geological Surv. Prof. Pap. 244, fig. 2 (Cole, 1952 [1953]).

over the island and a marked launch channel encircles it. Metal markers, bearing the name of the trail and the distance in hectometers from the laboratory or from the end of the trail heading toward the laboratory, are set at 100-meter intervals on the trails. The 1 : 20,000 Army Map Service topographic maps (contour interval 20 feet, converted to an interval of 20 meters on plate 1), now available, and especially the network of trails and their markers, convert the island into an area that has horizontal control perhaps unequaled elsewhere in American tropical forests. The island therefore offers an exceptional opportunity for geologic work.

Streams arranged in a radial pattern drain the island. A few of the streams have been casually named; for example, Lutz Creek and Allee Creek for the minor streams along the east and west sides, respectively, of the laboratory clearing. On a recent map of a small part of the island (Schneirla, 1956, fig. 4, and earlier publications), the stream on which fossil locality *42h*[3] is located is appropriately labeled Fossil Creek and that crossed by the Shannon, Balboa, and American Museum of Natural History (A.M.N.H. of plate 1) Trails is labeled Shannon Creek. Perhaps other investigators have named streams in which they were interested. In describing the geology it would be convenient to have names for the principal streams, but the trails are so closely spaced that a brief phrase is sufficient for locating a stream with reference to the nearest trail. The major streams and some of the minor streams, such as that on the east side of the laboratory clearing, are perennial, but during the dry season their flow is greatly reduced.

The topographic maps used as a base for plate 1 were constructed photogrammetrically. The top of the forest canopy is so uneven, ranging from 15 to 45 meters above the ground, that some minor drainage features inevitably were misinterpreted. Corrections in streams and trend of contours, particularly in the western part of the island, were sketched in the field and transferred to plate 1.

Nearly all the slopes are steep except in an area of considerable extent at the top of the island, which is designated the upland surface. The 20-meter contours of plate 1 show this surface as an area of low relief above an altitude of about 120 meters. The stream courses in

[3] The localities at which fossils were collected are described on pages 34-35, and all except *42i*, which is very close to *42h*, are plotted on plate 1. They have number and letter designations because they are intercalated in a series of report numbers established before the fieldwork on Barro Colorado was undertaken. The same series of report numbers is being used in a report to be published as Professional Paper 306 of the U. S. Geological Survey.

the upland surface are wide swales, dry in the dry season. The upper part of the upland surface is sparsely forested and the swales are covered with a dense growth of pita (wild pineapple), indicating, as suggested by Enders and Chapman, that much of the upland surface formerly was cultivated.

The present remnant is all that is left of a surface formed at a time when the streams were graded to a base level (the ancient Río Chagres) several tens of meters higher, with respect to present sea level, than Río Chagres before flooding of Gatun Lake. The origin of the upland surface is mentioned again on page 33.

Steep-gradient streams flowing in narrow ravines are now destroying the remnant of the upland surface. These streams are cutting farther and farther back into the surface by headward erosion. A neck of the surface, extending northeastward toward the laboratory clearing, is now being cut off from the main body. At the base of the neck, a northward-flowing steep-gradient stream and its tributaries (crossed by bridges on the Wheeler Trail northeast of the summit of the island) captured the headwaters of southward-flowing low-gradient streams. Barring unforeseeable events, the headward erosion of all the streams will continue until the upland surface is completely consumed.

In general the topographic features reflect the geologic background, but the upland surface is an exception. It bevels a thick cap of basalt and also conglomerate, the most durable rocks on the island—an indication that the surface bears witness to a long interval of erosion. The high, rugged nothern part of the island, westward from the laboratory clearing, is underlain by conglomerate of the Bohio formation, which is not readily eroded. The stream courses in that area are narrow ravines or miniature gorges. Rugged slopes are formed by the same kind of rock southwestward from the western part of the Barbour Trail. On the west side of the second main stream west of the Drayton Trail, the slope is very precipitous for a vertical distance of 30 meters.

The softer rocks of the Caimito formation form subdued slopes and more open ravines than the hard rocks of the Bohio formation. Such features are characteristic of both the marine rocks in the western and central parts of the island and the nonmarine volcanic rocks in the eastern part, although the volcanic rocks include thin flows of basalt and small intrusive bodies of basalt.

GENERAL GEOLOGIC FEATURES

Though no account of the geology of Barro Colorado has been published, the island has appeared on several geologic maps. MacDonald's small-scale map (about 1 : 260,000), published in 1915 and again in 1919, shows the Bohio formation cropping out over the entire island (MacDonald, 1915, pl. 4; 1919, pl. 153). MacDonald, who was resident geologist during the last two years (1911-13) of the canal-construction period, was not carrying on geologic mapping—he was engaged in engineering geology. He saw the readily identified Bohio formation at the north end of Loma de Palenquilla during trips on the French Canal and Río Chagres, and later along the north coast of Barro Colorado during trips on Gatun Lake. A geologic map of the Gatun Lake area on a scale of 1 : 62,500 was published in 1950 (Jones, 1950, pl. 2). That map shows the same major rock units on Barro Colorado as plate 1 of the present account. Aside from the greater detail on plate 1 commensurate with its larger scale (1 : 20,000), the chief difference is that on plate 1 the eastern third of the island is shown to be underlain not wholly by basalt, but by a volcanic facies of the Caimito formation that includes basalt. The representation of Barro Colorado on a recently issued 1 : 75,000 geologic map of the Canal Zone and adjoining parts of Panamá (Woodring, 1955) is a generalized version of plate 1. The generalization includes the showing of basalt in the eastern third of the island and the omission of a branch of the Barro Colorado fault.

A visitor to Barro Colorado, who missed the basalt at the stream crossed by the Nemesia Trail 60 meters west of Nemesia 2, could travel every meter of the 36 kilometers of trails without seeing a single outcrop of unweathered rock. He would think, if he thought about it at all, that the island is geologically monotonous: an expanse of red clay with here and there scattered "boulders," or less rounded masses, that have an oxidized ferruginous coat of varying thickness and a heart of hard black rock. The red clay is a product of oxidation and hydration. At least in field features, the red-clay product from different parent material cannot be distinguished. There is one partial exception to that generalization. If the weathering has not gone too far and the clay, as seen in stream banks, shows somewhat rectangular, small, whitish blobs, it may be concluded that the blobs are kaolinized ghosts of feldspar crystals and that the parent material presumably is basalt. It would be uncertain, however, whether it is solid basalt, agglomerate containing fragments of basalt, or conglomerate made up of basalt boulders.

The high-gradient streams have cut through this mantle of red clay, ranging in thickness from a few meters to 15 meters, and afford satisfactory exposures of fresh rock. In fact, many of these streams are lined by continuous, or practically continuous, outcrops for considerable distances. Outcrops can be seen also on some of the low-gradient streams, particularly along these underlain by the marine rocks of the Caimito formation, but many of them, especially short streams, are not rewarding.

Exposures of unweathered rock away from streams were found only in the northwestern part of the island, where conglomerate of the Bohio formation crops out along the shore of the bold headlands jutting into Gatun Lake. These headlands are open to a long fetch of the lake, and every afternoon during the dry season white-capped waves are raised by the trade winds. The westernmost peninsula, which is narrow and very precipitous, is the only place where natural outcrops—again conglomerate of the Bohio formation—were observed on the crest of a ridge.

The geology of Barro Colorado is basically simple. As may be seen in figure 3, only two of the six major sedimentary rock units cropping out in the Gatun Lake area are found on Barro Colorado: the Bohio and Caimito formations. The outcropping strata of both are of late Oligocene age. Neither the base of the Bohio nor the top of the Caimito is represented on the island. Both formations include two mapped units of different facies. The bulk of the Bohio is nonmarine, but the formation includes thin tongues of marine strata. In the western and central parts of the island the Caimito consists of marine strata, whereas in the eastern part the marine strata are replaced by nonmarine volcanic rocks.

SEDIMENTARY ROCK FORMATIONS AND FOSSILS

BOHIO FORMATION

The Bohio formation was named for Bohío (originally Bohío Soldado), a village on the Panama Railroad, located on a bluff overlooking Río Chagres (fig. 1). The site of Bohío is close to the north border of plate 1, north of French Lock Point on de Lesseps Island. That island, Orchid Island, and the northwestern part of Barro Colorado, therefore, are in the type region of the formation. During the goldrush travel across the isthmus and later as the center of French operations, Bohío was a town of several thousand inhabitants. In the Canal Zone the name, which is in use for the long peninsula north of Barro Colorado and for the point at the end of the peninsula, is anglicized

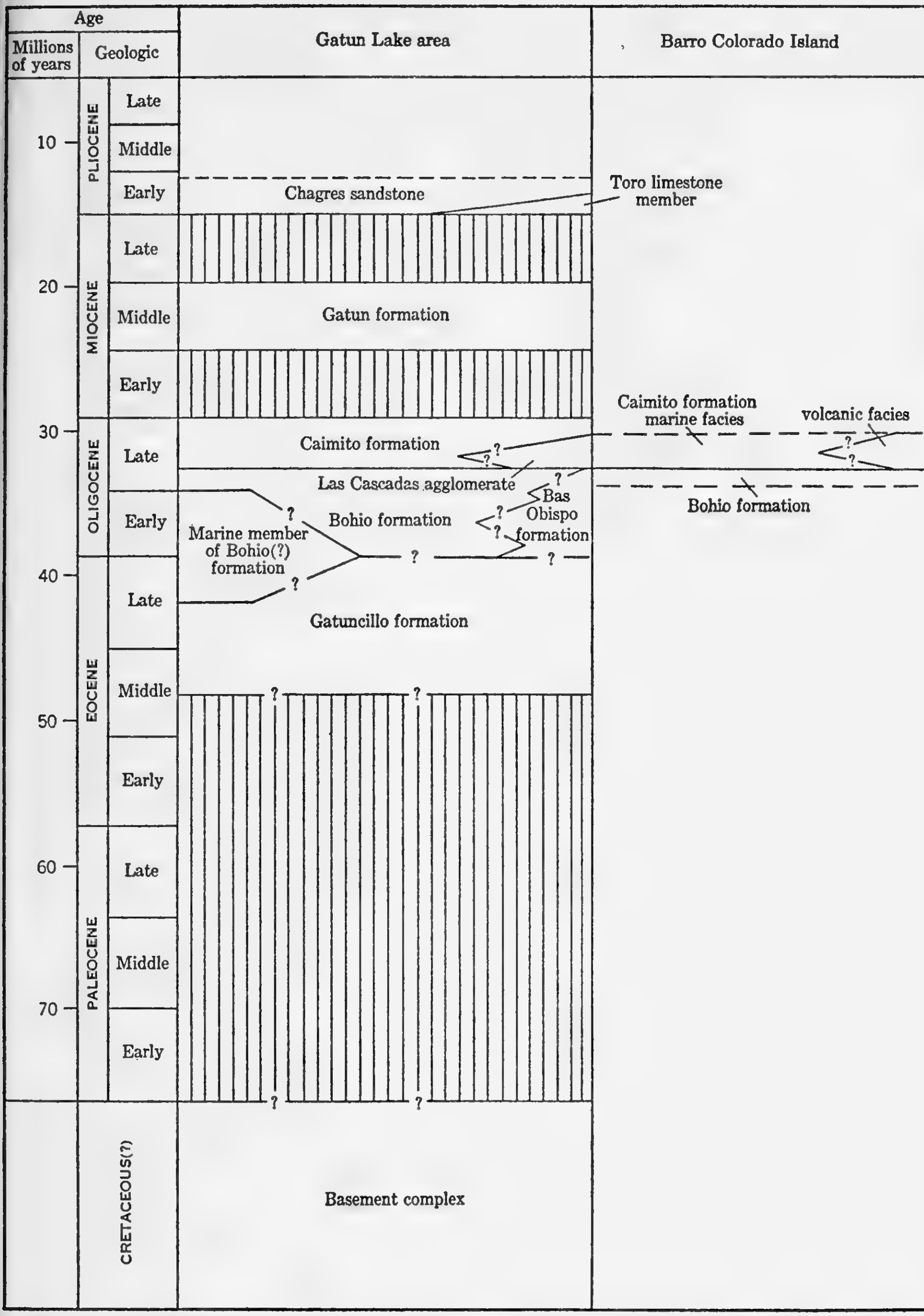


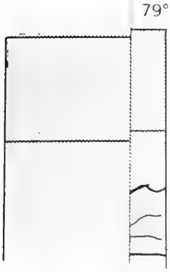
FIG. 3.—Sedimentary rock formations in Gatun Lake area and on Barro Colorado Island. Vertical ruling indicates gap. Broken horizontal line indicates that base or top of formation is not represented. Approximate age in years adapted from Simpson (1947, p. 481).

and the accent is dropped. The formation was named by R. T. Hill, the first American geologist to study the geology of the canal route (Hill, 1898, p. 183). He used the spelling "Bujio," which appears on some early maps.

The maximum thickness of the Bohio formation in the Gatun Lake area is estimated to be 300 meters. On Barro Colorado, however, only about the uppermost 125 meters are exposed. The entire formation, overlying the Gatuncillo formation, of middle and late Eocene age, crops out northwest of Gamboa. On Barro Colorado the Bohio includes both nonmarine and marine strata.

Nonmarine strata.—The Bohio is the most distinctive sedimentary rock formation in the Gatun Lake area. The principal constituent is conglomerate made up almost entirely of boulders, cobbles, and pebbles of basalt. There is no conglomerate like it in older or younger formations. Moreover, the basaltic debris is embedded in a matrix consisting chiefly of coarse-grained, angular grains of basalt. The conglomerate is rudely stratified or unstratified and unsorted, and includes some imperfectly rounded and angular pieces of basalt. Boulders that have a diameter of 2 meters are not unusual, but the maximum diameter generally is a little less. In extensive exposures, such as those on the headlands west of the laboratory clearing, an occasional boulder of other rocks may be seen: altered lava, diorite, and slaty rock. Sharp-edged pieces of white chert are strewn along a shallow ravine near the northwest end of the Standley Trail and also downstream from locality *42h*, east of the Shannon Trail. Both localities are in the outcrop area of the Bohio formation. Though the chert was not seen in place, it presumably is derived from chert boulders in the conglomerate.

In the laboratory clearing and along the ravines emptying into Gatun Lake east and west of the landing, the conglomerate may be readily observed. That fresh rock is not far below the surface in the clearing is indicated by the hillside excavation for the new laboratory building near the southwest end of the clearing. At a depth of a meter rotten remnants and ghosts of boulders and cobbles can be made out. They consist of igneous rock, evidently basalt, showing kaolinized feldspar crystals. The weathered rock in the excavation disintegrates into coarse-grained sand. A 2-meter boulder in the ravine east of the landing, 10 meters upstream from Gatun Lake, looks like a small outcrop of basalt. It is breaking up along joints into sharp-edged fragments. Good exposures of conglomerate, including a long chute just below the Chichi Cottage, halfway down the slope from the laboratory, are readily accessible along the ravine at the west edge of the



EXPLANATION

SEDIMENTARY ROCKS

pper Oligocene

Tcm | Tcv

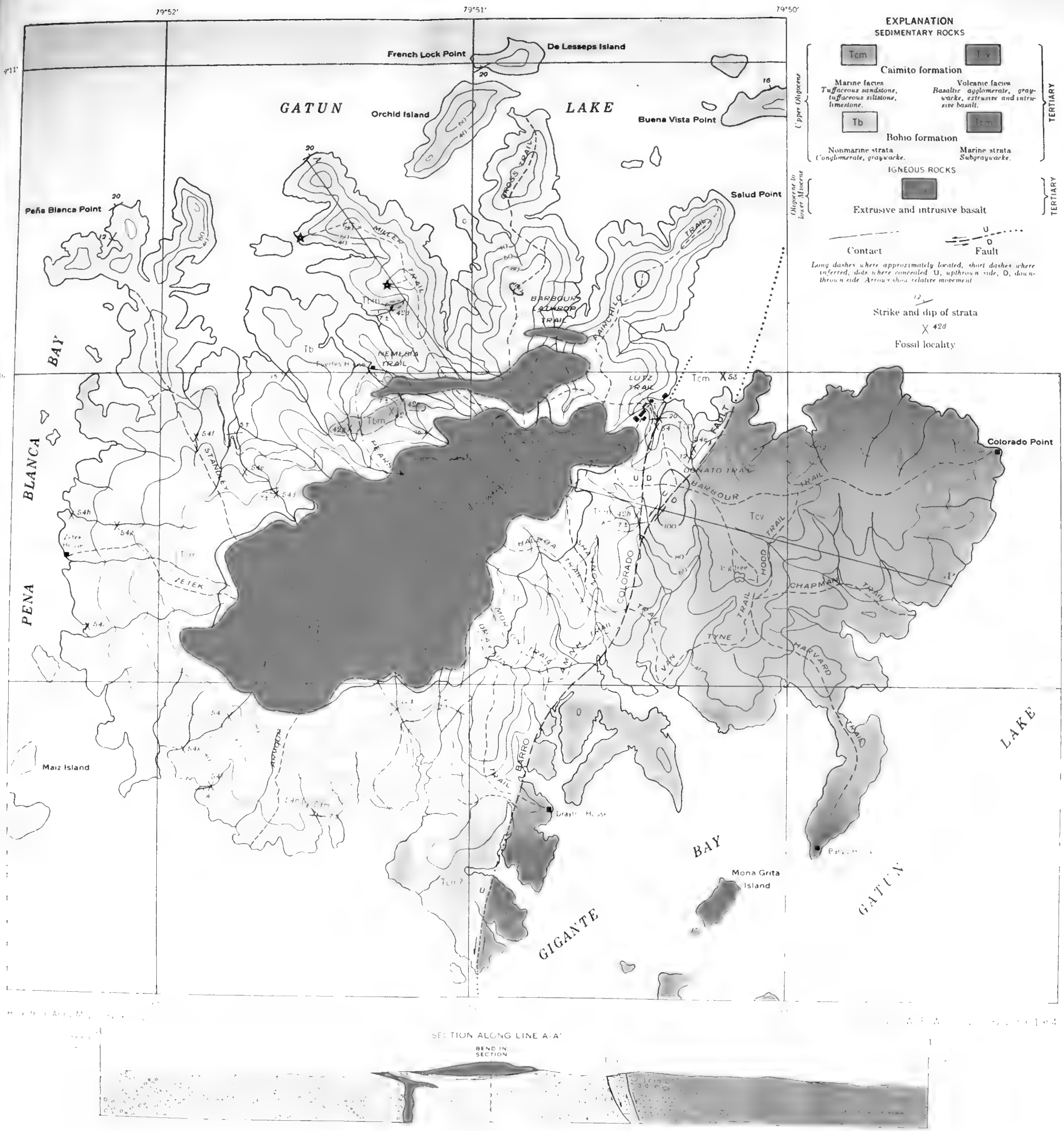
Caimito formation

Marine facies
Tuffaceous sandstone, tuffaceous siltstone, limestone.

Volcanic facies
Basaltic agglomerate, graywacke, extrusive and intrusive basalt.

TERTIARY

Th | Thm



GEOLOGIC MAP AND STRUCTURE SECTION OF BARRO COLORADO ISLAND, CANAL ZONE

clearing. In fact, conglomerate forms waterfalls, cascades, chutes, or pavements on every stream in the outcrop area of the Bohio, both west of the laboratory and in the narrow strip extending from the Barbour Trail south-southwestward to the south coast west of the Drayton Trail. On the first stream east of the northwest end of the Standley Trail, a pavement of conglomerate extends to the edge of Gatun Lake. The most extensive exposure close to the laboratory is at Salud Point. The view of Salud Point shown on plate 3 suggests a beach boulder rampart. Though the big boulder in the left foreground and others at the water's edge are loose, the others are in rock outcrop.

Interlayered with the conglomerate are beds of massive sandstone like that forming the matrix of the conglomerate. Most of the sandstone contains scattered small cobbles and pebbles. Such sandstone, made up principally of coarse, poorly sorted angular grains of basalt in a claylike binder, and containing some feldspar but little quartz is a particular kind of sandstone called graywacke. Both the conglomerate and the graywacke have features of nonmarine deposits, and silicified wood is found in the Bohio of the Bohio Peninsula (Berry, 1918, p. 32).

Marine strata.—Fossiliferous marine or brackish-water sandstone of another type was found in three areas: West of the Miller Trail (locality 42*d*), south and southeast of Fuertes House (localities 42*e*, 42*f*, 42*g*), and between the Van Tyne and Shannon Trails (localities 42*h*, 42*i*). Upstream from locality 42*f* sandstone containing crumbly molds of unrecognizable pelecypods is underlain by carbonaceous shale, 75 centimeters thick. Some of the sandstone is as poorly sorted and as coarse-grained as the graywacke, but all of it is made up of less basalt, more feldspar and quartz, and less of the claylike binder. This type of sandstone is designated subgraywacke. Carbonized plant debris, apparently mostly bits of wood, is abundant in most of the subgraywacke. At locality 42*d*, however, the subgraywacke has little carbonized debris, and some of the rock, in the form of harder, irregularly shaped lumps, is somewhat calcareous.

Fossils and age.—Locality 42*g* is the only place where fossils were found in conglomerate: a cluster of oyster shells in the hard matrix around a cobble. A considerable number of marine fossils occur in the subgraywacke, especially at locality 42*d*, which yielded 80 species representing 6 phyla. Though no marine fossils were heretofore known in the present outcrop areas of the Bohio formation in the Gatun Lake area, Wyse (1886, p. 17) mentioned fossil shells near Bohío Soldado, and Howe (1908, pp. 220-221) found them in carbonaceous sandstone penetrated in coring operations at the French

Lock site. His description fits the carbonaceous subgraywacke of Barro Colorado. The lock-site excavation now is the launch channel between Orchid and de Lesseps Islands. Anyone who has passed through the channel will remember the concrete French canal markers, shaped like bottle-necked sentry boxes, lined up on the islands.

The fossils collected are listed in the table on pages 15-17.

Except for *Elphidium* aff. *E. craticulatum* and *Quinqueloculina akneriana,* the smaller Foraminifera, all from locality 42*d,* are poorly preserved. *Heterostegina antillea, Archaias compressus, Miogypsina antillea,* and *M. gunteri* from Barro Colorado localities have recently been described and illustrated by Cole (1957). The remaining larger Foraminifera, as represented at other localities in the Canal Zone, were treated in his 1952(1953) publication.

The two species of corals include an incomplete specimen of *Galaxea.* In a personal communication, J. W. Wells reports that, except for an undescribed species in the lower Miocene Tampa limestone of Florida and the Barro Colorado form, *Galaxea* is a tropical western Pacific genus ranging from Pliocene to Recent.

The list of mollusks is preliminary and shows hardly more than the generic makeup, aside from some among the first 13 species—the only ones studied so far. The new species among these and eventually the other identifiable species are to be described in a report, "Geology and Paleontology of Canal Zone and Adjoining Parts of Panamá," to be published as U. S. Geological Survey Professional Paper 306. The mollusks found at locality 42*d* are notable, not only on account of their diversity and the large number of specimens, but also because they include the only nautiloid in some 260 collections of Tertiary mollusks from the Canal Zone and adjoining parts of Panamá now being studied. The nautiloid is a species of the genus *Aturia,* widely distributed in both hemispheres in deposits of Eocene to Miocene age.

The fossils from localities 42*d,* 42*g,* 42*h,* and 42*i* indicate a shallow-water marine environment. *Anomalocardia* (locality 42*i*), however, now is a brackish-water genus and probably always has been adapted to that environment. *Neritina* (locality 42*g*), *Crassostrea* (the type of which is the eastern oyster, *C. virginica*), the only fossil from locality 42*e* and occurring also at 42*d* and probably (in the form of a young shell) at 42*g,* and *Tagelus* (locality 42*i*) tolerate a fairly wide range of salinity. Locality 42*f* yielded a mixture of fresh-water (*Hemisinus*), brackish-water (*Polymesoda, Anomalocardia*), brackish-water or marine (*Crassostrea, Tagelus*), and marine genera. At locality 42*f* the fossils were collected from slide material choking the stream

Fossils from upper part of Bohio formation

[R, rare; F, few; C, common; A, abundant]

	Localities					
	42d	*42e*	*42f*	*42g*	*42h*	*42i*
Smaller Foraminifera (identifications by Ruth Todd):						
Amphistegina? sp.	R					
Elphidium aff. *E. craticulatum* (Fichtel and Moll)	C					
Eponides? sp.	R					
Massilina sp.	R					
Peneroplis? sp.	R					
Quinqueloculina akneriana d'Orbigny	R					
Quinqueloculina sp.	R					
Triloculina sp.	R					
Larger Foraminifera (identifications by W. S. Cole):						
Heterostegina antillea Cushman					A	
Archaias compressus (d'Orbigny)	A					
Lepidocyclina (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé	R				R	
Lepidocyclina (*Lepidocyclina*) *giraudi* R. Douvillé	R					
Lepidocyclina (*Lepidocyclina*) *waylandvaughani* Cole	R					
Lepidocyclina (*Nephrolepidina*) *vaughani* Cushman	R					
Miogypsina (*Miogypsina*) *antillea* (Cushman)	R				C	
Miogypsina (*Miogypsina*) *gunteri* Cole					R	
Unidentified sponge spicule	R					
Corals (identifications by J. W. Wells):						
Asterosmilia exarata (Duncan)	R					
Galaxea sp.	R					
Mollusks (identifications by W. P. Woodring):						
Gastropods:						
Solariella n. sp. cf. *S. depressa* Dall	R					
Neritina sp.				R		
Hemisinus (*Longiverena*) n. sp., cf. *H. atriformis* Cooke			A			
Crepidula? sp.				R		
Natica (*Naticarius*) sp.	F			?R		
Polinices sp.	F			?R		
Sinum sp.	F					
Globularia (*Globularia*) aff. *G. fischeri* (Dall)	A			F		
Pachycrommium aff. *P. guppyi* (Gabb)	R					
Turritella cf. *T. altilira* Conrad	R					
Turritella n. sp. aff. *T. venezuelana* Hodson	A			?F		
Cerithium (*Thericium*) n. sp.	A			?R		
Orthaulax cf. *O. pugnax* (Heilprin)	R					
Cymatid, genus?	R					
Ficid, n. genus	R			R		
Muricid?, genus?	R					
Mitrella sp.	R					

Fossils from upper part of Bohio formation—continued

	Localities					
Mollusks—continued						
Gastropods—continued	*42d*	*42e*	*42f*	*42g*	*42h*	*42i*
Buccinid, genus?	R					
Nassarius sp.	R					
Mitra (*Thiara*) sp.	R					
Plochelaea cf. *P. crassilabrum* Gabb	R					
Agaronia? sp.	R			R		
Cancellaria sp.	R					
Conus sp.	C					
Strioterebrum sp.	R					
Borsonine? turrid, genus?	R					
Clavine turrid, genus?	R					
Acteon sp.	R					
Acteocina sp.	R					
Atys sp.	A					
Scaphander sp.	A			C		
Pyramidella sp.	R			R		
Scaphopods:						
Dentalium sp.	R					
Siphonodentalium? sp.	R					
Pelecypods:						
Nucula? sp.	R					
Adrana cf. *A. crenifera* (Sowerby)	C			R		
Orthoyoldia? sp.						R
Anadara cf. *A. notabilis* (Röding)	R					
Anadara (*Cunearca*) sp.	R			?R		
Pecten (*Flabellipecten*) aff. *P. gatunensis* Toula	R					
Anomia aff. *A. berryi* Spieker	R					
Crassostrea sp.	R	R	R	?R		
Venericaria? sp.						R
Polymesoda sp.			R			
Lucinoma sp.			R			
Myrtaea sp.	R					
Miltha cf. *M. woodi* (Olsson)	R					
Divaricella sp.				R		
Diplodonta sp. (large)	R		A	R		
Diplodonta sp. (small)	F					
Trachycardium cf. *T. dominicense* (Gabb)	A			R		
Trachycardium cf. *T. dominicanum* (Dall)						R
Dosinia aff. *D. delicatissima* Brown and Pilsbry	C					
Macrocallista cf. *M. maculata* (Linné)	R			?R		
Chione cf. *C. spenceri* Cooke	A			F		R
Anomalocardia sp.			A			C
Pleiorytis cf. *P. caroniana* (Maury)	R					
Tellina sp.			R	R		R
Tellinid, n. genus	R					

Fossils from upper part of Bohio formation—continued

	Localities					
Mollusks—continued						
Pelecypods—continued	*42d*	*42e*	*42f*	*42g*	*42h*	*42i*
Semele sp.	R					
Semele? sp.	R					
Tagelus sp.			F			R
Solecurtus sp.	R					
Mactrid?, genus?			F			
Labiosa aff. *L. undulata* (Gould)						R
Mesodesma? sp.	C			F		
Corbula sp. (large)			R			
Corbula sp. (small)	F			R		
Thracia sp.	R					
Cephalopod:						
Aturia cf. *A. curvilineata* Miller and Thompson	R					
Ostracodes (identifications by I. G. Sohn):						
Cytheridea (s.l.) sp.	C					
Cytherura? sp.	R					
Cytherine? cytherid, genus?	R					
Genus?	R					
Genus?, aff. *Macrocypris*	R					
Decapod crustaceans (identifications by H. B. Roberts):						
Callianassa aff. *C. vaughani* Rathbun	R					
Callianassa floridana Rathbun	F					
Undeterminable callianassid limb fragments	C					
Unidentified fish tooth	R					

to the east and leaving a scar on the ridge slope, where the locality is plotted.

The larger Foraminifera and mollusks show that the upper part of the Bohio formation is late Oligocene, agreeing with the age previously determined for the upper part of the formation at the continental divide along the Transisthmian Highway east of the Canal Zone (Woodring and Thompson, 1949, pp. 231-232; Cole, 1952 [1953], p. 6). All the larger Foraminifera except two (*Archaias compressus* and *Miogypsina gunteri*) are found in late Oligocene rocks elsewhere in the Canal Zone and all occur in late Oligocene deposits of other regions. *Lepidocyclina* and *Miogypsina* became extinct in Miocene time. *Lepidocyclina* first appeared in the early Eocene and *Miogypsina* in the late Oligocene.

Like late Oligocene molluscan fanuas elsewhere, that from the Bohio of Barro Colorado has as a minor element an Eocene survivor (*Globularia*), a genus that has a time span of late Oligocene to early Miocene (*Orthaulax*), and a strong representation of genera and subgenera that first appeared in late Oligocene time and reached their fullest development in late Tertiary and modern seas (*Naticarius, Dosinia, Chione, Anomalocardia*). *Globularia,* however, survived until late early Miocene time. In the Canal Zone *Globularia* aff. *G. fischeri* is found in formations of both late Oligocene and the early half of early Miocene age, and *G. fischeri* itself occurs in the late early Miocene of Florida. The Barro Colorado species of *Anomalocardia* is the earliest species of that genus.

CAIMITO FORMATION

The Caimito formation takes its name from a construction-period junction on the Panama Railroad near the present Darien station, 8 kilometers west of Gamboa. The formation was named by MacDonald (1913, p. 569). Though no type locality was specified, he evidently intended Caimito and its vicinity to be the type region. It is not a good type region, but the characteristic lithology is shown there and, according to the regional relations near Darien, it is evident that the Caimito overlies the Bohio formation.

The prevalence of rhyolitic tuff, generally greatly diluted by detrital material, is a distinctive feature of the Caimito formation as far as the Gatun Lake area is concerned. The tuff (partly vitric and partly devitrified) forming a 15-meter cliff at the north abutment of the bridge at Barbacoas (10 kilometers west of the present site of Gamboa), where the original line of the Panama Railroad crossed Río Chagres, is presumed to be an example of undiluted tuff of the Caimito. The tuff at Barbacoas was described by practically every geologist and engineer who examined the rocks along the railroad. Boutan's (1880, pp. 19-20) early account is a good example and so is R. T. Hill's (1898, pp. 184-186), whose publication includes petrologic descriptions of the tuff by Wolff and Turner. There is a possibility that the tuff represents overlapping younger deposits of the lower Miocene Panamá formation, but that possibility seems to be remote. This matter can no longer be resolved, for the entire area is under Gatun Lake.

The Caimito is the most widely distributed formation in the Gatun Lake area. It consists chiefly of tuffaceous sandstone and tuffaceous siltstone. Hard algal-foraminiferal limestone, soft marly foraminiferal limestone, conglomerate, tuff, and agglomerate (coarse, angular, waterlain volcanic debris in a tuff matrix) are minor but significant constituents in the marine facies of the formation. The conglomerate lacks the great basalt boulders of conglomerate in the Bohio formation and, except for local basal deposits, is made up of cobbles and pebbles representing a greater variety of rock types. The matrix of the conglomerate (even of the local basal basaltic conglomerate), unlike conglomerate of the Bohio, contains tuff (Jones, 1950, p. 900). The total thickness of the Caimito is estimated to be at least 300 meters, but on Barro Colorado only about the lowest 100 meters of the marine facies crops out. The thickness of the volcanic facies on the island is estimated to be about the same.

Jones (1950, pp. 900-901) recognized three members in the Caimito formation of the Gatun Lake area. The lower member, consisting of basaltic conglomerate, was found only locally. The middle member is made up of tuffaceous sandstone and lenticular limestone, and the upper member (the thickest and most widely distributed part) of tuffaceous sandstone and siltstone, tuff, agglomerate, and sandy limestone. Whether the lower member represents a distinct time interval and is overlapped by the middle member or grades northwestward (seaward) into strata like those in the middle member—and is therefore indistinguishable from the middle member—is uncertain and may be indeterminable, as much of the critical area is under water. At all events, the marine facies of the Caimito of Barro Colorado, resting directly on the Bohio formation, consists of rocks like those in the middle member. Jones found that to the east-southeast, near and southeast of Gamboa, the Caimito grades into volcanic rocks of the Las Cascadas agglomerate of the Gaillard Cut area (the part of the canal excavation southeastward from Gamboa across the continental divide). He reached the conclusion that only the lower member grades into the Las Cascadas, but it seems to be more probable that more of the Caimito, if not the entire formation, is involved in the gradation.

The actual contact between the Caimito and Bohio formations was not observed on Barro Colorado Island, although on several streams in the northwestern part of the island the contact lies within narrow stratigraphic and horizontal limits. The contact evidently represents a sharply marked change in rock types and doubtless indicates a discontinuity. If so, it is a minor discontinuity, for the strata below and above the contact are of late Oligocene age.

A marine facies of the Caimito crops out in the western and middle parts of Barro Colorado and a nonmarine volcanic facies in the eastern part.

Marine facies.—Well sorted or moderately well sorted, tuffaceous, fossiliferous sandstone, ranging from gritty and coarse-grained to very fine-grained and silty, is the chief constituent of the marine facies. Soft sandstone of medium grain is the most widespread type. Some of the sandstone, however, is slightly or moderately calcareous and therefore moderately hard. Medium-grained, somewhat carbonaceous sandstone, containing slightly calcareous lumps, forms a pavement upstream from the mouth of the first stream east of the end of the Armour Trail (locality 54*m*). Gritty, calcareous somewhat carbonaceous sandstone and somewhat calcareous flaggy sandstone are exposed on the second stream west of the end of the Armour Trail (locality 54*l*). Silty, very fine-grained, richly fossiliferous sandstone was found at locality 54*n*, on the same stream as that for 54*m*, just mentioned. Conglomerate made up of small pebbles was observed about 100 meters downstream from locality 54*j* on the stream crossed by the Conrad Trail at Conrad 2.

Lenticular beds of limestone, not more than a few feet thick, are widespread on the north slope of the island. Though the limestone is a minor constituent, it is conspicuous. Hard algal-foraminiferal limestone is the common type. Soft, marly, foraminiferal limestone crops out in an area straddling the northwestern part of the Standley Trail. Such limestone is accessible at locality 54*f*, 30 meters downstream from the Standley Trail on the stream crossing the trail 60 meters northwest of Standley 11. Limestone of a different type strikes across the lower fork of the first long stream east of the Armour Trail. It is hard and contains scattered pebbles and fragments of calcareous algae, mollusks, and echinoid.

Nonmarine volcanic facies.—East of the Barro Colorado fault the marine facies is absent. In its place are nonmarine volcanic rocks and detrital rocks derived from a volcanic source: basaltic agglomerate; gritty, coarse-grained, poorly sorted, tuffaceous graywacke; and moderately coarse-grained, somewhat better sorted, tuffaceous graywacke. Agglomerate is exposed on the little stream heading at Barbour 12 (the third stream east of the laboratory clearing) and forms a small gorge downstream from locality 42*h* east of the Shannon Trail. Outcrops of basalt in this area of volcanic rocks evidently represent thin flows and small intrusive bodies.

It cannot be directly demonstrated that the volcanic and associated tuffaceous detrital rocks are the equivalent of some part of the marine facies of the Caimito formation. Nevertheless that interpretation is supported by the relations between the Caimito formation and the Las Cascadas agglomerate. There is no indication of interfingering of thin volcanic strata with marine rocks on the second stream east of the laboratory clearing. Likewise there is no indication of interfingering of thin marine strata with volcanic rocks on the next stream to the east. To be sure, interfingering may take place on the intervening ridge, but that is unlikely in view of the short distance between the streams: 350 meters. Therefore it is concluded that the two facies are separated by a fault, the Barro Colorado fault. The further conclusion is reached that the volcanic and associated detrital rocks are intermediate in the transition between the marine deposits of the Caimito formation and the wholly volcanic rocks of the Las Cascadas agglomerate and that the intermediate rocks, instead of being in their normal geographic position south-southwest of Barro Colorado, have been displaced northward along the fault.

Fossils and age.—Fossils are widespread and locally abundant in the marine facies. Very fine-grained silty sandstone at locality 54*n* yielded planktonic discoasters and other coccolithophores and a rich fauna of smaller Foraminifera, including a large number of planktonic species. A preliminary list of the coccolithophores is as follows.

Discoasters and other coccolithophores from Caimito formation at locality 54n

[Identifications by M. N. Bramlette. R, rare; F, few; C, common; A, abundant]

Discoaster deflandrei Bramlette and Riedel	C
Discoaster aff. *D. deflandrei* Bramlette and Riedel (some characters intermediate between those of *D. deflandrei* and *D. woodringi*)	C
Discoaster woodringi Bramlette and Riedel	C
Discoaster aff. *D. challengeri* Bramlette and Riedel	F
Discoaster perplexus Bramlette and Riedel	F
Thoracosphaera imperforata Kamptner	F
Sphenolithus abies Deflandre	F
Sphenolithus? sp.	C
Coccolithus cf. *C. pelagicus* (Wallich)	C
Coccolithus cf. *C. leptoporus* (Murray and Blackman)	R
Coccolithus sp.	C
Discolithus sp.	F
Helicosphaera aff. *H. carteri* Kamptner	C
Rhabdosphaera cf. *R. claviger* (Murray and Blackman)	R
Unidentified coccoliths, including many having diameter of 2 to 3 microns	A

The coccolithophores, as outlined by Bramlette and Riedel (1954, p. 386), are minute biflagellate protists found in vast numbers in the near-surface waters of the oceans. They have a calcareous skeleton. The discoasters are not known to be living and therefore their relations to typical coccolithophores are uncertain. Some of the species in the preceding list were described in the paper just cited.

The following is a preliminary list of smaller Foraminifera collected at locality 54*n*.

Smaller Foraminifera from Caimito formation at locality 54n

[Identifications by H. M. Bolli. R, rare; F, few; C, common; A, abundant]

Amphistegina sp.	R
Angulogerina byramensis (Cushman)	R
Angulogerina cooperensis Cushman	F
Anomalinoides trinitatensis (Nuttall)	F
Arenobulimina? sp.	R
Bermudezina cubensis (Palmer and Bermúdez)	R
Bolivina byramensis Cushman	F
Bolivina caudriae Cushman and Renz?	R
Bolivina cf. *B. cochei* Cushman and Adams	F
Bolivina sp.	F
Bulimina cf. *B. alazanensis* Cushman	R
Bulimina inflata alligata Cushman and Laiming	R
Bulimina (*Globobulimina*) *perversa* Cushman	R
Bulimina pupoides d'Orbigny?	R
Cassidulina bradyi (Norman)	R
Cassidulina laevigata d'Orbigny	F
Cassidulina subglobosa Brady	F
Cassigerinella chipolensis (Cushman and Ponton)	F
Catapsydrax cf. *C. dissimilis* (Cushman and Bermúdez)	R
Catapsydrax cf. *C. stainforthi* Bolli, Loeblich, and Tappan	R
Ceratobulimina alazanensis Cushman and Harris	R
Chilostomella sp.	R
Cibicides americanus Cushman	F
Cibicides aff. *C. compressus* Cushman and Renz	F
Cibicides sp.	F
Clavulina carinata Cushman and Renz	F
Ehrenbergina caribbea Galloway and Heminway	F
Elphidium sp.	F
Gaudryina flintii Cushman?	F
Globigerina bradyi Wiesner	F
Globigerina ciperoensis angustiumbilicata Bolli	A
Globigerina cf. *G. ciperoensis ciperoensis* Bolli	F
Globigerina cf. *G. trilocularis* d'Orbigny	C
Globigerina venezuelana Hedberg	F
Globigerinoides triloba immatura LeRoy	F
Globorotalia kugleri Bolli	F
Globorotalia mayeri Cushman and Ellison	C
Globorotalia obesa Bolli	F
Globorotalia opima nana Bolli	F
Globorotaloides suteri Bolli	F
Gümbelina cubensis Palmer	R
Gümbelina goodwini Cushman and Jarvis	R
Gümbelina paralleli Beckman	R
Gümbelina sp.	R
Gümbelina sp., group of *G. trinitatensis* Cushman and Renz	R
Guttulina jarvisi Cushman and Ozawa?	R
Guttulina sp.	R
Gyroidina cf. *G. parva* Cushman and Renz	F

Gyroidina sp. ....F
Gyroidinoides byramensis campester (Palmer and Bermúdez)........F
Höglundina elegans (d'Orbigny)?...F
Lagena sp. ....R
Lagena cf. *L. sulcata* (Walker and Jacob)..............................F
Lenticulina sp. ....R
Nodosaria longiscata d'Orbigny..F
Nodosaria obliqua (Linné)? ....R
Nodosaria spinicosta adelinensis Palmer and Bermúdez..............R
Nodosaria vertebralis (Batsch) ....R
Nonion incisum kernensis Kleinpell...R
Nonion pompilioides (Fichtel and Moll).....................................F
Planularia sp. ....R
Planularia venezuelana Herberg?..R
Planulina sp. ....R
Plectofrondicularia floridana Cushman ....R
Plectofrondicularia morreyae Cushman.......................................R
Pseudoglandulina comatula (Cushman) ....F
Pseudoglandulina laevigata (d'Orbigny) ....R
Pullenia bulloides (d'Orbigny)..R
Ramulina polita Bermúdez?...R
Reophax acosta Bermúdez...R
Robulus sp., group of *R. americanus* (Cushman)........................C
Robulus sp. ....R
Robulus sp., group of *R. subaculeatus glabratus* (Cushman).........F
Saracenaria senni Hedberg...R
Schenckiella pallida (Cushman)..R
Sigmoilina tenuis (Czjzek)...F
Siphogenerina aff. *S. multicostata* Cushman and Jarvis..............R
Siphogenerina transversa Cushman...C
Siphonina sp. C
Siphonodosaria verneuili (d'Orbigny)...F
Siphonodosaria nuttalli gracillima (Cushman and Jarvis)?..........F
Sphaeroidina variabilis Reuss ....F
Spiroloculina jarvisi Cushman and Todd?...................................R
Textularia cf. *T. excavata* Cushman ....F
Textularia cf. *T. vasicaensis* Bermúdez....................................F
Uvigerina auberiana attenuata Cushman and Renz.......................F
Uvigerina capayana Hedberg ....F
Uvigerina isidroensis Cushman and Renz ....R
Uvigerinella sparsicostata Cushman and Laiming........................R
Vaginulina aff. *V. alazanensis* Nuttall.......................................F
Valvulineria inaequalis (d'Orbigny?)..F
Virgulina sp. ....R
Vulvulina pachyheilus Hadley ....R

Smaller Foraminifera are fairly common in the Caimito formation of Madden basin, east of the Canal Zone, and in the Pacific coastal district east of Panamá City, but the fauna at locality 54*n* is by far the largest found anywhere. It is especially rich in planktonic species: the species of *Cassigerinella, Catapsydrax, Globigerina, Globigerinodes, Globorotalia,* and *Globorotaloides.* A collection from locality 53, including *Siphogenerina,* has not been identified.

Larger Foraminifera from the Caimito are listed below.

Larger Foraminifera from Caimito formation

[Identifications by W. S. Cole. R, rare; C, common; A, abundant]

	Localities				
	53	54*f*	54*h*	54*k*	54*l*
Operculinoides panamensis (Cushman)					A
Heterostegina antillea Cushman		R			
Heterostegina israelskyi Gravell and Hanna		A			R
Archaias compressus (d'Orbigny)			R		
Lepidocyclina (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé	A	R	C	A	C
Lepidocyclina (*Lepidocyclina*) *giraudi* R. Douvillé					R
Lepidocyclina (*Lepidocyclina*) *yurnagunensis morganopsis* Vaughan	R				
Lepidocyclina (*Nephrolepidina*) *vaughani* Cushman	R				
Miogypsina (*Miogypsina*) *antillea* (Cushman)	C	A			C
Miogypsina (*Miolepidocyclina*) *panamensis* (Cushman)		R			

Larger Foraminifera are the most widespread fossils in sandstone, siltstone, and limestone of the Caimito formation. In fact, with a little search the small orbitoid *Lepidocyclina canellei* can be found in most outcrops of those rock types. In weathered sandstone, however, the fossils are leached and rotten. Collections were made at 12 localities, but only 5 were selected for identification. Hand specimens of the soft marly limestone at localities 54*e* and 54*f* contain hundreds of *Heterostegina,* closely matted and lying flat parallel to the bedding. In the preceding list the occurrences for locality 53—on the north coast of the islet (Slothia Island) off the laboratory landing, where the fossils are found in sandy calcareous siltstone—are taken from Cole's 1952(1953) publication (p. 7), which includes illustrations of *Lepidocyclina canellei* from that locality. In his recent publication (1957) the species of *Heterostegina* and *Miogypsina* are described and illustrated.

The type material of *Lepidocyclina canellei* was collected by an engineer of the first French canal company on Río Chagres at Peña Blanca. As shown in figure 1, Peña Blanca was located 1.2 kilometers northwest of what now is Peña Blanca Point at the northwest end of Barro Colorado. It got its name from an outcrop of soft whitish rock, probably calcareous siltstone. Lemoine and R. Douvillé (1904, p. 20) named *Lepidocyclina canellei* for the original collector. It is one of the most widely distributed fossils of late Oligocene age in the entire Caribbean region.

The following mollusks were found in the Caimito formation.

Mollusks from Caimito formation

[Identifications by W. P. Woodring. R, rare; F, few; C, common; A, abundant]

	Localities						
	54*g*	54*h*	54*j*	54*k*	54*l*	54*m*	54*n*
Gastropods:							
Solariella? sp. (immature)					R		
Calyptraea? sp.						R	
Natica (*Natica?*) sp. (operculum)				R			
Polinices sp.		R	?R	?R			
Neverita? sp.						R	
Architectonica (*Architectonica*) sp.		R		R			
Semicassis (*Echinophoria*) sp.		R	R		R		
Ficus cf. *F. pilsbryi* (B. Smith)		R			R		
Ficid, n. genus	R						
Tritiaria? sp.	R	R	F				
Metula? sp.						R	
Vexillum sp.	R						
Ancilla sp.			R				
Cancellarid?, genus?				R			
Conus sp.		R					
Strioterebrum sp.		R		R			
Turricula (*Orthosurcula?*) sp.			R				
Turriculine turrid, genus?							R
Cochlespira sp.	R						
Bathytoma sp.			R				
Borsonia? (*Paraborsonia?*) sp.				R			
Scobinella sp.	?R	F		R		R	
Crassispira sp.	R						
Leptadrillia? sp.				R			
Clavine turrid, genus?							R
Atys sp.							R
Pyramidella sp.				R			R
Vaginella cf. *V. chipolana* Dall			F		R		
Cavolina sp.	R		R				
Scaphopods:							
Dentalium cf. *D. uscarianum* Olsson	R	C	F	A	R	F	R
Dentalium sp.		A		F			
Pelecypods:							
Nucula sp.		R					R
Acila cf. *A. isthmica* Brown and Pilsbry				F	F	R	R
Nuculana? sp.						R	
Saccella sp.		R		C	R	R	

Mollusks from Caimito formation—continued

	Localities						
Pelecypods—continued	54*g*	54*h*	54*j*	54*k*	54*l*	54*m*	54*n*
Orthoyoldia? sp.		R					
Dimya? sp.					R		
Ostreid, genus? (immature)							R
Venericardia? sp.		R					
Callucina? sp.	R	A	R	C	R	R	
Parvilucina sp.				R			
Lucinoma sp.		C		?F		R	
Microcardium sp.			?R	F			
Lirophora? sp. (immature)							R
Gemmine venerid, genus? (immature)					R		
Tellina sp. (of medium size)				R		R	
Tellina sp. (small)		R		R		R	
Tellina (*Phyllodina*) sp.		R					
Labiosa sp.					R		
Cuspidaria sp.						R	

The identifications in the preceding list are preliminary, except those for the first eight species. As may be seen from the list, all except a few of the species are rare, a notable exception being the large species of *Dentalium, D.* cf. *D. uscarianum.*

Locality 54*n* yielded the following ostracodes, most of which are poorly preserved.

Ostracodes from Caimito formation at locality 54n

[Identifications by I. G. Sohn. R, rare; F, few]

Cytherella 2 spp.	F
Bairdoppilata? sp.	R
Paracypris? sp.	R
Xestoleberis? sp.	R
Krithe sp.	F
Cytheridea sp.	R
Kangarina sp.	R
Cytherura or *Cytheropteron* 2 spp.	F
Brachycythere sp.	R
Hemicythere sp.	R
Trachyleberis 3 spp.	F
Loxoconcha? sp.	R
Genus?, aff. *Orthonotacythere*	R

The fossils from the Caimito formation indicate both shallow-water and moderate-depth environments. The algal-foraminiferal limestone on the north slope of the island and the pebbly limestone on the south slope containing fragments of calcareous algae, mollusks, and echinoid (fragments of *Aequipecten, Amusium,* and *Clypeaster*) point to shallow water. The other fossiliferous strata contain a faunal assemblage indicating depths of 100 to 200 meters. Though the occurrence of great numbers of planktonic coccolithophores and planktonic foraminifera in itself does not demonstrate deposition in moderately deep water, the absence of adult typically shallow-water fossils at locality 54*n* and elsewhere support the inference that much of the formation actually represents a moderately deep-water environment. The mollusks include a relatively large percentage of moderately deep-water turrid gastropods (*Turricula* and the eight genera following that genus) and pteropods (*Vaginella, Cavolina*), a planktonic group of gastropods. Heretofore only a shallow-water facies was known in the Caimito, at localities eastward and southward from Barro Colorado—that is, at localities farther landward in the Caimito sea.

The Caimito formation, like the exposed part of the Bohio formation on Barro Colorado, is of late Oligocene age. In a personal communication, M. N. Bramlette reports that the assemblage of coccolithophores suggests that found in the *Globigerinatella insueta* zone of Trinidad and other Caribbean localities. He adds that it does not suggest assemblages of later age, but may be the equivalent of that in the *Globigerina dissimilis* zone, which underlies the *Globigerinatella insueta* zone. (Though both zones formerly were considered of Oligocene age, they are now designated as Miocene.)

H. M. Bolli assigns the foraminiferal fauna at locality 54*n* to the recently defined *Globorotalia kugleri* zone of Trinidad (Bolli, 1957, p. 118). According to the recent downward shifting of the Oligocene-Miocene boundary adopted by the micropaleontological laboratory of the Trinidad Oil Co., Ltd. (so as to include in the lower Miocene the presumed Caribbean equivalents of the European Aquitanian stage), the *Globorotalia kugleri* zone is at the top of the Oligocene. The downward shifting of the Oligocene-Miocene boundary was suggested by H. G. Kugler (1954). It has the effect of bringing into agreement age assignments of Caribbean foraminiferal zones and molluscan zones. The age advocated for the molluscan zones agrees with age assignments adopted by the U. S. Geological Survey for southeastern United States.

The assemblage of larger Foraminifera is typical for upper Oligocene throughout the Caribbean region.

The molluscan fauna cannot be compared with other Caribbean faunas, not even with the fauna of the Caimito itself at other localities. So far only a few species have been recorded from formations in the Caribbean region that are of late Oligocene to early Miocene age and are of comparable depth facies: such as the Uscari shale of southeastern Costa Rica and the Las Perdices shale of Colombia. The mollusks of the Caimito, however, are intermediate between those of Eocene and Miocene age. When they are studied, they may be found to include species closely related to those in the Oligocene Vicksburg group of southeastern United States, which contains faunas of comparable depth facies. In southeastern United States *Scobinella* is an Eocene and Oligocene genus, but in the Caribbean region it survived until early Pliocene time. If the fossil from the Caimito listed as *Borsonia?* (*Paraborsonia?*) sp. is a species of *Paraborsonia,* it is the earliest species of what is otherwise a Miocene subgenus.

IGNEOUS ROCKS

BASALT

Basalt is hard black rock, generally showing in hand specimens crystals of feldspar and ferromagnesian minerals in a dense groundmass. It occurs as lava flows and intrusive bodies. In the form of somewhat angular or rounded boulderlike masses, covered with an oxidized rind, it is the rock most frequently seen along the trails on Barro Colorado, especially on and immediately below steep slopes leading to the upland surface. Not only are the angular and boulderlike masses strewn along the trails, but the heads of streams draining the upland surface, notably those in the swalelike valleys in the surface itself, are choked with them. Though the "boulders" are indistinguishable from real boulders, that term is reserved for the large, rounded, or imperfectly rounded, product of stream and wave erosion. With few exceptions, the "boulders" seen along the trails are the product of spheroidal weathering. They are formed by the breaking off of angular blocks along joints and the smoothing of the edges by spalling of the oxidized rind. They may be seen in place in the low cliff of weathered basalt at Colorado Point, at the end of the Barbour Trail. At a few places in the northwestern part of the island basalt boulders, weathered out of conglomerate of the Bohio formation, were found on trails as follows: On steep slopes on the Fairchild Trail, on the Gross Trail between Gross 8 and 9, on the Miller Trail at Miller 18 and farther northwest, and on the Pearson Trail between Pearson 10 and 11. These boulders, however, generally are smaller than the "boulders" resulting from spheroidal weathering. Areas of basalt cannot be exactly outlined by the occurrence of the boulderlike masses, for they creep far down slopes and are carried by floods far downstream.

The areal relations of the thick cap of basalt almost coinciding with the upland surface indicate that it is a flow with a maximum exposed thickness of about 85 meters. The outer edge of the flow in general is marked by a steep slope and concentrations of "boulders" resulting from spheroidal weathering. The foot of the steep slope at an altitude of 75 meters on the Snyder-Molino Trail 100 meters southwest of the old laboratory, for example, was mapped as the edge of the basalt. An outcrop of fairly fresh rock was seen in the thick cap along the stream on which locality *42e* is located, but nowhere else.

Basalt also occurs on the island as dikes and sill-like intrusive bodies. (Sills are parallel to the layering of intruded layered rock and dikes cut across the layering.) Two sill-like bodies were mapped on the north slope of the island. An outcrop of fresh basalt in the larger body may be seen at the crossing of the stream on the Nemesia Trail 60 meters west of Nemesia 2. Other outcrops are accessible on a stream 15 meters north of Barbour-Lathrop 7 and farther north on the same stream.

Dikes a few feet wide—too narrow and of too limited known extent to plot on plate 1—were observed in outcrop areas of the Bohio formation on both the north and south slopes of the island.

For the most part the basalt in the volcanic facies of the Caimito formation is greatly weathered and not identified with any assurance. Much of the weathered rock probably is basaltic agglomerate. Nevertheless both extrusive and intrusive basalt seem to be present. The fairly fresh basalt on the stream immediately below the crossing of the Chapman Trail at Chapman 9 and upstream on the east fork of the same stream is thought to represent thin flows. Jones (1950, p. 901) mentioned columnar basalt, presumably intrusive, on the south coast of the island.

The extrusive and intrusive basalt are indistinguishable in field examination. No microscopic study of these igneous rocks was undertaken. The following notes on similar rocks of the same age elsewhere in the Canal Zone are extracted from a manuscript by D. F. MacDonald that was found in the papers of W. H. Dall at the U. S. National Museum. The larger crystals and most of the groundmass of a basalt flow in the Gaillard Cut area consist of feldspar, mostly labradorite, and augite. The groundmass is distinctly crystalline, though very fine-grained. Magnetite, apatite, and ilmenite are accessory minerals. Epidote fills cracks in broken feldspar crystals and occurs in cloudy masses in the interior of feldspar crystals. Labradorite, andesine, and augite are the principal constitutents among the larger crystals in basalt forming dikes in the Gaillard Cut area. Some of these dike rocks also contain enstatite and a little biotite. The groundmass is made up of laths of plagioclase and grains of augite, but generally includes a little glassy material. Magnetite and ilmenite are the chief accessory minerals and a little chlorite and serpentine are present.

In the Gatun Lake area basalt is not known to be younger than the Caimito formation. In that area, however, no deposits of early Miocene age crop out. In the Gaillard Cut area basalt intrudes formations of Oligocene(?) and early Miocene age, and basalt flows are interbedded with the Oligocene(?) rocks and the dated Oligocene formations in the southeastern part of the Gatun Lake area. The basalt on Barro Colorado represents this Oligocene and early Miocene episode of volcanic and intrusive activity.

STRUCTURE

Structurally Barro Colorado west of the Barro Colorado fault is a shallow, irregularly warped syncline trending in an east-northeastward direction and plunging westward. East of the fault the structure is unknown, except in the northwestern segment where the strata dip southeastward. In the northwestern part of the island the Bohio formation evidently is arched in a gentle asymmetric anticline, the north limb being steeper than the south limb. The crest of the anticline was not satisfactorily located. Indeed, there is a remote possibility that the strata dipping in opposite directions are separated by an undetected fault. The 20° dips on the north coast of the island and on de Lesseps Island are taken from Jones's (1950, pl. 2) map. Except for that area, the strata generally dip more gently. Two other exceptions may be noted: the 35° northwestward dip on the stream on which locality *42e* is located and the 20° northward dip adjoining the minor western branch of the Barro Colorado fault. The 35° dip was measured in strata including readily deformed carbonaceous shale and is not of regional significance. The 20° dip is attributed to deformation resulting from movement along the fault.

The Barro Colorado fault and its minor branch are the only faults that were recognized. The fault is shown on Jones's (1950) map, but on that map and also on a more recent map (Woodring, 1955) the main fault north of the split into two branches was not shown. The fault is thought to extend northeastward and southwestward beyond the island, as indicated on the maps just cited. The relative vertical displacement is downward to the east a few tens of meters on the minor branch, and on Bohio Peninsula, north of Barro Colorado, the relative displacement on the main fault also is downward to the east. As outlined in the discussion of the volcanic facies of the Caimito formation (p. 21), there is fairly convincing evidence that the principal displacement on the main fault is horizontal, the east side being displaced northward relative to the west side. In M. L. Hill's (1947, pp. 1670-1671) useful classification, the Barro Colorado fault is a left lateral fault. (A left lateral fault is a wrench—Blatt of German geologists—or transcurrent fault, along which the side opposite an observer looking across the fault is relatively displaced to the left.) The displacement may be as much as 10 to 15 kilometers.

When I first briefly visited Barro Colorado in 1947, under the guidance of S. M. Jones, he pointed out two outcrops at locality 54, on the stream along the east side of the laboratory clearing. Conglomerate of the Bohio formation striking east-northeastward was exposed in the stream bed and fossiliferous calcareous sandstone of the Caimito formation on the east bank, striking more to the north. In view of the regional relations of the two formations in this area, it was concluded that the two outcrops were separated by a concealed fault, now designated the minor branch of the Barro Colorado fault. In 1954 no trace of either outcrop could be found. They evidently were covered by debris during floods in one or more of the intervening wet seasons. Downpours of 104 millimeters of rain in 1 hour and 266 in 24 hours have been measured on the island (Zetek, 1956, p. 132).

The Bohio and Caimito formations probably were deformed in early Miocene time before deposition of the middle Miocene Gatun formation. This matter is discussed in the forthcoming U. S. Geological Survey publication.

BARRO COLORADO'S CONTRIBUTION TO GEOLOGIC HISTORY OF PANAMÁ LAND BRIDGE

Though Barro Colorado is only a small segment of the Panamá land bridge and its rocks represent only a very small fraction of the geologic history of the bridge since the known history began in Cretaceous(?) time, it offers contributions to that history. Its chief contributions are in late Oligocene paleogeography and paleontology. Its sedimentary rocks and fossils amply confirm what had been known or inferred previously: that the Bohio sea and the Caimito sea advanced southeastward from the ancestral Caribbean Sea. The shallow-water marine fossils from the Bohio formation and the moderately deep-water fossils, including the planktonic species, from the Caimito formation are new additions to documents covering the geologic history of the bridge.

During the early part of late Oligocene time when the upper part of the Bohio formation was deposited, high-gradient streams flowing northward from a volcanic center west of the present Canal Zone deposited a great quantity of coarse basaltic debris on an alluvial plain, the seaward edge of which shifted northward and southward. Locality *42f*, south of Fuertes House, was close to the mouth of one of the streams. The fossils found there include snails that lived in the stream, other mollusks that lived in the brackish tidal inlet at the mouth, and still others that lived in the sea outside the inlet. Localities *42d* and *42h* were farther out in the sea but close to the shore. At that time there was no land bridge, for marine deposits are found in the upper part of the Bohio formation at the continental divide east of the Canal Zone.

Deposition of the coarse basaltic material ceased as a result of a change in the regimen of the streams, following mild deformation. When deposition was resumed at the beginning of Caimito time, the sea had advanced farther inland south of Barro Colorado and inundated an extensive area to the east and southeast. Volcanoes, located in the same general region as the earlier basaltic center, contributed rhyolitic ash to the sediments, which were of much finer grain than the earlier basaltic sediments. Though Barro Colorado then was the site of moderately deep-water deposition, shallow-water deposits accumulated here and there on mounds that reached upward to at least about 100 meters below the surface of the water, where calcareous algae could grow.

It may be worth while to attempt to date the island's upland surface in terms of what is known about the late Tertiary and Pleistocene history of the bridge, although the island itself has nothing to contribute to dating, other than the preservation of a remnant of a surface that evidently is not very old. During, or after, emergence and tilting of the early Pliocene Chagres sandstone, the land stood at least some 60 meters (perhaps as much as 90 meters) higher, with respect to sea level, than at present. This high stand took place during late Pliocene and Pleistocene time (early Pleistocene, according to subsequent history), for then the land bridge was completed and the great interchange of North American and South American land mammals was under way (Simpson, 1950, pp. 379-383). During the high stand an extensive area now covered by shallow water in the Bay of Panamá presumably was dry land and the bridge was at least twice as wide as it now is. The ancient Río Chagres and its tributaries cut deep, wide valleys, which were partly outlined by drilling operations during construction of the canal and later. These valleys then were filled with sediments, evidently in middle or late Pleistocene time, during a lower stand of the land with reference to sea level. At Gatun Dam, at an altitude of 6 meters above sea level, the sediments have a thickness of some 60 meters. According to Thompson's (1947, p. 22) description of these Pleistocene deposits, they consist of silty clay, plastic clay, and black organic muck. The black muck is the most characteristic, and at some localities the thickest, constituent. It includes lenses of matted, partly decomposed wood, leaves, and other plant remains. The muck is a swamp deposit, probably laid down in mangrove swamps. It should yield a rich harvest to anyone interested in pollen and spores.

In the valley of Río Chagres the muck extends inland to Gamboa and on the Pacific side, where the Pleistocene deposits are not known to have a thickness of more than 15 meters, to the upper end of Miraflores Locks. Marine fossils have been found as far inland as the lower end of Gatun Locks and the upper end of Miraflores Locks. In other words, during this episode of Pleistocene submergence the width of the isthmus was two-thirds of the present width and a wide tidal inlet extended 35 kilometers inland from the sea at the site of Gatun Locks.

The surface of low relief, represented by the upland surface on Barro Colorado, evidently was formed during the later part of this episode of submergence, at a time when the ancient Río Chagres was flowing in an alluviated valley some tens of meters above the present valley. R. T. Hill's (1898, p. 183) Baila Monos Plain, now submerged, may be part of the ancient valley.

If the channel cutting and channel filling took place at the same time in the Caribbean and Pacific parts of the bridge, the relations between land and sea are not solely the result of eustatic changes of sea level resulting from glaciation and deglaciation in high latitudes, for the channels on the Caribbean side are four times as deep as those on the Pacific side. The latest relative movement, an emergence of a few meters, affects both coasts and may be due entirely to a eustatic lowering of sea level.

The wood and other plant material in the Pleistocene muck is not suitable for radiocarbon dating, even if it were young enough. A very high moisture content is a characteristic feature of the muck (Thompson, 1947, p. 22).

FOSSIL LOCALITIES

Report No.	Permanent USGS No.	Field No.	Description
			Bohio formation
42*d*	18837	207	Northern part of island, stream heading west of Miller Trail near Miller 17, about 100 meters above mouth. Somewhat calcareous, medium-grained subgraywacke. W. P. Woodring, 1954.
42*e*	18835	205	Northern part of island, stream southeast of Fuertes House, about 275 meters above mouth. Conglomerate. W. P. Woodring, 1954.
42*f*	18836	206	Same stream as that for locality 42*e*, but about 60 meters upstream and from slide on west side of stream. Poorly sorted subgraywacke. W. P. Woodring, 1954.
42*g*	18832	203	Northern part of island, stream crossing Pearson Trail at Pearson 6, about 365 meters above mouth. Poorly sorted subgraywacke. W. P. Woodring, 1954.
42*h*		215	Eastern part of island, stream east of Shannon Trail, about 365 meters above mouth. Somewhat calcareous, coarse-grained gritty subgraywacke. W. P. Woodring, 1954.
42*i*	18845	215*a*	Same stream as that for locality 42*h*, but 30 meters downstream. Soft muddy subgraywacke. W. P. Woodring, 1954. Not plotted on plate 1.
			Caimito formation
53		53	North coast of low islet (Slothia Island) 400 meters northeast of laboratory landing. Soft sandy calcareous siltstone. S. M. Jones and W. P. Woodring, 1947.
54		46	Stream on east side of laboratory clearing, 150 meters above mouth at landing. Calcareous tuffaceous sandstone. W. P. Woodring, 1947.
54*a*			Northeastern part of island, second stream east of laboratory clearing, 150 meters above mouth. Soft sandstone. W. P. Woodring, 1954.
54*d*		202	Northwestern part of island, stream heading north of Zetek Trail at Zetek 9, about 550 meters north-northwest of Zetek 9. Calcareous tuffaceous sandstone. W. P. Woodring, 1954.

FOSSIL LOCALITIES—continued

Report No.	Permanent USGS No.	Field No.	Description
			Caimito Formation
54*e*		202*a*	Same stream as that for locality 54*d*, but about 200 meters downstream. Soft marly limestone. W. P. Woodring, 1954.
54*f*		201	Northwestern part of island, stream crossing Standley Trail 60 meters northwest of Standley 11, about 30 meters downstream from trail. Soft marly limestone. W. P. Woodring, 1954.
54*g*	18840	210	Western part of island, first stream north of Zetek House, about 300 meters above mouth. Soft medium-grained sandstone. W. P. Woodring, 1954.
54*h*	18841	210*a*	Same stream as that for locality 54*g*, but at mouth. Soft sandstone containing calcareous lumps. W. P. Woodring, 1954.
54*i*		211	Western part of island, mouth of small stream 450 meters south-southeast of Zetek House. Soft sandstone. W. P. Woodring, 1954.
54*j*	18833	204	Southwestern part of island, stream crossing Conrad Trail at Conrad 2, about 365 meters upstream from mouth. Soft sandstone. W. P. Woodring, 1954.
54*k*	18834	204*a*	Same stream as that for locality 54*j*, but about 60 meters upstream from mouth. Soft sandstone. W. P. Woodring, 1954.
54*l*	18842	212	Southwestern part of island, second stream northwest of end of Armour Trail, 60 meters above mouth. Gritty sandstone and somewhat calcareous sandstone. W. P. Woodring, 1954.
54*m*	18843	213	Southwestern part of island, small stream 400 meters northeast of end of Armour Trail, 15 meters above mouth. Medium-grained sandstone containing somewhat calcareous lumps. W. P. Woodring, 1954.
54*n*	18844	213*a*	Same stream as that for locality 54*m*, but 100 meters above mouth. Very fine-grained silty sandstone. W. P. Woodring, 1954.

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I am indebted to the following paleontologists for identification of fossils: coccolithophores, M. N. Bramlette, of the Scripps Institution of Oceanography (University of California) and the U. S. Geological Survey; smaller Foraminifera of the Caimito formation, H. M. Bolli, of the Trinidad Oil Company, Ltd.; larger Foraminifera, W. S. Cole, of Cornell University and the U. S. Geological Survey; corals, J. W. Wells, of Cornell University and the U. S. Geological Survey; decapod crustaceans, H. B. Roberts, of the U. S. National Museum; smaller Foraminifera of the Bohio formation, Ruth Todd, of the U. S. Geological Survey; ostracodes, I. G. Sohn, of the U. S. Geological Survey. I also am indebted to A. A. Olsson, Research Fellow of the Academy of Natural Sciences of Philadelphia, for advice concerning the mollusks, and to my colleagues W. H. Bradley and W. T. Pecora for reading the manuscript and offering suggestions for improvement.

SUMMARY

Barro Colorado, the largest and highest island in Gatun Lake, has a maximum diameter of $5\frac{1}{2}$ kilometers, an area of 15 square kilometers, and reaches an altitude of 164 meters above sea level, or 138 meters above the normal level of Gatun Lake. With the exception of the laboratory clearing of $2\frac{1}{2}$ hectares and insignificant clearings elsewhere, the entire island is forested.

The high central part of the island is a remnant of a surface of low relief—the upland surface—formed in middle or late Pleistocene time when the streams were graded to a base level several tens of meters higher, with respect to present sea level, than Río Chagres before flooding of Gatun Lake.

Two fossiliferous sedimentary rock formations, the Bohio and the Caimito, crop out on Barro Colorado and the outcropping strata of both are of late Oligocene age. Neither the base of the older formation (Bohio) nor the top of the younger crops out. The outcropping thickness of the Bohio is estimated to be 125 meters, that of the Caimito 100 meters. Two mapped units of different facies in both formations are recognized: a prevailing nonmarine facies and a minor marine facies in the Bohio, an extensive marine facies and a more restricted nonmarine volcanic facies in the Caimito.

Small dikes and sill-like bodies of basalt intrude the Bohio formation and the volcanic facies of the Caimito formation, and in nearby areas rocks of the marine facies of the Caimito also are intruded by basalt—the last intrusive episode in the Gatun Lake area. The thick cap of basalt on the upland surface evidently is a flow. Thinner basalt flows and basaltic pyroclastic rocks are found in the volcanic facies of the Caimito formation.

Structurally the island west of the Barro Colorado fault is a shallow, irregularly warped syncline trending in an east-northeastward direction and plunging westward. The Barro Colorado fault and a minor branch of that fault trend northeastward. The facies distribution of the Caimito formation indicates that the principal displacement on the main fault is horizontal, the east side being displaced northward relative to the west side; that is, the evidence is fairly conclusive that the main fault is a left lateral fault. The displacement may be as much as 10 to 15 kilometers.

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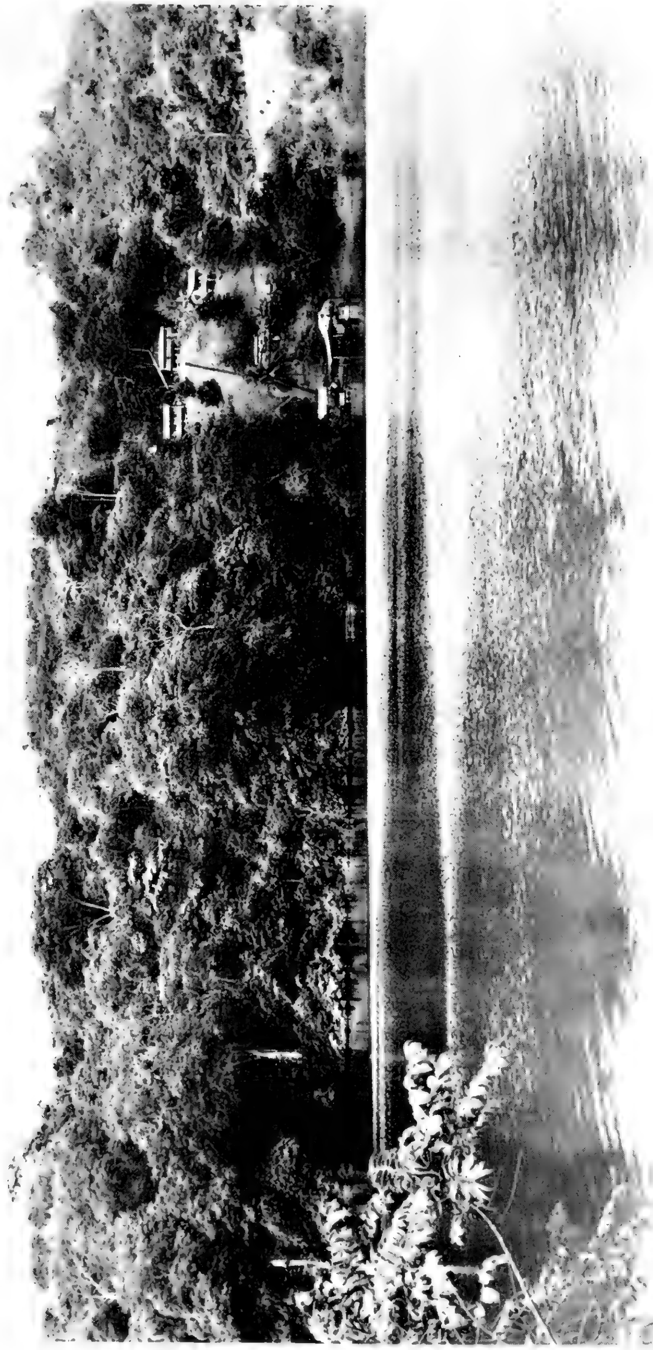

Laboratory clearing and surrounding forest, Barro Colorado Island.

Boulder conglomerate of Bohio formation at Salud Point, Barro Colorado Island. Photograph by Geological Section, Special Engineering Division, Panama Canal Company.

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A NEW THEORY ON COLUMBUS'S VOYAGE THROUGH THE BAHAMAS

(WITH FIVE PLATES)

BY
EDWIN A. LINK AND MARION C. LINK

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FOREWORD

The discovery of the New World was one of those turning points that shape the course of history. Since the birth of Christ there had not been an occurrence so potentially important to the history of western civilization. Of all the events of that epoch-making voyage, none equals that moment when white breakers off the island of Guanahaní were sighted in the light of an early morning moon.

Columbus remained at Guanahaní only a very short time and then in a flush of excitement pushed on to other islands. He never returned to the point of his first landfall, his energies being devoted to new and more alluring lands to the south.

During the period of the first Spanish settlements in the West Indies, the Bahamas lay off the beaten path and they returned to obscurity to be visited only by slave raiders and pirates. The question of the site of the first landfall seems to have received little attention until early in the nineteenth century. Since that time several widely divergent theories have been advanced on the landfall site and Columbus's first days in the New World. The principal source from which historians have drawn in propounding their theories is the transcription from Columbus's Journal appearing in Bartolome de las Casas. Bartolome is supposed to have made his transcription from the Journal that Columbus had sent to the Court at Barcelona after his return to Spain.

It is highly unlikely that Columbus would send the original of the Journal prepared on shipboard but would most probably send a "smooth" copy. Thus the Journal as it appears in the surviving Las Casas manuscript must be at least third-hand. Two other factors add to the confusion. The appearance of the Bahamas has changed considerably since the first landfall. The large trees that grew on the islands in the time of Columbus have disappeared almost without exception, and many of the islands now present a much lower silhouette from a distance. The loss of the trees has led to extreme erosion of the soil, and islands once fertile are now comparatively barren and rocky.

Also, it should be remembered that Columbus approached these islands as a man full of wonder. He and his crews believed they were in the fabled East Indies known to Europe only through obscure writings and rumor; and Columbus was sailing into the unknown. When we sail into the Bahamas today, we can visualize the entire archipelago on the strength of accurate modern charts. It is impossible for a modern man to approach these islands with the same attitude with which Columbus approached them. Thus a psychological barrier is added to those of inaccurate documentary sources and completely altered terrain.

For these reasons the site of Columbus's landfall will probably never be known with certainty. (The possibility of discovering additional Columbus material in Spain is very slim indeed.) At best we can attempt to formulate a theory that contains fewer contradictions with the Journal than others and that is based on the limits of possibility imposed by distance and known sailing capabilities of Columbus's ships. The paper presented here attempts to do just that. The authors, Edwin A. and Marion Link, are well fitted for such a task.

Edwin A. Link is the inventor of the world-famed Link Trainer. He has pioneered improvements in air navigation technique that are now accepted practice on all the world's airways. This same interest in the subject of navigation is demonstrated in his life-long experience in offshore sailing.

Mr. Link became interested some years ago in tracing some of the early history of the New World through the newly expanding medium of marine archeology. Since that time he has developed equipment and processes for underwater search and recovery that have yielded invaluable additions to our knowledge of life at sea some centuries ago. In this connection he first became interested in Columbus's discovery of the New World, the controversy over the place of his first landfall, and the final resting place of the flagship *Santa María,* which foundered on a reef somewhere in the vicinity of the harbor at Cap Haïtien, Haiti. A carefully planned expedition to this area in the spring of 1955 resulted in the recovery of an anchor which there is good reason to believe came from this long lost and famous ship. Following this effort, when climatic conditions made it no longer possible to work on this site, Mr. Link turned his attention to tracing the route of Columbus on his first voyage through the Bahamas.

Marion Link's experience as a journalist and writer and her intense interest in history are demonstrated in the development of the paper presented here.

In publishing this monograph the Smithsonian Institution of course takes no sides in the major problems considered, but wishes only to assist in making available to scholars the Links' interesting thesis concerning a highly important event in American history.

Mendel L. Peterson
Head Curator of Armed Forces History
U. S. National Museum
Smithsonian Institution

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A NEW THEORY ON COLUMBUS'S VOYAGE THROUGH THE BAHAMAS

By Edwin A. Link and Marion C. Link

(With Five Plates)

INTRODUCTION

It is our belief that Christopher Columbus made his first landing in the New World on the shores of the Caicos Islands and not on Watling as is generally accepted today. We have also reached the conclusion that Columbus's little fleet followed a course through the Bahamas differing from any previously put forth by other investigators of his first landfall and route.

These convictions are the result of a most careful search of available charts, both past and present, and a thorough study of original source material and the studies and opinions of later-day historians. This was followed by a personal reconnaissance of the possible courses that Columbus might have sailed through the Bahamas, covering the whole area first by airplane and then by small boat.

It was our intention at the start of our search to compare especially two suggested courses—one commencing at Watling Island, the presently acknowledged San Salvador(1),[1] and continuing on to Rum Cay, Long Island, Crooked Island, and past the Ragged Islands to Cuba as advanced by several scholars including the well-known historian, Dr. Samuel Eliot Morison(2); the other proposed by Capt. P. Verhoog, Dutch Columbophile and retired officer of the Holland-America Line(3), beginning with a landfall at Caicos and leading from there to Mayaguana, to Acklin, to Great Inagua, and thence toward the Ragged Islands and Cuba.

Dr. Morison, who has made probably the most complete investigation into the Columbian voyages since the landfall, records his beliefs as to the probable First Landing and the track followed thereafter in his magnificent two-volume book "Admiral of the Ocean Sea" published in 1942. Dr. Morison actually sailed what he believed to be the Great Explorer's course from Watling Island through the Bahamas to Cuba(4).

[1] Numbers in parentheses refer to Notes on pages 26-30.

Captain Verhoog, whose lifetime hobby has also been concerned with Columbus, bases his conclusions on a thorough study of the subject from the original sources, augmented by experience gained from frequent sailings through the Bahamas as captain of large steamers en route to and from the Caribbean and South America. He summarizes his conclusion that Caicos was Columbus's San Salvador in a carefully considered treatise entitled "Guanahaní Again," published in Amsterdam in 1947. Both men, besides being thorough scholars, are also practical seamen and navigators.

In our own reading we had never felt that the area around Watling Island answered Columbus's description of San Salvador. But when we first read Verhoog's "Guanahaní Again" we were immediately struck with the reasonableness of his arguments for selecting Caicos as the site of the First Landing. We had long ago eliminated all other theories, including those of Navarrete, Markham, Washington Irving, G. V. Fox, and Capt. A. B. Becher of the Royal Navy(5), because of palpable fallacies in their deductions. Only the conclusions of Dr. Morison, which are similar to those advanced by Lt. J. B. Murdock of the U. S. Navy in 1884(6), and of Captain Verhoog as to these suggested courses seemed reasonable.

And as we examined these latter possibilities, we resolved to make an attempt to verify or refute the conflicting claims of Morison and Verhoog by tracing both routes by boat and by airplane after first making a thorough study of each.

Our first step was to apply each passage in the Admiral's account of his first voyage to both Morison's and Verhoog's theories. We then took a modern chart of the Bahamas and traced out the two tracks, measuring off distances and directions as their sponsors pictured them (chart 1, opp. p. 32). Both had many good points and both contained many discrepancies. This is certainly understandable when one considers the inaccuracies and outright errors that must be included in Columbus's account because of the loss of the original Journal, as well as in inaccurate copies of the text that have come down through the centuries. Available copies today have not come from the original Journal but from Las Casas's "Historia de la Indias"(7), in which he abridged most of the original log, repeating in detail only those entries from October 12 to 24.

It was a common practice in those days of hand-written copies to assemble a group of copiers, each making his own copy at the dictation of a reader. Thus errors could easily creep into the text depending on the accuracy and sharpness of hearing of the writers(8). Las

Casas's rendering of Columbus's Journal from the explorer's not too legible handwriting could in itself have been responsible for many errors.

As to charts, there are none in existence today of Columbus's original voyage through the Bahamas(9). And after the discovery, the Spaniards were so busy colonizing the areas to the south that many years elapsed before any thought was given to the original landfall. For centuries the Bahama Islands were very sketchily and inaccurately charted, and the designated place of landing varied with each mapmaker. To add to the confusion, the names given to these islands were seldom twice the same.

After centuries of study by numerous investigators, researchers today have come to realize that their best chance of establishing the details of Columbus's landfall and course is by resorting to the original Journal and applying the information derived from it to the most accurate of present-day charts(10). But even here there are problems, for these charts too, some of them dating back more than a century, contain many errors. There seemed to be only one way to overcome these difficulties, and that was actually to sail the most likely courses, thereby affording an opportunity to check Columbus's descriptions of the places he visited with the existing topography of those same islands today.

It was during our study of the Journal that we were struck with a passage concerning Columbus's approach to the second island. Researchers in the past have all concluded that Columbus visited and named four islands on his voyage through the Bahamas, namely, San Salvador, Santa María de Concepción, Fernandina, and Isabella. We read and reread various translations of the Journal for Sunday, October 14, and Monday, October 15, which indicated that Columbus had sailed for a second island after visiting San Salvador, but "as from this island I saw another, larger, to the west, I clewed sails up to navigate all that day until night, and still was not able to reach the westerly point; this island I named Santa María de Concepción."

As we studied the charts while attempting to apply this passage, we saw that by using Caicos as the first island it would have been possible for Columbus to sail past the north shore of Mayaguana and on toward Samana, which could have been his Santa María de Concepción, where he could have anchored at the western end for the night. From there he could have gone on to Long Island, which could have been his Fernandina. From here on, the course seemed naturally to follow that laid out by Morison to Crooked Island and thence to the Ragged Islands.

The more we studied this route, the greater its possibilities seemed. There is no need here to go into the reasons by which Morison and Verhoog reached their contradictory conclusions. Our concern was to compare their two theories and then to investigate the possibilities in this new idea which had evolved.

Capt. P. V. H. Weems, USN Retired, a world authority on navigation(11), and Mendel L. Peterson, Lt. Comdr. U. S. Navy Reserve and curator of armed forces history, U. S. National Museum, Smithsonian Institution, accompanied us on *Sea Diver* (pl. 1, fig. 1), our 65-foot diesel trawler, to check and compare the three possible tracks. Captain Weems had first introduced us to the Verhoog theory and was an ardent champion of its feasibility. Mr. Peterson, who was well grounded in the history of that period, supplied a fund of information and a completely open mind to the problem.

We visited Turks Island, Caicos, Watling, Great Inagua, Crooked, and Long Islands and sailed the courses between these islands and any others where Columbus might have gone. We studied every sentence in that particular section of the Journal, attempting to apply them to the situation as suggested by each of the three theories.

But first we flew(12) over these islands several times to obtain a clearer picture of their layout and the possible courses from one to the other. Our view of them from the air was a revelation, for in the wide expanse revealed below us, we could visualize topography and relative distances as in no other way.

Ours was the first expedition to visit the Bahamas in search of the Columbus track with the intention of investigating not one but three possible solutions. Most students of the subject had reached their conclusions only from a study of books and charts without ever having had the opportunity to visit the places in question. Morison had sailed only the course he had previously determined was the correct one, while Verhoog had viewed only the main channels of the islands from the deck of a fast ocean liner. We were fortunate to be able to appraise each possible course first-hand on the scene.

Because we found many differences in various translations from the Spanish into English, we early realized the necessity of enlisting the aid of a competent Spanish language scholar to interpret the original text for us. This we found in Dr. Armando Álvarez Pedroso(13) of Havana, Cuba, author of "Cristóbal Colón, Biografía del Descubridor," a man well versed in old Spanish and necessarily a thorough student of Columbus.

To test our theory of the existence of an unnamed island that Columbus passed by after leaving San Salvador, we asked Dr.

Pedroso upon our first meeting to read the original Spanish text for October 14 and 15 and to make a simple chart of his interpretation of it. He verified our conclusions completely. Later, in order to confirm his own interpretation, Dr. Pedroso queried Dr. Ramón Menéndez Pidal, president of the Royal Academy of Spanish language in Madrid, who replied that he could find no fault with it. Since then we have asked many others to interpret this section of the Journal, with the same result. Almost invariably they conclude that Columbus passed an island that he did not name before anchoring for the night off the shore of one he called Santa María de Concepción.

Without taking undue liberties with the text of the Journal we were able to conclude that it was entirely feasible for Columbus to have landed at Caicos and to have sailed from Mayaguana to Samana to Long Island to Crooked. It was impossible to follow either Dr. Morison's or Captain Verhoog's proposed courses without finding startling and many times unexplainable discrepancies.

To substantiate our conclusions we shall attempt to set down the questions we faced, to compare the sites we visited and their relative agreement with the descriptions in Columbus's Journal, and to point out the errors in each theory.

COLUMBUS'S LANDFALL

But first let us follow the *Santa María,* the *Niña,* and the *Pinta* as they approach the shores of the New World. Let us try to visualize this Caicos Archipelago as the setting for the First Landfall.

It is the night of October 11, 1492, and Columbus's little fleet is boiling along toward the west with sails full set. For several days there have been evidences of land, including a variety of birds, broken branches, even a carved stick; and the sailors are eagerly watching for their first glimpse of the Indies for which they are searching. They are particularly keen because Columbus has offered an award of 10,000 maravedís(14) annually from his sovereigns to him who first sights land.

Columbus too is on the alert, and at 10 o'clock he calls Pero Gutiérrez to verify the sight of a light he has descried on the horizon. Soon after, a sailor on the forecastle calls out that he sees a light(15). They increase the vigilance of their watch, and at 2 o'clock Rodríguez de Triana catches the first glimpse of the white banks and beaches of Guanahaní glowing in the moonlight(16).

Nearly 500 years later from aboard *Sea Diver,* 7 miles north of the northernmost point of Turks Island, our party found that we could see the top of its high bluff and the lighthouse that surmounts it. We realized that Columbus, standing on the poop deck of the *Santa María* 14 feet above the water on that historic night, could easily have seen the flicker of an Indian campfire on this point as it appeared and disappeared behind the rolling seas(17). Or if the light "like a small wax candle raised and lifted up" were a torch carried in the canoe of some Indian fisherman a few miles offshore, according to the dip tables it would still have been visible to Columbus 5 miles away(18).

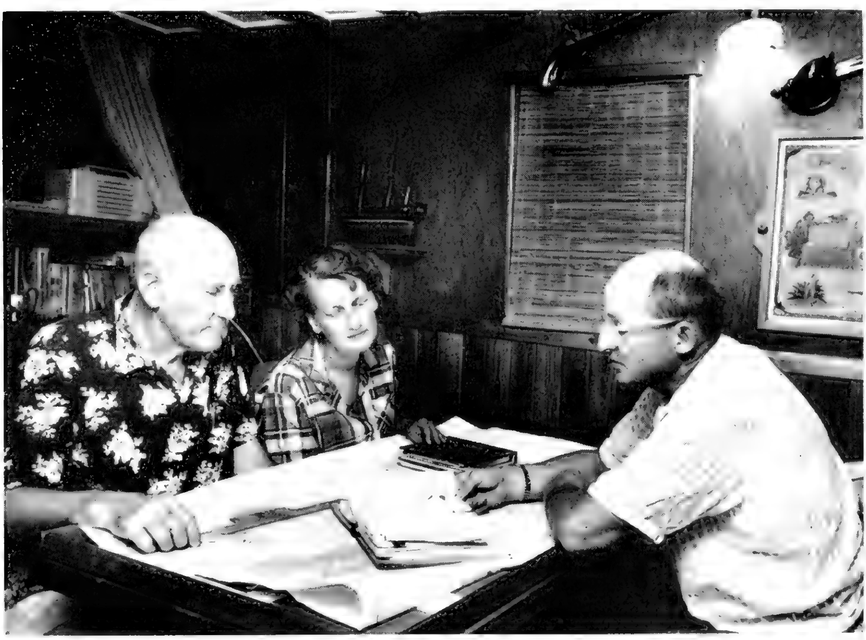
In either case, the glimpse of a light in the enveloping darkness argued convincingly the presence of land nearby. And although Rodríguez de Triana is named in the Journal as being the first actually to sight land, Columbus used the presence of this light to justify his claim for the reward of the 10,000 maravedís annually for himself. This he would never have done unless he was convinced that the light they saw was real and therefore necessarily on land or near land.

Sea Diver approached Caicos to the west on approximately the same course Columbus could have followed, with the lighthouse on Turks Island bearing 170°, its beach just visible 7 miles away. At noon *Sea Diver's* log records sighting directly ahead a spot known as Grassy Creek with a white sand beach. We were 2 miles offshore, and the water depth was 60 feet. Perhaps it was near here that Columbus dropped his anchor at daylight and launched the ship's boats to go ashore. Although Columbus makes no mention of anchoring, there is little doubt that he did so, as the three ships remained in this location for nearly three days, and in order to launch the long boats, which were carried over the main hatch, it was necessary to drop the sails so that the main yardarm could be used to swing them over the side.

Columbus's description of Guanahaní(19) easily fits Caicos, which is "very large and very flat; with very green trees, and much water. In the center of it, there is a very large lagoon; there are no mountains, and all is so green that it is a pleasure to gaze upon it." According to Las Casas the island was bean-shaped(20), about 15 leagues in length(21). It was also known as Triango(22), or Triángulo, thus attributing to it a 3-sided formation.

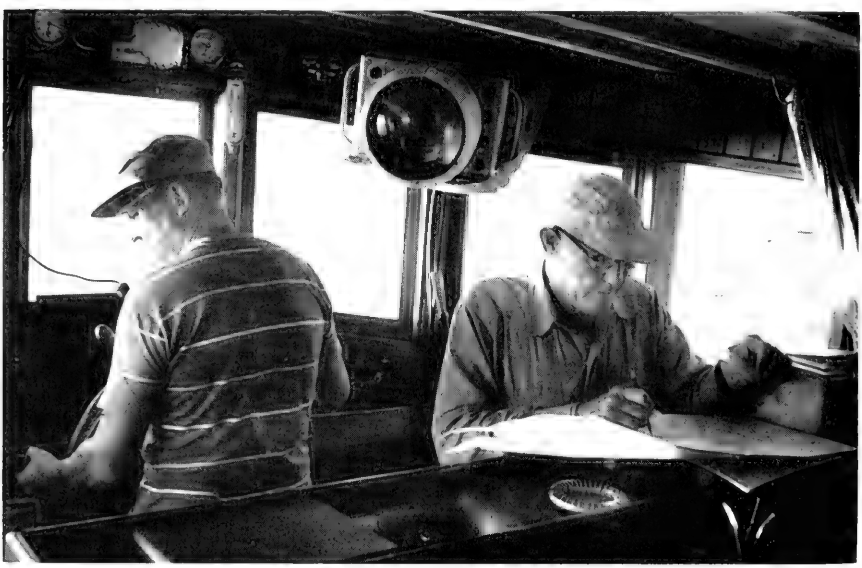
We attempted to take *Sea Diver* into Grassy Creek harbor to anchor, with the intention of launching a small boat and cruising around the north point of the island as Columbus might have done. However, when we were only partly inside we encountered so many coral heads we decided to turn back. We could have gone in easily in a smaller boat. Farther in we could see that the water was calm and would make an excellent small-boat harbor close to shore, where

1. *Sea Diver*, 65-foot diesel trawler owned by E. A. Link, which was used in surveying the possible courses Columbus may have sailed through the Bahamas, anchored off a low Bahamian cay close beside a native fishing sloop.



2. In *Sea Diver's* deck cabin, Capt. P. V. H. Weems and Mr. and Mrs. Link study charts and notes concerning the proposed expedition. (Photograph by Peter Stackpole, courtesy Life magazine.)

1. Dr. Armando Álvarez Pedroso examines bones from a lead casket with a plate bearing the name of the Great Discoverer, which has been in the keeping of the cathedral of Santa Domingo since 1542. Dr. Pedroso was signally honored, as this ceremony is reserved by the Dominican Government for its most distinguished guests. (Photograph by S. Ferreira Quartel.)



2. Ed Link at the wheel of *Sea Diver* while Captain Weems plots course from north of Turks Island to Caicos where the expedition believes Columbus made his first landfall. (Photograph by Peter Stackpole, courtesy Life magazine.)

there was an ideal location for an Indian village on the banks of the creek. In fact, we subsequently found the ruins of a later settlement there. It seemed very possible that it was along this shore that "they saw naked people, and the Admiral went ashore in the armed boat" and planted the royal standard to claim this territory for Spain.

Columbus spent the remainder of that day, October 12, and the next in becoming acquainted with the people, exploring the nearby land, and attempting to converse with the natives in sign language to aid in determining the geography of the islands that surrounded him. He inquired where gold could be found and was told that "going to the south or rounding the island to the south, there was a king who had great vessels of it, and very many."

On Saturday night he recorded in his Journal, "I resolved to wait until the following afternoon, and, after, to leave for the southwest, for, as many of them indicated to me, there was land to the south and to the southwest and to the northwest, and that those of the northwest used to come to attack them very often."

At dawn on Sunday he ordered the ship's longboat and the boats of the caravels to be made ready and "went along the island in a north-northeasterly direction, in order to see the other part, which lay to the east, to see what was there, and also to see the villages." As they progressed along the shore there was a constant pageant of Indians with gifts lining the shore and making gestures for them to land. Columbus wrote that he "feared to do so, seeing a great ridge of rocks which encircled the whole of that island, and in the middle there is deep water and a harbor large enough for all the ships of Christendom, the entrance to which is very narrow. It is true that inside this belt there are some shoals, but the sea is no more disturbed than the water in a well."

He also noted where a fort could be built, "a piece of land, which is formed like an island although it is not one, on which there were six houses; it could be cut in order to form an island, in two days." Near the said piece of land, he said, was the loveliest grove of trees and much water. "I examined the whole of the harbor, and afterward returned to the ship and set sail. I saw so many islands, that I could not decide to which I would go first."

SEA DIVER TRACES COLUMBUS'S ROUTE

With *Sea Diver* once more in deep water and clear of the scattered coral heads off Grassy Creek, we headed north-northeast as Columbus had recorded to follow the coastline toward Cape Comete, which jutted into the sea ahead of us. To the south a barrier reef followed the outline of the shore. The whole long, low coast was dotted with white beaches and occasional ledges. The high trees which must have graced this island in Columbus's time were now replaced by a low scrub and an occasional second-growth pine. There were several likely sites for Indian villages along the way with an occasional inlet where small boats could take shelter. Two miles below Cape Comete we found a sand beach protected by a continuation of the reef, then more rocks continuing to the point. Perhaps it was here that Columbus first went ashore.

A continuous reef made out around Cape Comete, then curved west and northwest following the direction of the shore. It was between this reef and the scalloped, curving sandy shore that we found the beginning of a reef harbor "large enough for all the ships of Christendom, the entrance to which is very narrow." For the reef continued in a solid line as far northwest as the eye could see, enclosing a sea "no more disturbed than the water in a well." In the distance we could see many islands fading into the horizon and were particularly aware of what appeared to be an unusually large island to the west beyond the irregular, low rounded hills and white beaches. Once around Cape Comete, *Sea Diver* was in much quieter water, even outside the reef, for we were now sheltered from the prevailing southeast wind.

Here Columbus could easily have seen, as he records in his Journal, "so many islands that I could not decide to which I would go first." (See pl. 4, fig. 1.) The Indians he had taken aboard "made signs to me that there were very many, so many that they could not be counted, and they mentioned by their name more than a hundred."

It is easy to see why, with these glimpses of land to the west, Columbus would enthusiastically return to his fleet and get it underway in that direction. There is nothing that says he headed southwest. Instead the Journal records, "For that reason I sought for the largest and resolved to steer for it, which I am doing. It will be 5 leagues away from this island of San Salvador; the others, some are farther away and some are less."

Sea Diver sailed past two headlands, either of which might have served as the "land formed like an island although it is not one" of Columbus's description. We had previously flown over these and observed that they were high, with narrow necks connecting them with the shore. They jutted out into the ocean, while visible behind each of them was a fair-sized lake which certainly in those early days must have been surrounded by "the loveliest grove of trees." One was

Cape Comete; the other, at the entrance to Lorimer Creek, guarded a narrow channel between the reefs leading into the tremendous reef harbor, which could indeed have held all the ships in Christendom at that time (pl. 3, fig. 1). Today this harbor has silted up from erosion due to the removal of trees and vegetation upon the bordering land. The Going-Through Creek, which used to be 20 feet deep, is now only 4 feet(23); but not so long ago when sisal was raised on these lands, this harbor was used by many seagoing ships. We later took *Sea Diver* into Jacksonville at the end of the harbor where we found the remains of a dock and a railroad formerly used to transport sisal.

We went ashore on Cape Comete with the small boat after anchoring *Sea Diver* outside the reef. Quick brown iguanas scurried out of our way across the hot stones of the point. Stone tables were lined up along the ridge where today's fishermen spread conchmeat to dry for preservation. It was easy to visualize the six thatched houses of the Arawaks which Columbus had seen. Just past the narrow neck of the point on the mainland was the glimmer of a lake. We examined the possibilities of separating this bit of land from the island proper. It would take more than two days work, but it could be done. We did not go ashore on the second point at Lorimer Creek, for we already knew from the air photos we had taken (pl. 3, fig. 1) that this also would easily fit the description of an islandlike piece of land which could easily be separated from the mainland and which was near trees and water.

We sailed the courses to and from Turks Island and up and down this eastern shore many times, as our headquarters for *Sea Diver* over a period of weeks was at Cockburn Harbour, South Caicos. During that time Captain Weems (pl. 3, fig. 2) spent two days in a small native sailing boat with two Bahamians exploring the shoreline of Caicos and its inner harbors. At many places where he went ashore he saw stumps of huge trees, testimony to the size of those from which the Indians once fashioned their dugout canoes. He was told that near Jacksonville there were to be seen Indian carvings in shallow caves. He reported many scattered lakes and the ruins of old plantation buildings. He saw wild horses and pigs. He was convinced that this reef harbor at Lorimer Creek was that which Columbus had admired. And he was impressed at the illusion of "many islands" fashioned from the continuation of the Caicos group visible to the northwest.

Columbus must have gotten his small fleet underway early in the afternoon of that Sunday to reach the end of North Caicos by dark. He lay to that night fearing to come to land to anchor before daylight because of possible coral heads in the water between him and shore. By daylight he found himself within sight of Mayaguana, the next island "and as the island was more than 5 leagues distant, or maybe 7, and the tide delayed me, it was about midday when I arrived at said island, finding that the coast which lies toward the island of San Salvador runs north-south and has 5 leagues, and that the other, which I followed, runs east-west and has more than 10 leagues."

It is impossible to see Mayaguana Island from Caicos. We also found it impossible to see from one island to another anywhere on these suggested courses of Columbus, although Columbus frequently notes seeing the island ahead. Granting that several centuries ago the air may have been clearer, and that the additional height due to the tall trees on these islands at that time would make it possible to pick up the land at greater distances, it is doubtful if Columbus even then could have seen even the shortest stretch under consideration(24). Instead, it is more likely that he used the verb loosely to mean that he understood (perhaps from the captive Indians aboard) that such an island was there and that he picked up his next landfall each time after leaving the previous island in the distance.

It must be borne in mind that Columbus had no means of measuring distance from one island to the next or of figuring the length of a coastline except the practiced judgment of a lifetime at sea and then much would depend on the height of the land which he could not know. Hence his estimate of 10 leagues for the north shore of Mayaguana which the fleet followed was fairly close, while that of 5 leagues for the shore facing San Salvador was much too high, for he only glimpsed from a distance the shoreline leading away to the south.

Even though Columbus were correct in setting down a guess as to the number of miles or leagues from one point to another, or the length of a shoreline, we still would not know the answer in terms of today's nautical miles, for there is no agreement as to the length of a Columbus mile or league. Whenever Verhoog converts Columbus leagues into miles he multiplies by 4, that is, 1 Columbus league is equal to 4 nautical miles. On the other hand, Morison figures 4 Roman miles of 4,850 feet to 1 Columbus league. Thus his Columbus league would be 3.185 nautical miles. But Morison complicates this by declaring that Columbus used both a shore league and a sea league and that his shore league was only 1.5 nautical miles(25).

We preferred to chart the possible courses, then plot the exact distances from one point to the next in nautical miles (charts 1 and 2). By applying the elapsed time given by Columbus between these points, it was then possible to ascertain whether that particular

1. The harbor at Jacksonville, Grand Caicos, guarded by a peninsula near Lorimer Creek entrance and protected by a solid barrier reef on the seaward side. (See Journal, Sunday, October 14.)

2. Captain Weems examines remains of an old fort on the peninsula near Lorimer Creek, Grand Caicos, where Columbus may have contemplated erecting a fortification. (See Journal, Sunday, October 14.)

1. View of Grand Caicos Island with Lorimer Creek in the background, demonstrating why Columbus could have been deluded into the idea of seeing many islands. (See Journal, Sunday, October 14.)

2. There is little fresh water to be found in the Bahama Islands today, and even in Columbus's time it was probably difficult to locate. Here, some of *Sea Diver's* crew collect fresh water for her tanks from a lagoon near Fort George, Caicos. Left to right: Edward Kemp, Vital Jetty, and Captain Weems. (See Journal, Wednesday, October 17.)

section of the course was feasible. His estimates of distance may have been subject to error, but we felt it was safe to rely upon the elapsed time he stated. Thus we knew that between dawn and noon it would have been possible for the three ships to sail the 30 miles between the southern end of Long Island and the northern tip of Crooked Island, as Morison claims, while it would have been impossible for the same ships in the same time to sail the course from the southern tip of Acklin Island to the northernmost point of Great Inagua 87 miles away at an average speed of 12 knots, as Verhoog suggests.

There is no record of the sailing speed of the *Santa María.* We are told only that it was slower than the two caravels. However, we do know that a broad and clumsy craft with a deep, round belly such as the *Santa María*'s could not be pushed through the water with much speed. We also know that a square rigger did not have the capacity for speed of the present-day rigs. Yet today 8 knots is a good speed for any of the trim sailing craft that cruise Bahamian waters. With all sails set and the best conditions of wind and sea, they scarcely ever exceed 12 knots. It is inconceivable that the ships of Columbus's time could have reached these speeds. We believe that 8 knots is about as fast as the *Santa María* would ever have traveled. On the other hand, with apparently normal winds, Morison has Columbus averaging under 2 knots on his suggested course from Watling Island to the western end of Rum Cay. With light winds he averages $2\frac{1}{2}$ knots from Rum Cay to Long Island; yet in rain and failing winds, he would have covered approximately 70 miles from the northern to the southern tip of Long Island at an average speed of 6 knots. How can one account for these variations?

In applying our theory, as can be seen from table 1, at no time would Columbus have to exceed the possible speeds in order to cover the point-to-point distances in the declared space of time. With the brisk east or southeast wind normal in these areas he could easily have covered the distance from San Salvador to Santa María, at no time averaging more than 7 knots; and later when he was badgered with rain and failing winds he still could have made the $2\frac{1}{2}$ to 5 knots required.

So, wherever possible, we compared the exact mileage between points with whatever estimates of distance Columbus had given, using approximately 3 nautical miles to a Columbus league. But we knew that errors in dead reckoning could be made even by the Great Navigator; for, while sometimes the distance quoted was for a course actually sailed, at other times it was merely a careful guess made after gazing at a faraway horizon or a coastline disappearing into the distance. He had no instruments to aid him.

When he estimated first 5 and later 7 leagues from San Salvador to the next island, the 5 was a guess ahead, the 7 after he had sailed the course. But it took him so much longer than he had expected that he stated he believed a tide had held him back. We found no currents anywhere we sailed in the Bahamas, in deep, open water, strong enough to affect seriously either time or distance(26). Furthermore,

TABLE 1.—*Columbus's First Voyage to the New World: Average Sailing Speeds Through the Bahama Islands (Link Theory)*

Track covered	*Distance* (nautical miles)	*Hours* (approx.)	*Average speed* (approx. knots)
October 14:			
Left Caicos—early afternoon.			
Off Northwest Caicos—by dark...........	40	6	7
October 15:			
To east of Mayaguana—dawn............	40	10	4
Off northwest Mayaguana—noon..........	35	7	5
Off southwest Samana—sunset...........	50	7	7
	165	30	5.5
October 16:			
Left Samana—10 a.m. or noon.			
Arrived Long Island—in night............	60	12	5
Arrived Long Island—at dawn............	60	18	3
October 17:			
Left north of Clarencetown harbor—before dark.			
Arrived south end of Long Island—in early morning	30	12	2½
October 19:			
Left Long Island—dawn.			
Arrived Crooked Island—before noon......	30	6	5

Columbus had absolutely no means of judging current when he was away from shore.

The amount of magnetic variation that influenced Columbus's compass in the fifteenth century is today a subject of much speculation and the cause of great differences of opinion. Morison notes that Columbus's routes seldom crossed a region where the compass variation was more than 6° or half a point, and that a good part of the time while in the West Indies he was in the zone of no variation(27). Verhoog's opinion, on the other hand, swings from a variation of 20°, more or less, either easterly or westerly, to a later decision that it must have been more than a point, probably about 15°, easterly, more or less(28).

As in the Watling theory, we did not find it necessary to apply any variation in order to work out the route from Caicos we believe Columbus followed, whereas Verhoog was forced to apply corrections for magnetic variation in order to make certain sections of the Journal fit his suggested course. How else explain his variance with the compass headings which Columbus gave between Fernandina and Isabella, and again when he left Isabella for Cuba by way of the Columbus banks, south of the Islas de Arena?

We quote the next passage because of its importance in substantiating our theory that Columbus passed by Mayaguana Island without stopping and without naming it, and that the second island, which he named Santa María de Concepción and on which he landed, was Samana, or Atwood Island as it is known today, some 50 miles beyond.

> And as from this island I saw another, and larger, to the west, I clewed sails up(29) to navigate all that day until night, and still was not able to reach the westerly point; this island I named "Santa María de Concepción" and, about sunset, I anchored near the said point to see if there was gold there . . .

Columbus had every reason to sail past the reef-guarded north coast of Mayaguana, for there is no way through the reefs for its entire length. Also if he continued to hold the same course that he probably steered along the northeast shore of Caicos, it would have carried him past Mayaguana to a position within sight of Samana. In studying the chart, one may question why he would choose an island apparently as small as Samana when he might equally well have headed for Acklin, as Verhoog suggests. We had previously noted in our study of the charts that Acklin, while much larger in area than Samana, was low and flat on its northern part, while Samana had hundred-foot elevations. We later checked this from the air, approaching on the course we felt Columbus may have taken, at a low altitude over the water. We were able to discern Samana long before Acklin came in sight.

We later proved this on *Sea Diver* by setting a similar course from off the north shore of Mayaguana. When our radarscope showed we had reached a spot which was 12 miles from Acklin and 13 from Samana, it was possible to see Samana from the masthead, but Acklin was still invisible. Eight miles from Samana the whole shoreline could be seen from the deck by eye. It covered at least 45° of the horizon and, with the tops of its hundred-foot hills, looked like a large island.

Columbus then goes on to say, "It was nevertheless my will not to pass any island without taking possession of it, although having taken one, it could be . . . said of all. And I anchored and was there until today, Tuesday, when at dawn I went ashore in the armed boats and landed." This could be interpreted as an explanation for not stopping at these other islands along the way, as, having taken possession of one, he had taken possession of all, particularly as this statement follows the one in which he said he sailed until night in an attempt to reach the westerly point.

Whether Columbus anchored at the northwest point of Mayaguana as Verhoog believes, or the southwest point of Samana where he spent the night and part of the next day exploring the island, is answered by his noting that "as the wind blew more strongly across from the southeast, I didn't want to detain myself, and went back to the ship." A sudden wind from the southeast would not have disturbed a ship in the shelter of the northwest part of Mayaguana Island but would have made the anchorage at Samana a risky spot (30). Consequently, "After that I set sail to go to the *other* large island which I was seeing to the west," Columbus records.

Although at this point, instead of sailing on to Long Island, which we believe was Columbus's Fernandina, we set *Sea Diver*'s course toward Acklin Island to check the possibilities of Verhoog's theory that *it* was Fernandina, let us for the sake of continuity follow Columbus to Long Island. We will return later to indicate why we do not believe Acklin could have been Columbus's Fernandina.

The three Spanish ships left the island of Santa María about 10 a.m. (or noon) (31) and headed for Fernandina, which Columbus estimated was about 9 leagues to the west. As the wind was blowing from the southeast but veering south, they were able to hold a steady course toward the distant island which Columbus guessed to have a coastline of some 20 leagues running generally northwest and southeast. Because of light winds, Columbus was unable to reach the island "in time to be able to see the bottom in order to anchor in a clear place," and so he stood off and on until morning when he saw a village and anchored.

If we accept Columbus's statement in the Journal that Fernandina was 8 or 9 leagues to the west of Santa María, how then can we explain a route that shows Columbus sailing nearly 20 leagues to reach Long Island from present-day Samana? There is the remote possibility of an error in translation or interpretation over the centuries, but this is unlikely. As we have pointed out, however, there was a generous time allowance for him to have covered this 60 miles from 10 a.m. or noon of one day to sometime in the darkness of early morning of the next. Similar discrepancies exist in both Morison's and Verhoog's theories.

Indian canoes bringing gifts and food struck out from a village on Fernandina during the night and swarmed around the three ships. After sending men ashore for water, Columbus set out at noon to sail north-northwest in order to round the island. He said it was his wish "to follow the coast of this island *where I was, to the southeast,* because it all trended north-northwest and south-southeast, and I wanted to take the said route to the south and southeast" where "lies the island which they call Samoet, where the gold is." But the wind was blowing from the southwest and south, and their Indian counselors told them that they could reach Samoet more quickly by rounding Fernandina to the north.

"And when I was about 2 leagues from the cape of the island," Columbus wrote, "I found a very wonderful harbor with a mouth, or rather it may be said with two mouths, since there is an islet in the middle, and both mouths are very narrow, and inside it is more than wide enough for a hundred ships, if it be deep and clear and there be depth at the entrance."

Columbus thought it well to examine this harbor closely and to take soundings and so anchored outside and went into it with all the ships' boats only to find that it was shallow. Thinking that it was the mouth of a river, they carried water casks to be filled, but when they arrived they found no river. So while his men accompanied the people of a nearby village in a search for water, Columbus waited on the shore for two hours walking among the trees and enjoying the "loveliest sight that I have yet seen."

Columbus's description of the harbor corresponds almost perfectly to Clarencetown just a few miles north of the rocky cape that stands out prominently halfway down the lower section of Long Island. As we first viewed it from the air, the harbor at Clarencetown appeared large, protected by a point of land and an island and a line of reefs under water with apparently two channels leading into it. Later when we visited it with *Sea Diver* we found that only one channel was navigable. Within, there was only a limited section that would have been deep enough for the ships of that day. The surrounding territory must have been beautiful at that time with fertile soil and tall trees, for even today the little village there is a lovely spot.

From there Columbus navigated to the northwest until he "had discovered all that part of the island as far as the coast which runs east and west. . ." About then the wind fell and began to blow from the west-northwest, and they were forced to turn back. They "navigated all this night in an east-southeasterly direction, sometimes due east and sometimes southeast; this was done in order to keep clear from land, because there were very thick clouds and the weather was very bad. There was little wind and this prevented me from going to land to anchor."

The next morning, after a night when it rained very heavily from after midnight until near daybreak, found them at the end of the island to the southeast where they anchored until the weather cleared. They then continued the circuit of the island when they could do so "and anchored when it was no time to sail."

At dawn the morning of the 19th they set out to seek Samoet, the island that was to yield the gold they were seeking. Columbus sent *Pinta* to the east-southeast, *Niña* to the south-southeast, and he guided *Santa María* to the southeast. They were to follow these courses until midday, then change courses and rejoin *Santa María* if they had not sighted the island, but they had only been underway 3 hours when they saw an island to the east, "and all the three vessels reached it before midday at its northern point, where there is an islet and a ridge of rocks on its outside, to the north, and another between it and the main island."

Far away on the western coast they could see a distant cape toward which they headed. It was "indeed lovely, round and very deep, with no shoals off it. At first the shore is stony and low, and farther on there is a sandy beach. . . . the coast forms a big neck of land (32), and is very thickly wooded with very large trees." Back of it there was one elevation which could not be called a mountain but which beautified the rest of the island, and there was much water in the center of the island. Columbus anchored that night off this cape, which he named Cape Hermoso, noting, "I believe that it is on an island separated from that of Samoet and there is another small island in between."

We on *Sea Diver* found Columbus's description of Isabella fitted Crooked Island almost perfectly when we visited there, anchoring overnight south of Bird Rock, which was probably Columbus's Isleo. From the air we had previously noted a long L-shaped lagoon just inshore from the point opposite Bird Rock (pl. 5, fig. 1) (this does not appear on the present-day charts) and a large lake a few miles inland. The 200-foot hill near the center of the island and the wide curving sweep of beach from the point south-southwest to a conspicuous cape in the distance, even the break that separated Crooked from Fortune Island with a tiny island in the middle, all met Columbus's description. When we went ashore we found fertile ground and stumps of tremendous trees; the smell of flowering shrubs and flowers was heavy in the air.

The next morning Columbus weighed anchor from Cape Hermoso and "anchored off the southwest point of this island of Samoet which point I named 'Cape de la Laguna' and which island I named 'Isabella'." He hoped to steer northeast and east from the southeast and south, for he understood from the Indians aboard that there he would find the village and its king. But he "found the bottom so shallow everywhere that I could not enter or navigate to that point." And seeing that it would be a very great detour to follow the route to the southwest and around the southern end of the island, he determined to return by the way he had come from the north-northeast to the west.

Thus he must have anchored at the break between Crooked and Fortune Islands, hoping to find a way across the bight within. Then realizing that this was impossible, he reasoned that it would be closer to sail back toward the present Bird Rock, his Isleo, and then along the northern coast to seek the Indian village in the eastern part than to go to the southwest and so around the long part of the archipelago.

After anchoring at Cape del Isleo the next morning they went ashore and found a village from which the inhabitants had fled and "very extensive lagoons, and on them and all around them there are wonderful woods." He was deeply impressed by the beauty of the island and remarked about the powerful perfume of flowers. They took water for the ships in a lagoon near the cape and lingered here for four days. Columbus was forced to change his plan to round the island to the north for "the wind must blow from different directions and it does not blow just as men may wish." There was no wind, only a dead calm, and it rained heavily during this time. Also his observations on the natives who finally appeared convinced him that there was little gold there.

On Wednesday, October 24, is recorded the last entry in Columbus's own words: "This night, at midnight, I weighed anchor from the island of Isabella, from Cape del Isleo, which is on the north side, where I was anchored, to go to the island of Cuba." He navigated to the west-southwest.

It would have been impossible for him to sail in this direction if Cape Hermoso actually lay west of Cape del Isleo as recorded October 19(33). This must necessarily be an error in the Journal's text, for he could not have sailed south-southwest against a coastline running east and west without running aground. Furthermore, when Columbus approached the north point of Isabella from Fernandina, east-west, he would have sighted Cape Hermoso long before sighting and reaching Cape del Isleo.

The fleet was afflicted with more rain and a failing wind as they set out for Cuba. They were with little wind until after midday "when it began to blow very lovingly"(34), and they set all sails to catch whatever wind there was. At nightfall Columbus recorded that Cape Verde on the southwest part of Fernandina lay to his northwest about 7 leagues distant. About then the wind commenced to blow so hard that he shortened sail, apprehensive of making such speed in the stormy night. At dawn he figured they had only gone 2 leagues the whole night.

They continued to the west-southwest until 9 that night making 5 leagues, then changed course to the west. The next afternoon they sighted land, a string of "seven or eight islands in a row, all lying from north to south." These were undoubtedly the Ragged Islands, for the fleet finally anchored in shallow water south of them. "It was everywhere shallow water for 5 or 6 leagues" is a perfect description of the Columbus banks south of the Ragged Islands. The captive Indians told them it was a day and a half journey by canoe from these islands to Cuba. Sure enough, after sailing to the south-southwest all day, "before night they saw land."

As *Sea Diver's* owner was already familiar with the vicinity of the Ragged Islands and the Columbus banks, having previously visited them on *Sea Diver* in search of the wreck of an ancient Spanish treasure ship, we did not retrace this leg of the voyage. He verified that the topography corresponded in every way with Columbus's description and his approach from Crooked Island. He concurred completely with Morison and the others who had previously selected Crooked Island and the Ragged Islands as Columbus's route to Cuba. But after our investigation of Caicos and the route leading from there, we were more eager than ever to compare this possible course with the one commencing at Watling Island. This was next on our plan of search.

We anchored *Sea Diver* off the small settlement of Cockburntown on the west coast of Watling Island within sight of a marker commemorating Columbus's first landing(35). A tall monument also has been erected on a high bluff on the east shore(36), a spot very difficult of access either by land or sea, as it would require portaging a boat from lake to lake to reach it by land, and the sea on the eastern shore is so rough and the scattered coral heads so dangerous that it would be foolhardy to try to reach it by boat.

Previously we had flown over this island, noting that it was nearly

1. Present-day Bird Rock with its lighthouse can be seen off the northwest point of Crooked Island, which was probably Columbus's island of Samoet. The conspicuous lagoon in the foreground does not appear on present-day charts of this island. (See Journal, Sunday, October 21, and Monday, October 22.)

2. Coral-encrusted anchor believed to have come from the *Santa María*, Columbus's flagship, found by the Link expedition in the harbor of Cape Haitien, Hispaniola, in the spring of 1955, is accepted for his country by Prefect Guillaume Sam, Governor of northern Haiti. To his left are the Honorable Roy T. Davis, American Ambassador to Haiti, Mr. and Mrs. Link, and Captain Weems. (Photograph by Peter Stackpole, courtesy Life magazine.)

half lakes and that the rocky headlands and sandy beaches of its eastern shore were almost inaccessible owing to the broken coral heads offshore. Only one part of the island appeared approachable for a boat of any size—that small section along the western coast where we anchored *Sea Diver.*

On our first day at Watling we completely circumnavigated the island with *Sea Diver,* first heading north along the west coast and then skirting the coral reefs that form the reef harbor on the north shore. As we headed south, *Sea Diver* rolled heavily in the big seas which stormed the rocky eastern shore and broke upon the scattered coral heads. There was no solid reef anywhere on the east side of the island. Nowhere was there a sign of a protected landing or a calm bit of water for anchoring.

Even Dr. Morison conceded that Columbus must necessarily have landed on the west coast of Watling, although Columbus makes no mention of such a fact. To the contrary his Journal reads: "They reached a small island of the Lucayos" and "Immediately they saw naked people, and the Admiral went ashore in the armed boat." As Watling is some 13 miles long by 7 miles wide, it would have taken several additional hours to reach the landing spot that Morison picks on the western shore (37).

On the second day we anchored *Sea Diver* off Green Cay on the northwest side of the island and headed our small boat across the reef harbor toward the rocky point on the eastern shore which Morison believes may have been Columbus's "piece of land formed like an island although it is not one." We had scarcely left *Sea Diver* when we regretted our rashness, for we found ourselves heading into a choppy sea which threatened to drown our outboard, and we did not dare turn back for fear of being swamped. When we reached the point we found salt spray dashing high above the cliffs on the seaward side. In order to negotiate the return to *Sea Diver* with a following sea it was necessary for two of the party to go to Cockburntown by land. Was this the harbor "no more disturbed than the water in a well"?

WATLING ISLAND NOT COLUMBUS'S SAN SALVADOR

After this investigation of Watling Island and its environs, following a survey of Rum Cay and the northern tip of Long Island, we concluded that Watling could not have been Columbus's San Salvador for the following reasons:

1. There is little possibility that Columbus could have seen a light

4 hours before sighting San Salvador if he were approaching Watling Island, for there are no islands to the east of Watling in any direction, and no fisherman would venture 30 miles out to sea in an open canoe at night with strong winds and heavy seas, even though he were able to maintain a light for the necessary period of time. However, in approaching Caicos it would be simple to glimpse a light on or near Turks Island 4 hours previous to the landfall. Columbus certainly could not have been mistaken when he claimed to see a light, for several others on board also saw it; and he would never have claimed the 10,000 maravedís from his sovereigns without the light as proof that land also was necessarily there.

2. The eastern coast of Watling is virtually unapproachable, with heavy seas breaking over thickly scattered coral heads along the rocky shore. There is no mention in the Journal of Columbus's having gone to the western side of the island to land.

3. Watling Island does not fit the description of San Salvador as well as Caicos. True, it does have a large lake in the middle, but it is not "very large and very flat" as compared with Caicos. It is 13 miles long, about a third the length of Caicos, while Las Casas describes San Salvador as 20 leagues long; and while Watling might be described as bean-shaped, it is certainly not triangular, as Las Casas implies.

4. Columbus describes "a great ridge of rocks that encircled the whole of that island." The only line of barrier reefs on Watling are on the north side where they form a large harbor. Elsewhere there are only scattered coral heads.

5. If Columbus landed on the west shore of Watling and went in the ships' boats in a north-northeast direction to explore, this would have brought him to the reef harbor on the north side, which he described as "no more disturbed than the water in a well." We found it so rough even in a moderate prevailing wind that we were forced to put two of our party ashore before we dared return across it. Also the commanding officer at a nearby U. S. Naval base(38) told us that his men were forbidden the greater part of the time to go out on it in small boats because of its rough condition. On the contrary, we had found the reef harbor on the northeast side of Caicos to be sheltered from the prevailing wind.

6. We visited a rocky island point on the east side of the harbor fordable from the mainland at low tide which might have been Columbus's "piece of land which is formed like an island although it is not one," but unlike Caicos this point had no body of water near it on the shore, and because of the heavy salt spray from the ocean it is

doubtful if "the loveliest grove of trees that I have ever seen" would have flourished near it. There are none today.

7. There is no justification for the statement "I saw so many islands that I could not decide to which I would go first." Watling is too small to give the impression of many islands within itself, and no other islands are visible in any direction. Even with the added height of the virgin forests of that day, it is doubtful if Columbus could have sighted Rum Cay, the nearest island, whereas the Caicos archipelago is made up of many islands.

8. Rum Cay is too small to answer Columbus's description of the second island: "The coast which lies toward the island of San Salvador runs north-south and has 5 leagues, and that the other, which I followed, runs east-west and has more than 10 leagues." Rum Cay is 6 to 12 miles. Rum Cay is southwest of Watling and does not "lie toward" it, as does Mayaguana to Caicos.

9. Although it does not appear on the charts, we found Columbus's "maravilloso puerto," according to Morison, a few miles north of Burnt Ground on the northern part of Long Island, a shallow indentation separated from the sea by two narrow mouths and a rocky islet between them. It had no depth whatsoever, and neither entrance was deep enough to permit access by the ships' boats. It was far too small to hold a hundred ships. We hold with Lieutenant Murdock (who otherwise selected the same route for Columbus as Morison) that Clarencetown harbor farther down the eastern shore answered the description more aptly (39).

10. The coast does not run east and west at the northern tip of Long Island, but after rounding the point it immediately falls off to the southwest. Thus it would be impossible for Columbus to have "discovered all the part of the island as far as the coast which runs east-westerly."

11. Furthermore, with rain and failing winds, it is doubtful if Columbus could have covered the distance from the northwesternmost point of Long Island to the southern end from dusk of one night to dawn the next day, a distance of approximately 70 miles.

From here on we have no differences with the accepted theory that Columbus went on to Crooked Island and from there to the Ragged Islands, the Columbus banks, and Cuba.

COLUMBUS'S ROUTE TO CUBA NOT BY WAY OF MAYAGUANA, ACKLIN, AND GRAND INAGUA

It now only remains to show why, even though the first landfall was on Caicos, Columbus's fleet did not sail to Cuba by way of

Mayaguana, Acklin, and Great Inagua as Verhoog believes. Instead, we are convinced they passed by Mayaguana to Samana, and then to Long Island, where their route joined the one proposed by Morison and other like-minded researchers. These are our reasons:

1. The eastern coast of Acklin Island is almost completely guarded by a barrier reef more than a mile offshore. Columbus states that "all the coast is free from rocks, except that there are some stones near the land under water." Because it would be next to impossible to go to a village on the shore through the reefs, Verhoog causes him to sail northward along the coast until he reaches an anchorage spot near the northeast point. It should be noted that there is no barrier reef along the shore of Long Island.

2. Acklin Island runs generally northeast-southwest, while Columbus describes Fernandina in several passages as running northwest-southeast, and later describes sailing it to the southeast to reach the southern point.

3. On a course from Mayaguana to the point where Verhoog indicates that Columbus made contact with Acklin, the fleet would have passed very close to French Cays, two large, flat land masses which at that time may have had trees and appeared more prominent than today. There is no mention of them.

4. Either from the chart or glimpsing it from the air, one might possibly visualize the break between Crooked and Acklin Islands as the "maravilloso puerto" that Columbus described 2 leagues from the cape. However, when *Sea Diver* sailed this course we found that the barrier reef kept us more than a mile from shore, making it impossible to see any details of this spot which Columbus described so vividly. We could not even make out an opening in the shore line. "At a distance of two lombard shots from land(40), the water off all these islands is so deep that it cannot be sounded," according to Columbus.

5. When the wind shifted and Columbus "navigated all this night in an east-southeasterly direction, sometimes due east and sometimes southeast," he would not have found himself the next morning as he describes "at the end of the island to the southeast," for Acklin Island swings sharply to the southwest. The distance of approximately 80 miles is also too great to have been covered overnight, for Columbus states there was little wind.

Columbus's fleet weighed anchor from the southern end of Fernandina at dawn on Friday, October 19, to reach the island he later called Isabella. Thus Verhoog would have him sail from the southern tip of Acklin to Great Inagua. Before Columbus had sailed for 3 hours he reported seeing an island to the east toward which they started. They reached it "before midday, at its northern point, where there is an islet and a ridge of rocks on its outside, to the north, and another between it and the main island. . . . There was a north wind, and the said islet lay on the course of the island of Fernandina, from which I had departed east-west" and extended for 12 leagues to a cape he named Cape Hermoso.

At 4:30 in the morning on April 5, 1955, *Sea Diver's* bearing was 65° on Castle light just off the southwest point of Acklin. She was on a course of 120° heading for Great Inagua island. At her cruising speed of 8 knots we calculated it would take us 11 hours to cover the 87 nautical miles between us and the northeast point of Great Inagua.

Our lookout from the masthead did not sight land until 3:12 that afternoon. Already it was three hours past the time Columbus recorded having arrived at his destination. At 4 p.m. we could distinguish Little Inagua off the port bow with the higher hills of Great Inagua many miles ahead on the starboard bow. At 5:30, almost dusk, we finally reached Northeast Cape on Great Inagua. Columbus, supposedly having arrived there at noon with his clumsy sailing vessels, would already have sailed the additional 44 miles to Cape Hermoso (Northwest Point) where he reported anchoring for the night.

Little Inagua with its 5 miles of beaches on the west, and 7 on the south, lay 5 miles to the north of us. It was certainly no "isleo"(41), for it was almost the size of Rum Cay. We wondered how Columbus's ships would have had time to investigate the reefs that he reported lying north and south of it and still have had time to reach Cape Hermoso before dark. Also we found that Northeast Cape (Verhoog's Cape del Isleo) would have provided no good anchorage, for on the seaward side it was bordered with reefs and beset by heavy seas, while on the inward side there was very deep water right up to the shoreline. The southern shore of Little Inagua was completely exposed to the heavy seas of the open ocean. There was no place for Columbus's ships to have spent the four days preceding their departure for Cuba.

As a result of this journey and a later one to the western shore, we found these additional discrepancies in Captain Verhoog's theory:

6. Columbus said he navigated east-west to reach the northern point of Isabella, off which was an islet. We found it necessary to sail a course of 120° to reach Northeast Cape on Great Inagua from Acklin Island.

7. Columbus's fleet sighted the island 3 hours after leaving Fernandina and sailed the entire distance from dawn until noon. We on *Sea Diver* did not sight land for 9 hours after leaving Acklin, and it

was a total of 11 hours before we reached the cape, traveling at a speed of 8 knots.

8. There are reefs along the greater part of the northern shore of Great Inagua including the northern shore of Northwest Point. Columbus says "with no shoals off it."

9. Verhoog then takes Columbus to Southwest Point, which he selects as Cape de la Laguna "in order to steer northeast and east from the southeast and south," where he understood he would find the Indian village and its king. He found the water everywhere so shallow he could not *enter* or navigate to that point.

Although this is a perfect description of the bight inside Crooked Island, it certainly does not describe Great Inagua. Nor would Columbus have said "following the route to the southwest, it was a very great detour." However, at Crooked Island archipelago he would have had to sail southwest from Cape de la Laguna in order to round the island to the south. Verhoog says Columbus turned back because of the shallow waters off the south side of Great Inagua, but a glance at the chart will show that this was no more discouraging than many places he had already been and that he could easily discern deep water to seaward.

10. According to Verhoog, Columbus sailed over 200 miles from Great Inagua to reach Cuba when it would have been possible to take a direct route of only 48 miles from his anchorage at Southwest Point. His explanation that the longer course was a canoe route(42) does not hold, as, except for the Columbus banks, the entire route would have been across deep ocean waters far from land. However, the proposed route from Crooked Island to Cuba does qualify as the nearest and safest canoe route, as well as being one with which the Indians would have been familiar.

From the southern end of Great Inagua it would have been possible on clear days to see the high mountains of Cuba(43). *Sea Diver's* owner was able to see the Cuban ranges at an even greater distance from the Columbus banks. Certainly the Indians aboard would have been aware of Cuba's presence so nearby and would have counseled the shorter course.

11. When Columbus left for Cuba from Cape del Isleo (or Northeast Point) he sailed *west-southwest*. If this course had not carried him ashore on Great Inagua, it would have eventually taken him to Cuba—but not, as he states, by way of the Ragged Islands and the Columbus banks, which are *west-northwest* of this point.

12. This *west-southwest* course would never have taken him to a position where Verhoog's Cape Verde on the south point of Acklin

Island bore to the northwest of him at 7 leagues distance, as Columbus states. Also on this course he would have been forced to sail through the dangerous reefs along the east edge of the Columbus banks(44) in order to anchor there.

13. Neither would Columbus on this oblique course have seen the Ragged Islands like a chain of "seven or eight islands in a row, all lying from north to south." The course from Crooked Island, however, would have brought him straight toward these islands and then south to the Columbus banks, so that they would have answered this description.

Verhoog wonders about the mysterious large island of Baneque, northeast of Cuba. There is no doubt that Great Inagua was Baneque, but because Verhoog had already allocated it as Isabella, he was nonplussed. A brief study of Verhoog's own chart shows that on November 19 Columbus sailed north-northeast from Puerto Príncipe (Port Tanamo) on the north coast of Cuba, for a distance of 7 leagues. At this point the Journal records that Columbus "saw the island of Baneque due east," from which he was 60 miles away. A modern chart will also show that this could only be Great Inagua, for there is no other island in such a location.

By 10 o'clock the next morning he had navigated 18 leagues farther to the northeast-quarter-north, when he says "Baneque lay to the east southeast, from which direction the wind blew so that it was contrary . . . seeing that it did not change, and that the sea was rising he resolved to return to Puerto Príncipe. . . He did not wish *to go on* to the islet which he called *Isabella which was 12 leagues from him.* . . . because the Indians whom he carried with him whom he had taken in Guanahaní which he called *San Salvador and which was 8 leagues from that Isabella,* might get away."

As Great Inagua is already ruled out because of the contrary wind, only Crooked Island archipelago is left to qualify as Isabella. But to fortify his argument that Great Inagua was Isabella, Verhoog quotes the passage that San Salvador was 8 leagues (32 Columbus miles) from Isabella. True enough, Great Inagua is 34 miles from the Caicos Islands, while it is probably three times that distance from the Crooked Islands to either Caicos or Watling. That there is such a difference is not surprising, however, when one considers that Columbus could not see Isabella, or the Crooked Island archipelago, but only guessed at its location from the dead reckoning he had kept during the intervening weeks while the ships sailed across strange and uncharted waters. The 8 leagues he mentions must necessarily have been only a guess, which happened to correspond with the distance between Caicos and Great Inagua.

The fact that Great Inagua was Baneque and not Isabella is further supported by an entry in the Journal on December 5 when, as the *Santa María* was poised at the eastern end of Cuba with Haiti to the southeast, it records Columbus's desire once more "to go to the island of Baneque which lay to the northeast, according to that which the Indians he had with him said." Once again Great Inagua was the only possible island to the northeast of him.

CONCLUSION

As *Sea Diver* made her way from island to island in an attempt to ferret out every last clue to this 500-year-old mystery of where Columbus first landed and voyaged in his discovery of the New World, a great deal of time on board was spent in studying pertinent books and charts. With Captain Weems's knowledge of navigation and the sea, and Mendel Peterson's background of history, plus the lively interest of all of us in our subject, many profitable hours were devoted to discussion of all phases of the problem.

It was only after long and serious deliberation both during our journey and afterward, the gist of which I have attempted to record here, that we came to the conclusion that this new course which the expedition's leader had evolved contained fewer discrepancies and fitted more completely the descriptions given by Columbus from beginning to end than either of the other two.

Therefore, we submit as our considered opinion that Columbus landed first at the Caicos Islands and not at Watling Island and that he followed a course through the Bahamas from Mayaguana to Samana to Long Island, from there to Crooked Island, the Ragged Islands, the Columbus banks, and Cuba.

NOTES

1. Called Watling Island since the seventeenth century by the English. In 1926 it was named San Salvador or Watling Island by an Act of the British Parliament (16-17 George V, ch. 27).

2. Samuel Eliot Morison, professor of history at Harvard University, Rear Admiral, USNR; author of many books and papers on Columbus; leader of the Harvard-Columbus expedition in 1939 and 1940 with the barkentine *Capitana* and the ketch *Mary Otis*.

3. Capt. Pieter Verhoog's entire material on the Columbus landfall and track was lost during a bombardment of Rotterdam in 1943, and he had to start all over again. A student of Spanish literature and the early voyages of discovery,

he has been a contributor to Dutch newspapers and periodicals since he retired in 1953 as Commanding Officer of the SS. *Nieuw Amsterdam.*

4. On the ketch *Mary Otis.*

5. Martín Fernández de Navarrete, author of "Colección de los Viajes y Descubrimientos," vols. 1-3, Madrid, 1825-1829, consisting of many important documents from the Spanish archives including Las Casas's rendering of the First Voyage from Columbus's Journal in the first up-to-date transcription to appear in print. Navarrete selected Grand Turk Island as San Salvador, the route continuing to Caicos, Little Inagua, Great Inagua, and Cuba.

Washington Irving, author of a four-volume "Life and Voyages of Christopher Columbus," published in 1828, based on the findings of Navarrete. He selected Cat Island as San Salvador, then Concepción Cay, Exuma, Long Island, Mucarras, and Cuba.

Capt. A. B. Becher of the British Royal Navy, author of "Landfall of Columbus," published in the Royal Geographical Society Journal in London in 1856, selected Watling Island for the landfall, followed by Long Island, Exuma, Crooked, Ragged, and Cuba. He believed that Columbus passed an unknown island to reach Santa María de Concepción, in this case Rum Cay.

Hon. Gustavus V. Fox, served as assistant secretary of the Navy under Abraham Lincoln. He wrote a monograph, "An Attempt to Solve the Problem of the First Landing Place of Columbus in the New World," published by the U. S. Coast and Geodetic Survey in 1882. Samana or Atwood Island was his choice for the first landfall followed by Crooked, Long, Fortune, and Ragged.

Clements R. Markham, one-time president of the British Hakluyt Society, which published his "Life of Christopher Columbus" and translation of Columbus's Journal in 1882. He inclined toward Watling Island as the first landfall.

6. Related in his "Cruise of Columbus in the Bahamas, 1492," published in Proc. U. S. Naval Inst. in 1884.

7. Fray Bartolome de Las Casas's abstract of the Journal of Columbus on his First Voyage can be found in Cesare de Lolli's "Raccolta di Documenti e Studi," Publicati Dalla R. Commissione Colombiana, Rome, 1892-1894, as well as in Navarrete's record. Although the original log has been lost, it is believed it was originally in the possession of his son, Fernando Colón, and that it later came into the possession of Las Casas; for Fernando Colón's "Historie" compares very closely to Las Casas's interpretation in many passages, indicating that they came from the same source. The Las Casas manuscript is now preserved in Madrid.

8. For example, on October 16, in referring to the island of Fernandina, the Journal records, "and all this coast runs north-northwest and south-south*west,*" while on October 17 it reads, in referring to the same island, "because it all trended north-northwest and south-south*east.*" In the Spanish there is only this difference between SSW. and SSE.: *sursudueste* as compared to *sursueste.* It would be easy to make a mistake either in copying or setting type. Columbus also spelled the word for west *gueste* and *vueste.*

9. A chart of the location of Navidad, the first settlement in the New World, on the north coast of Hispaniola, made by the Admiral in 1493 is still in existence.

10. United States Navy Hydrographic Office charts Nos. 944 and 948 with British surveys of the Bahama Islands on the first chart from 1836 to 1885, and

on the second, from 1829 to 1848. These charts have been combined and reduced and are included as charts 1 and 2 following page 32 of this paper.

11. Founder of the Weems System of Navigation and a cofounder of the Institute of Navigation. Captain Weems is the author of many books on navigation and has invented and developed several navigation instruments and aids.

12. In a Grumman Widgeon owned by Mr. Link and based first at Nassau and later at Caicos Island.

13. Doctor of Laws, writer and member of Cuba's Academy of History. Dr. Pedroso has the honor to be one of the few to have viewed the remains of Columbus in their original lead casket in the Cathedral of Santa Domingo, in Ciudad Trujillo, Dominican Republic. (Pl. 2, fig. 1.)

14. This reward amounted to almost a year's salary for an ordinary seaman.

15. According to Oviedo's account. The seaman was told by Salcedo, the Admiral's servant, that it had already been seen.

16. Markham says that on the night of the 11th the moon rose at 11 p.m., and at 2 a.m. on the morning of the 12th it was 30° above the horizon. It would have been shining brightly on the sandy shores of an island some miles ahead, being in its third quarter.

17. Fernando Colón, in his "Vita del Ammiraglio," described the light as like a candle that went up and down as if people on shore were passing with it from one house to another. (Cap 21.)

18. If the poop deck of the *Santa María* were 14 feet from the water, a man standing on this deck, his eye level at 19 feet, would be able to see an object on the horizon 5 miles away, according to the Dip Table calculations in Weems, P.V.H., "Line of Position Book," 2d ed., Annapolis, 1928.

19. The Indian name for the island that Columbus christened San Salvador. The prefix *guana-* stands for "place of much water." Many Arawak names started thus if the location contained water, such as Guanabacoa, Havana, famous for its marvelous springs and fountains. The name does not come from the iguana as has been suggested previously.

20. "Tiene la dicha isla forma de una haba. . . ." Las Casas, Apologética Hist., cap. 1, p. 241.

21. "Isla de 15 leguas de luengo, poco mas o menos . . ." Las Casas, Historia de las Indias, I, cap. 40, p. 291.

22. "Esta primera tierra fué una isleta de las que llamamos de los Lucayos, que las gentes de éstas, islas por proprio nombre llamaban Guanahaní, la última sillaba aguda, que en las cartas del marear que agora se pintan, llaman *Triango,* como ignorantes, los pintores, de la antiguedad . . ." Las Casas, Apologética Hist., cap. 1, p. 241.

23. "The creeks dividing the islands, from Grand Caicos to South Caicos, are now fordable, yet it is not so long ago that vessels of some size could reach the inner waters of the bank by passing between the islands." West Indies Pilot, vol. 3, 3d ed., p. 168, London, 1933.

24. That of Watling Island to Rum Cay, a distance of 19 miles.

25. The theory of a land league and a shore league suits Morison's Watling theory very well, but nowhere in any records of Columbus's sailings is there mention of such a system. It could be very confusing when sailing in a group of islands like the Bahamas to know when to apply the proper standard.

26. Both Dr. Morison and Captain Verhoog agree that the effect of currents

in the Bahamas is negligible. (Admiral of the Ocean Sea, vol. 2, cap. 13, p. 255, and Guanahaní Again, pp. 17-19.)

27. Admiral of the Ocean Sea, vol. 1, cap. 13, p. 246.

28. Guanahaní Again, p. 64; Columbus Landed on Caicos, Proc. U. S. Naval Inst., vol. 80, No. 10, p. 1105, 1954.

29. ". . . y como desta isla vide otra mayor al oueste, *cargué las velas* por andar . . ." Spanish dictionaries agree that the verb *cargar* means to "press" or "crowd" or "load on," while *velas* means sails. However, Lieutenant Murdock says "any dictionary of nautical terms shows that the true rendering of *cargué las velas* is 'I clewed up the sails,'" meaning furled the sails. Unfortunately, the English term "to clew up sails" also seems to have an ambiguous meaning which may be interpreted either to make sail or to furl sail. According to Webster's New Collegiate Dictionary "clew" means "to haul a sail by means of lines up to a yard or mast."

The same phrase is used at the beginning of the entry for October 15 in the Journal: "Avía temporejado esta noche . . . é en amaneciendo *cargar velas,*" or, "I had lain to that night . . . ready to clew up sails at daybreak." Surely, the same phrase used as it is in two separate places in the record for October 15 must have the same meaning; and that meaning must necessarily be to make or crowd on sail, following as it does the explanation that Columbus had *lain to* that night.

30. "Poor anchorage on the south shore of Samana about two miles from the eastern end." West Indies Pilot, vol. 3, 3d ed., p. 15, London, 1933.

31. The Journal mentions, "So I departed at about 10 o'clock" in the entry for October 15, but the next day records, "I departed from the island of Santa María de Concepción, when it was already about midday."

32. ". . . haze una grande angla." This has been interpreted as "forms a big angle" by many translators, but the Spanish word would then be the masculine "ángulo" instead of the feminine "angla," and it is doubtful if such an error could have occurred in transcribing the original text.

33. "After the islet the coast runs to the west and extends for 12 leagues to a cape, which I named Cape Hermoso." Journal, Friday, October 19.

34. Gently, mildly.

35. Inscribed "Christopher Columbus made the first recorded landing in the New World on this beach, Oct. 12, 1492. Yawl *Heloise,* Feb. 25, 1951." By what right or proof this was erected is a matter for conjecture.

36. Placed there in 1891 by the Chicago Herald Expedition.

37. In the vicinity of Hall's Landing.

38. A United States guided-missile base established there recently.

39. See "The Cruise of Columbus in the Bahamas, 1492," by J. B. Murdock, USN, Proc. U. S. Naval Inst., vol. 10, No. 3, pp. 480-481, 1884.

40. Opinion varies between 500 and 1,000 yards for a lombard shot.

41. *Isleo*—a small island close to a bigger one; *isleta*—a small isle or islet; *isla*—isle or island.

Verhoog argues that Bird Cay off Crooked Island was too small to be an *isleo,* that it was an *isleta.* We argue that Little Inagua was too large and too far from Great Inagua to be called an *isleo,* that Columbus would have called it an *isla* just as he did the Islas de Arena, even though they were much smaller than Little Inagua.

His only use of *isleta* was in describing the "piece of land which is formed like an island although it is not one," when later on in the text he said; ". . . y después, junto con dicta *isleta*." He used *isleo* in describing the island at the entrance to the "maravillosa puerto," ". . . porque tiene un *isleo* en medio," and the small island near Isabella, ". . . adonde haze un *isleo*."

42. A route selected because of its proximity to land whenever possible and in the most sheltered waters.

43. There is a mountain range up to 4,020 feet on the eastern end of Cuba opposite Great Inagua.

44. The chart shows reefs, rocky heads, even a cay, with the notations "edges well defined" and "strong ripples."

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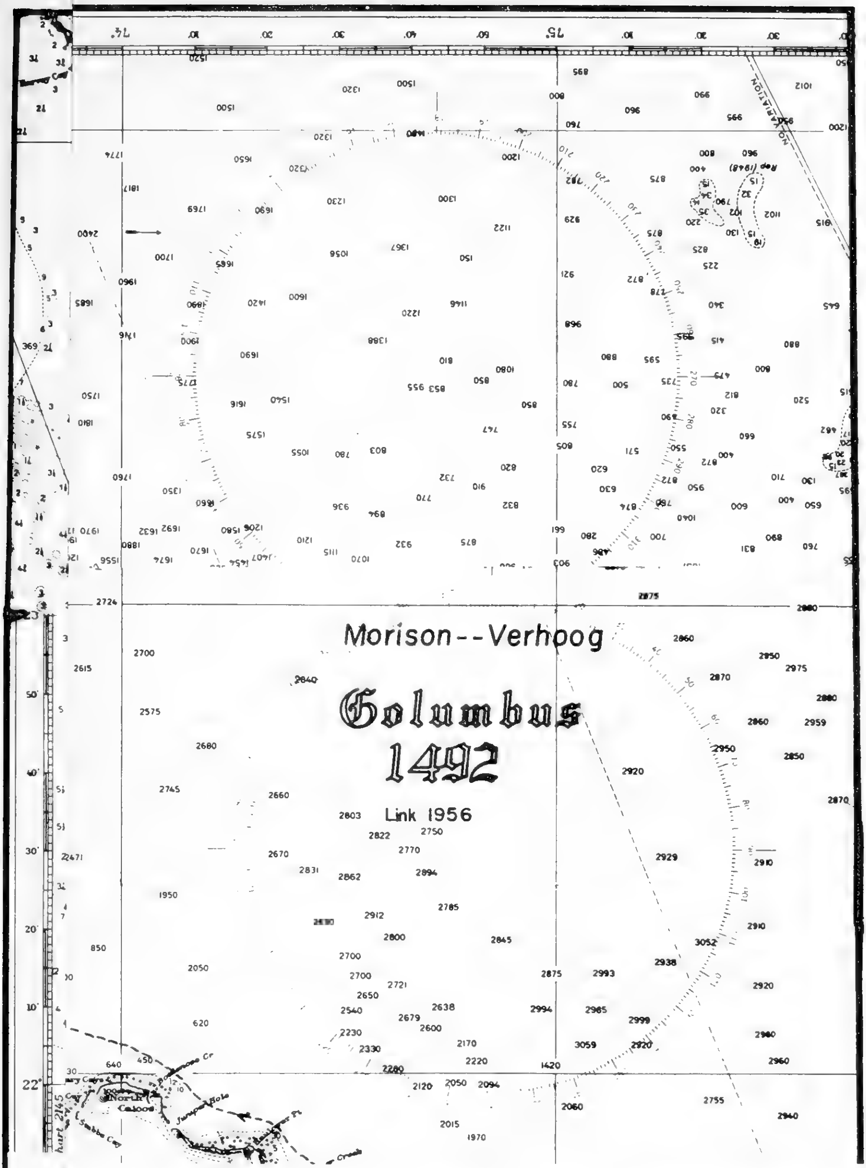
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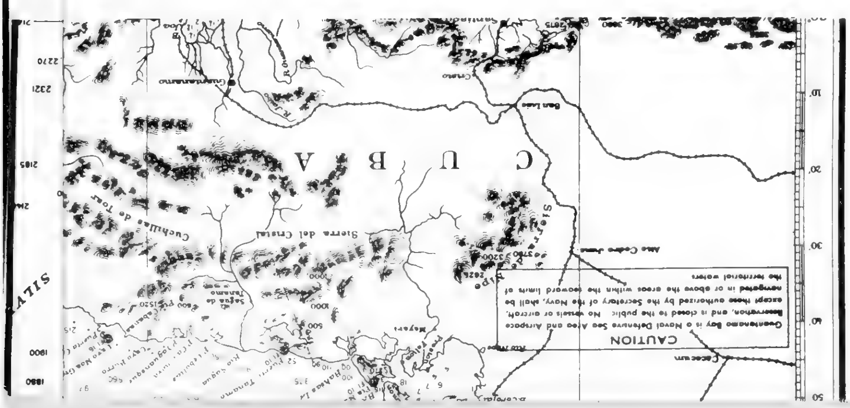
1492
Link 1956



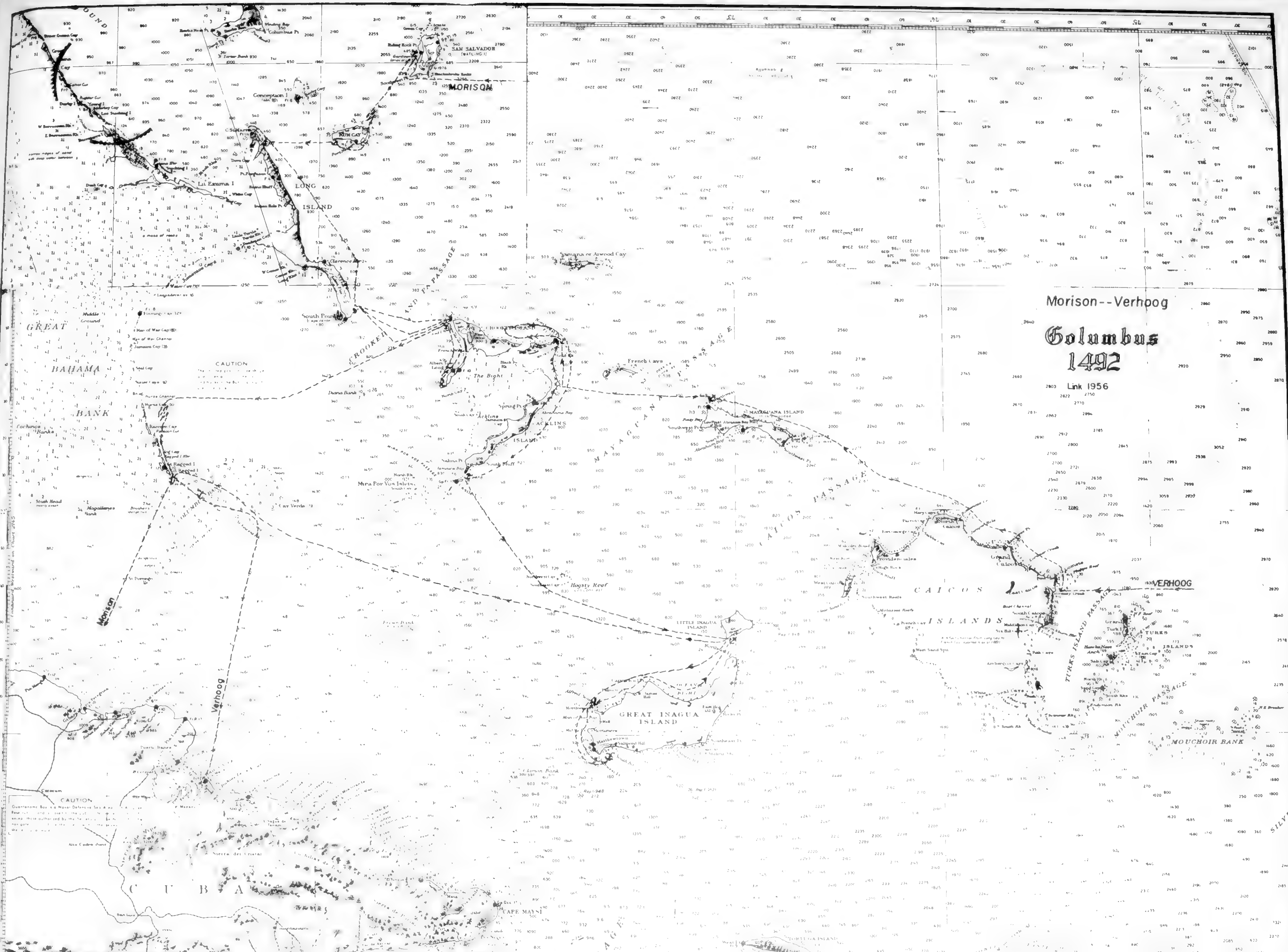
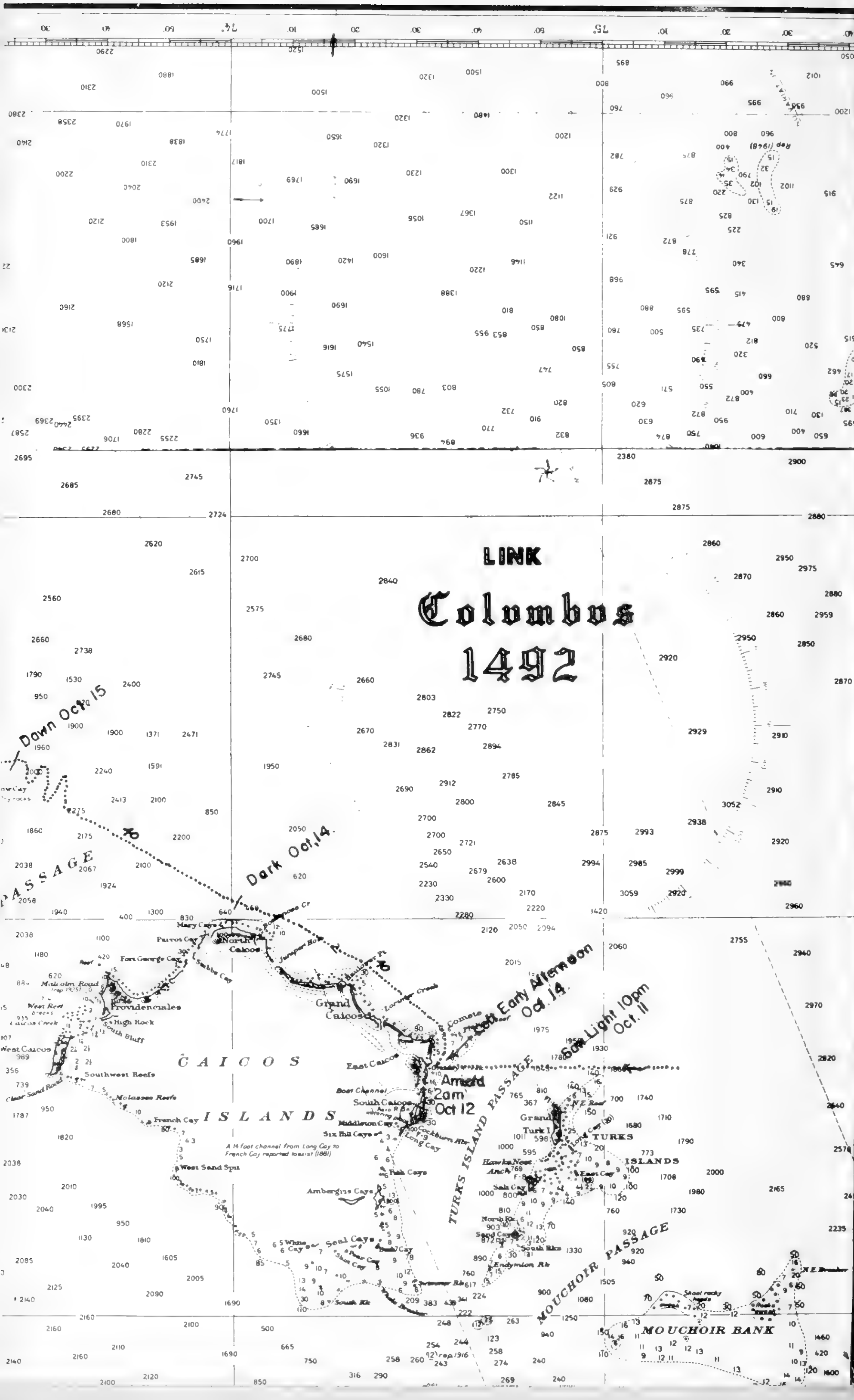

Morison--Verhoog
Columbus
1492
Link 1956
MORISON
VERHOOG
Morison
Verhoog
SAN SALVADOR
RUM CAY
LONG ISLAND
South Point
CROOKED AND PASSAGE
Samana or Atwood Cay
French Cays
MAYAGUANA PASSAGE
MAYAGUANA ISLAND
ACKLINS ISLAND
The Bight
Hogsty Reef
CAICOS PASSAGE
CAICOS
ISLANDS
TURKS ISLANDS
TURKS ISLAND PASSAGE
MOUCHOIR PASSAGE
MOUCHOIR BANK
SILVER
LITTLE INAGUA ISLAND
GREAT INAGUA ISLAND
GREAT
BAHAMA
BANK
CAUTION
C U B A
CAPE MAYSI
Concepcion I.
Conception I
Lt. Exuma I.
Columbus Pt.
Ragged I.
Mira Por Vos Islets

Chart 1



LINK
Columbus
1492
Down Oct 15
Dark Oct. 14.
Left Early Afternoon Oct. 14.
Saw Light 10pm Oct. 11
2am
Oct 12
PASSAGE
North Caicos
Grand Caicos
East Caicos
South Caicos
Providenciales
West Caicos
Mary Cays
Parrot Cay
Fort George Cay
Malcolm Road
High Rock
South Bluff
Southwest Reefs
Molasses Reefs
French Cay
CAICOS ISLANDS
Boat Channel
Middleton Cay
Six Hill Cays
Cockburn Hbr
Long Cay
A 14 foot channel from Long Cay to French Cay reported to exist (1881)
West Sand Spit
Fish Cays
Ambergris Cays
Seal Cays
South Rk
TURKS ISLAND PASSAGE
Grand Turk I.
TURKS ISLANDS
Hawks Nest Anch.
Salt Cay
Sand Cays
South Rks
Endymion Rk
MOUCHOIR PASSAGE
MOUCHOIR BANK
N.E. Breaker

APPENDIX

EXCERPTS FROM THE JOURNAL OF THE FIRST VOYAGE OF COLUMBUS (OCTOBER 11 THROUGH OCTOBER 27, 1492) AS TRANSLATED FROM THE SPANISH BY ARMANDO ÁLVAREZ PEDROSO

Thursday, October 11

He sailed to the west-southwest; they had a rougher sea than they had experienced during the whole voyage. They saw sandpipers and a green branch near the ship. Those in the caravel *Pinta* saw a cane and a stick, and they secured another small stick, carved, as it appeared, with iron, and a piece of cane, and other grass which grows on land, and a small board. Those in the caravel *Niña* also saw other indications of land and a small branch, covered with dog-roses. At these signs, all breathed again and rejoiced. On this day, to sunset, they went 27 leagues. After sunset, he sailed his former course to the west; they probably made 12 miles an hour, and up to two hours after midnight they had made 90 miles, which are 22 leagues and a half. And because the caravel *Pinta* was swifter and went ahead of the Admiral, she found land and made the signals which the Admiral had commanded. This land, a sailor, who was called Rodrigo de Triana, first sighted, although the Admiral, at 10 o'clock at night, being on the castle of the poop, saw a light. It was, however, so obscured that he would not affirm that it was land, but called Pero Gutiérrez, a gentleman of the bedchamber to the King, and told him that there seemed to be a light, and that he should look at it. He did so, and saw it. He also said the same to Rodrigo Sanchez de Segovia, whom the King and Queen had sent in the fleet as controller, and he saw nothing since he was not in a position from which it could be seen. After the Admiral had so spoken, it was seen one or two times, and it was like a small wax candle, raised and lifted up. Few thought that this was an indication of land, but the Admiral was certain that he was close to land. Accordingly, when they had intoned the "Salve Regina," that all sailors are accustomed to pray and chant in their manner, when they are all together, the Admiral asked and urged them to keep a good lookout from the forecastle and to watch carefully for land, and to the one who should first tell him that he saw land, he would give at once a silk doublet, apart from the other rewards which the sovereigns had promised, which were 10,000 maravedís annually to the one who first sighted it. Two hours after midnight, land appeared, at a distance of 2 leagues from them. They shortened all sail, remaining with the mainsail, which is the great sail without bonnets, and layed to, waiting for day, a Friday, on which they reached a small island of the Lucayos, which is called in the language of the Indians "Guanahaní." Immediately they saw naked people, and the Admiral went ashore in the armed boat, and Martín Alonso Pinzón and Vicente Yanez, his brother, who was captain of the *Niña*. The Admiral brought out the royal standard, and the captains went with two banners of the green cross, which the Admiral flew on all the ships as a flag,

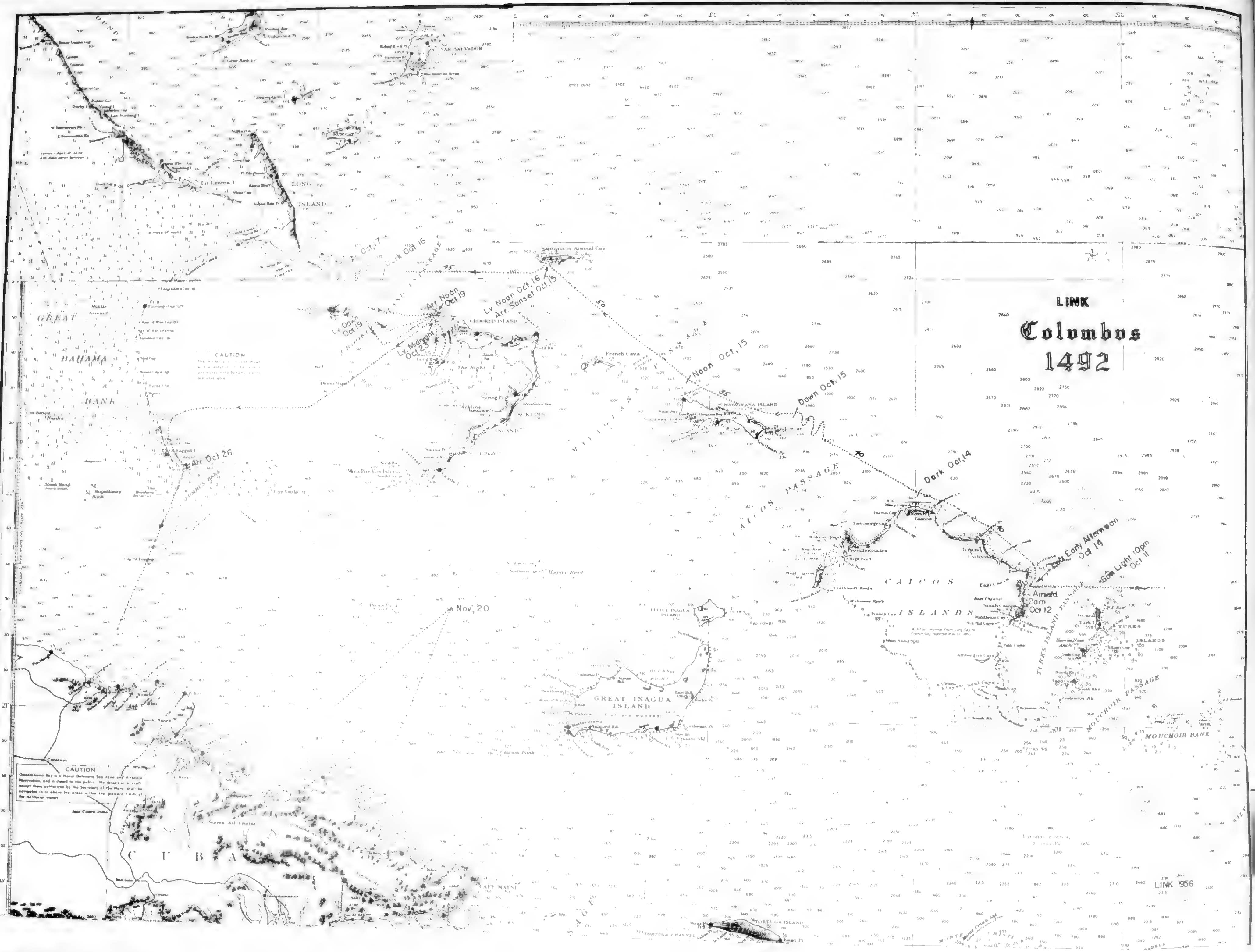

LINK
Columbus
1492
SAN SALVADOR
LONG ISLAND
GREAT BAHAMA BANK
CROOKED ISLAND
French Cays
MAYAGUANA ISLAND
CAICOS PASSAGE
CAICOS ISLANDS
TURKS ISLANDS
TURKS ISLAND PASSAGE
MOUCHOIR PASSAGE
MOUCHOIR BANK
LITTLE INAGUA ISLAND
GREAT INAGUA ISLAND
Providenciales
Grand Caicos
TORTUGA ISLAND
CUBA
CAUTION
Oct 17
Dark Oct 16
Arr Noon Oct 19
Lv Dawn Oct 19
Lv Midnight Oct 23
Lv Noon Oct 16
Arr. Sunset Oct 15
Noon Oct 15
Dawn Oct 15
Dark Oct 14
Arr Oct 26
A Nov. 20
Arrived 2am Oct 12
LINK 1956

Chart 2

APPENDIX

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Thursday, October 11

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"I," he says, "in order that they might feel great amity toward us, because I gathered that they were a people to be delivered and to be converted to our holy faith rather by love than by force, gave to a few of them some red caps and some glass beads, which they hung around their necks, and many other things of little value. At this they were greatly pleased and became so entirely our friends that it was a wonder to see. Afterward they came swimming to the ships' boats, where we were, and brought us parrots and cotton thread in balls, and spears and many other things, and we exchanged for them other things, such as small glass beads and hawks' bells, which we gave to them. In fact, they took all and gave all they had, with good will, but it seemed to me that they were very deficient people in everything. They all go naked as their mothers bore them, and the women also, although I only saw one, a very young girl. And all of the men whom I did see were young, as I did not see one who was over 30 years of age, very well built, with very handsome bodies and very good faces. Their hair is coarse and short, almost like the hairs of a horse's tail; they wear their hair down over their eyebrows, except for a few strands behind, which they wear long and never cut. Some of them are painted black, and they are the color of the peoples of the Canaries, neither black nor white, and some of them are painted white and some red and some in any color that they find. Some of them paint their faces, some their whole bodies, some only the eyes, and some only the nose. They do not bear arms or know them, for I showed them swords and they took them by the blade and cut themselves through ignorance. They have no iron. Their spears are certain reeds, without iron, and some of these have a fish tooth at the end, while others are pointed in different ways. They are all generally fairly tall, good looking, and well proportioned. I saw some who bore marks of wounds on their bodies and by signs I asked them what was that, and they indicated to me that people had come from other islands, which are near, and wished to capture them, and they had to defend themselves. And I believed and still believe that they came here from the mainland to take them as prisoners. They should be good servants and of quick intelligence, since I see that very soon, they repeat all that is said to them, and I believe that they would easily become Christians, for it appeared to me that they had no creed. Our Lord willing, I will take from here, at the time of my departure, six of them to your highnesses, so that they may learn to talk. I saw no beast of any kind in this island, except parrots." All these are the words of the Admiral.

Saturday, October 13

"As soon as day broke, there came to the shore many of these men, all young, as I have said, and all of a good height, very handsome people. Their hair is not curly, but loose and coarse as the hair of a horse; all have very broad foreheads and heads, more so than any people that I have seen until now. Their eyes are very lovely and not small. They are not at all black, but of the color of the Canarians; nothing else could be expected, since this is on the same line, from east to west, with the island of Hierro in the Canaries.[1] Their legs are very straight; none are bow-legged. They are not big bellied, their stomachs being very well shaped. They came to the ship in boats, which are made of a tree trunk and are like a longboat all made of one piece. They are very wonderfully carved, considering the country, so large, that some carried 40 and 45 men. Others are smaller, so that in some but a single man came. They row them with a paddle, like a baker's shovel, and they travel wonderfully.

If one capsize, all at once begin to swim and raise it upright, baling it out with gourds which they carry with them. They brought balls of spun cotton and parrots and spears and other trifles, which it would be tedious to write down, and they gave all for anything that was given to them. And I was attentive and tried to know if there was gold, and I saw that some of them wore a small piece hanging from a hole which they have in the nose, and from signs I was able to understand that, going to the south or rounding the island to the south, there was a king who had great vessels of it and very many. I endeavored to make them go there, and afterward saw that they were not inclined for the journey. I resolved to wait until the following afternoon, and, after, to leave for the southwest, for, as many of them indicated to me, there was land to the south and to the southwest and to the northwest, and that those of the northwest used to come to attack them very often. So I resolved to go to the southwest, to seek the gold and precious stones. This island is very large and very flat; with very green trees and much water. In the center of it, there is a very large lagoon; there are no mountains, and all is so green that it is a pleasure to gaze upon it. The people are very peaceful and since they long to possess something of ours, but thinking that nothing will be given to them unless they give something in return, so, as they have nothing, they take what they can and immediately jump into the water and swim. But all that they do possess, they give for anything which is given to them, so that they exchange things even for broken pieces of bowls and bits of broken glass. I even saw 16 balls of cotton being traded for three 'ceotis' of Portugal, which are worth a Castilian 'Blanca,' and in these balls there was more than 25 pounds of spun cotton. I forbade this and did not allow anything to be taken; I would command to be taken all of it, if there would be a large quantity, to be delivered to your highnesses; this grows here in the island; but owing to lack of time, I cannot give a definite account; and here is also found that gold which they wear hanging from the nose. But, in order not to lose time, I wish to see if I can make the island of Cipango. Now, as it is night, they all left to land . . . in their boats."

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[1] There is a note on the right side margin of this entry (Las Casas's handwriting) which reads: "The islet of Guanahaní is on Hierro's island latitude."

Sunday, October 14

"At dawn, I ordered the ship's longboat and the boats of the caravels to be made ready, and I went along the island in a north-northeasterly direction, in order to see the other part, which lay to the east, to see what was there, and also to see the villages. And I soon saw two or three, and people that came to the beach, calling us and giving thanks to God. Some brought us water, others various eatables; others, when they saw that I was not inclined to land, jumped into the sea and came, swimming, and we understood that they asked us if we had come from heaven. One old man got into the longboat, and all the rest of the men and women cried in loud voices: 'Come and see the men who have come from heaven; bring them food and drink.' Many men and women came, each one with something, giving thanks to God, lying on the ground and raising their hands to the sky, and then shouting us to come to land. But I feared to do so, seeing a great ridge of rocks which encircled the whole of that island, and in the middle there is deep water and a harbor large enough for all the ships of Christendom, the entrance to which is very narrow. It is true that inside this belt there are some shoals, but the sea is no more disturbed than the water in a well. And in order to see all this, I went this morning, in order to be able to give an account of all to your highnesses and also to know where a fort could be built. I saw a piece of land, which is formed like an island although it is not one, on which there were six houses; it could be cut in order to form an island, in two days, although I do not see that it is necessary to do so, for these people are very unskilled in arms, as your highnesses will see from the seven whom I ordered to be taken with us, so that they may learn our language and then send them back. However, when your highnesses so command, they can all be carried off to Castile or held captive in the island itself, since with 50 men they would be all kept in subjection and forced to do whatever may be wished. Near the said islet, moreover, there are the loveliest groves of trees that I ever saw, and as green and in as full leaf as those of Castile in the month of April and May, and much water. I examined the whole of that harbor, and afterward returned to the ship and set sail. I saw so many islands that I could not decide to which I would go first. Those men, whom I had taken, made signs to me that there were very many, so many that they could not be counted, and they mentioned by their name more than a hundred. For that reason I sought for the largest and resolved to steer for it, which I am doing. It will be 5 leagues away from this island of San Salvador; the others, some are farther away and some are less. All are very flat, without mountains, and very fertile; all are inhabited and they make war upon one another, although these people are very simple and very well-built men."

Monday, October 15

"I had lain to that night, fearing to reach land and anchor before daylight, as I did not know whether the coast was free from shoals, ready to clew up sails at daybreak. And as the island was more than 5 leagues distant, or maybe 7, and the tide delayed me, it was about midday when I arrived at said island, finding that the coast which lies toward the island of San Salvador runs north-south and has 5 leagues, and that the other, which I followed, runs east-west and has more than 10 leagues. And as from this island I saw another, larger, to the west, I clewed sails up to navigate all that day until night, and still was not able to reach the westerly point; this island I named 'Santa María de la Concepción' and, about sunset, I anchored near the said point to see if there was gold there, because those whom I had taken aboard from the island of San Salvador told me that there they wore very large golden bracelets on the legs and arms. I well believed that all that they said was a trick in order to get away. It was nevertheless my will not to pass any island without taking possession of it, although having taken one, it could be . . . said of all. And I anchored and was there until today, Tuesday, when at dawn I went ashore in the armed boats and landed. The people were many, naked, and of the same type as those of the other island of San Salvador; They allowed us to go through the island and gave us everything I asked from them. And as the wind blew more strongly across from the southeast, I didn't want to detain myself, and went back to the ship. A large boat was alongside the caravel *Niña,* and one of the men from the island of San Salvador who was in it, jumped into the sea and left on it; and during the middle of the night before, the other . . . and went after the boat, which fled so that there was not a boat that could have overtaken it, since he was way ahead of us. But they reached land and left the boat, and some of those with me went ashore after them, and they all escaped like chickens. The boat which they had abandoned we brought on board the caravel *Niña;* to this caravel it was coming from another direction, a second small boat with a man who wished to barter a ball of cotton, and some sailors jumped into the sea, because he would not come on board the caravel, and seized him. I was on the poop of the ship and saw everything, I ordered him brought to me and gave him a red cap and some small beads of green glass, which I put on his arm, and two hawks' bells, which I put in his ears, and ordered his boat, which was also in the ship's longboat, to be returned to him and sent him ashore. After that I set sail to go to the other large island which I was seeing to the west. I ordered that the other boat, which the *Niña* was towing astern, should be also set adrift. Afterward, on land, the other, to whom I had given the things mentioned and from whom I had refused to take the ball of cotton, although he wished to give it to me, was received by all of those people, and was much astonished and quite sure that we were good people and that the one who had run away had somehow wronged us and that accordingly we had kept him. It was to create this impression that I had so acted with him, ordering him to be set free and giving him the said presents, in order that we may be held in this esteem, so that when your highnesses again may send somebody here, they may not be unfriendly. All that I gave to him was not worth 4 pennies. So I departed at about 10 o'clock, with a southeast touching south wind, in order to pass over to this other island which is very large, and all these men, whom I carry with me from the island of San Salvador, make signs that there is in it very much gold and that they wear it as bracelets on their arms and on their legs, and in their ears and nose and on their necks. From this island of Santa María to this other there were 9 leagues, from east to west, and all this side of the island runs from northwest to southeast. It seems that the coast may extend for some 28 leagues or more on this side, and is very flat, without any mountain, as San Salvador and Santa María, and all of it beach, free from rocks, except that they all have some large stones near the land under water, for which it is necessary to keep a sharp lookout when the intention is to anchor, and not to anchor very near the shore, although the waters are always very clear and the bottom can be seen. At a distance of two lombard shots from land, the water off all these islands is so deep that it cannot be sounded. These islands are very green and fertile with very soft winds, and it is possible that there are many things in them, which I do not know, because I do not wish to delay, in order to look for gold, sailing to and visiting many islands. And since these give such proofs, because they wear it on their arms and legs (and it is gold, because I showed them some pieces of it which I have) I cannot fail, with the aid of Our Lord, to find the place whence it comes. Being in the middle of the channel between these two islands, namely, that of Santa María and this large one which I name 'Fernandina,' I found a man, alone in a boat, going from the island of Santa María to that of Fernandina. He was carrying with him a piece of their bread, about as large as the fist, and a gourd of water and a piece of reddish earth reduced to powder and then kneaded, and some dried leaves, which must be a thing highly prized among them, since already at San Salvador they presented me with some of them. He also carried with him a basket of their make, in which he had a string of glass beads and two Castilian pennies, through which I know that he came from the island of San Salvador and had crossed to that of Santa María and was on his way to Fernandina. He came alongside the ship. I had him come on board, as he wanted to do so, and ordered to bring his canoe on board also, and all that he had with him to be kept safe. I commanded that bread and honey should be given to him to eat, and something to drink, and will take him to Fernandina. Then I will give him back all his belongings, in order that he may extend a good opinion of us, so that with the favor of God, when your highnesses send some one here, those who come may receive honor and they may give us all that they have."

Tuesday and Wednesday, Octover 16 and 17

"I departed from the island of Santa María de Concepción, when it was already about midday, for that of Fernandina, which loomed very large to the westward, and sailed all that day in a calm. I could not arrive in time to be able to see the bottom in order to anchor in a clear place, for it is necessary to be very careful in this matter so as not to lose the anchors, and accordingly I stood off and on all this night until day, arriving then at a village, where I anchored, to which had come the man whom I found yesterday in the boat in the middle of the channel. He had given such good reports of us that all this night there was no lack of boats alongside the ship; they gave us water and everything they had with them. I ordered something to be given to each of them, that is to say, some small beads; a string of ten or a dozen glass beads; some brass timbrels, of the kind worth a penny each in Castile, and some leather straps; all these things they regarded as most excellent. When they came on board, I also ordered they should give them sugar molasses to eat. And afterwards, at the hour of tierce, I sent the ship's boat ashore for water, and with good will they made signs to my people showing where the water was; and themselves carried the full casks to the boat; they were delighted to please us. This island is very large, and I am resolved to go around it, because, as far as I can understand, there is in it or near it a mine of gold. This island is almost 8 leagues away from that of Santa María in an east-west direction; and this cape where I came, and all this coast runs north-northwest and south-

southwest; I saw quite 20 leagues of it, but it did not end there. Now, as this is being written, I have set sail with a south wind in order to try to go around the whole island and to go on until I find Samoet, which is the island or city where there is gold, as say all that come on board the ship, and also those from the island of San Salvador and from Santa María. These people are like those of said islands and have the same speech and manners, except that the ones here seem to me to be somewhat more civilized and courteous, and more intelligent, since I saw that they have brought cotton and other trifles to the ship and they know how to bargain better than the others. And in this land I also saw cotton cloths made like mantillas; the people are more capable and the women wear in front of their bodies a small piece of cotton, which scarcely hides their secret parts. This island is very green and flat and very fertile, and I have no doubt that the whole year they sow panic grass and reap it, and also other things. I saw many trees very different from ours, and many of them had branches of different kinds, and all coming from one trunk; one branch is of a kind and the other of another, and they are so unlike each other that it is the greatest wonder of the world. How great is the difference between one and another! For example, one branch has leaves like those of a cane and another like those of a mastic tree; and thus, on a single tree, there are five or six different kinds and all so different from each other. They are not grafted; so that it cannot be said that it is the result of grafting; on the contrary, they are wild and these people do not care for them. In them I have not seen any creed, and I believe that they would be speedily converted to Christianity, since they have a very good understanding. The fish here are so different from ours that it is a wonder; some of them are shaped like cocks, of the finest colors in the world: blue, yellow, red, and of all colors; others in a thousand different colorings, and the colors are so fine that there is not a man that would not be astonished and take a long time watching them. There are also whales. I saw no animals of any kind on land, except parrots and lizards. A boy told me that he saw a large snake. I did not see any sheep or goats or other animals, but I have been here a very short while, only half a day. But, if there had been any, I could not have failed to see one. I will describe the circuit of this island after I have gone around it."

Wednesday, October 17

"At midday I left the village where I was anchored, from which I had taken water, in order to go around this island of Fernandina; the wind was southwest and south, and since my wish was to follow the coast of this island where I was, to the southeast, because it all trended north-northwest and south-southeast, and I wanted to take said route to the south and southeast, because in that direction, as all the Indians whom I have with me say and from signs of another, towards the south, lies the island which they call Samoet, where the gold is, and since Martín Alonso Pinzón, captain of the caravel *Pinta,* where I stationed three of these Indians, came and told me that one of them very definitely made him understand that the island could be rounded more quickly in a north-northwesterly direction, and I saw that the wind would not help me on the course which I wished to steer, being favorable for the other course, I sailed north-northwest. And when I was about 2 leagues from the cape of the island, I found a very wonderful harbor with a mouth, or rather it may be said with two mouths, since there was an islet in the middle, and both mouths are very narrow, and inside it is more than wide enough for a hundred ships, if it be deep and clear and there be depth at the entrance. I thought it wise to examine it closely and sound it, and so I anchored on the outside coming into it with all the ship's boats; we saw that it was shallow. And as I thought, when I saw it, that it was the mouth of a river, I had ordered to bring barrels to fill them with water, and on land I found some eight or ten men, who immediately came to us and showed us a village near there, where I sent the people for water, some of them armed and some with barrels, and so they took it. And as it was some distance away, I was kept there for two hours. During this time I walked among the trees, and it was the loveliest thing that has ever been seen, seeing so much verdure in such a great scale like that of Andalusia in May; all the trees are as different from ours as day is from night, and so is the fruit, the grass, stones, and everything else. It is true that some trees were of the same kind as some in Castile, but yet there is a great difference in the whole, and the rest of the trees of other kinds are so many that there is no one who could identify or compare them with those of Castile. The people are like the ones already mentioned. They are of the same type and as naked and of the same height, and they offer what they have for whatever is given to them. Here I saw that some boys from the ships exchanged some little pieces of broken dishes and glass for their spears. The others, who went to get the water, told me that they had been in their houses and that they were inside very swept and clean, their beds and coverings being like nets of cotton. The houses are all like tents, and very high and with good chimneys, but in the many villages which I have visited I have not seen any with more than 12 to 15 houses. They saw here that married women wore cotton drawers, but girls do not, except some who were already 18 years old. There are here mastiffs and small dogs, and here they found a man who had in his nose a piece of gold, which might have been half the size of a Spanish gold coin, on which they saw letters. I was angry with them because they had not bargained for it and given whatever might be asked, in order that it could be examined, to see what kind of money it was. They replied to me that they didn't dare to bargain. After the water had been carried, I returned to the ship and set sail, and navigated to the northwest till I had discovered all that part of the island as far as the coast which runs east-westerly. Afterward all these Indians began to say that this island was smaller than the island of Samoet and that it would be well to turn back in order to arrive at it sooner. There the wind fell and then began to blow from west-northwest, and so blowing contrary to the course which we had been following. Therefore I turned back and navigated all this night in an east-southeasterly direction, sometimes due east and sometimes southeast; this was done in order to keep clear from land, because there were very thick clouds and the weather was very bad. There was little wind and this prevented me from going to land to anchor. This night it rained very heavily from after midnight until near daybreak, and it is still cloudy and ready to rain. We are at the end of the island to the southeast, where I hope to anchor until the weather clears, in order to see the other islands that I should visit. It has rained, more or less, every day since I have been in the Indies. Your highnesses may believe that this land is the best and most fertile and temperate and level and good that might be found in the world."

Thursday, October 18

"After it was light, I followed the wind and sailed around the island as far as I could, and anchored when it was no time to sail; but I did not land, and at dawn I set sail."

Friday, October 19

"At dawn I weighed anchors and sent the caravel *Pinta* to the east and southeast, and the *Niña* to south-southeast, while I sailed in the ship to the southeast, and gave orders that they should follow these courses until midday, and that they should then change their course and rejoin me. And then before we had sailed for three hours, we saw an island to the east, toward which we steered, and all the three vessels reached it before midday, at its northern point, where there is an islet and a ridge of rocks on its outside, to the north, and another between it and the main island, which the men from San Salvador, whom I have with me called 'Saometo' and which I named 'Isabella.' There was a north wind, and the said islet lay on the course of the island of Fernandina, from which I had departed east-west. After that islet the coast runs to the west and extends for 12 leagues to a cape, which I named Cape Hermoso. It is on the west part and it is indeed lovely, round and very deep, with no shoals off it. At first the shore is stony and low, and farther on there is a sandy beach which is the character of most of that coast, and there I anchored this night, Friday, until morning. All this coast, and the part of the island which I saw, is mainly a beach; the island is the loveliest thing that I have seen, for, if the others are very lovely, this is more so. It has many tall trees and they are very green, and this land has a bigger height than the other islands which have been discovered. There is in it an elevation, which cannot be called a mountain, but which serves to beautify the rest and it seems that there is much water in the middle of the island. From this part, to the northeastern side, the coast forms a big neck of land, and is very thickly wooded with very large trees. My wish was to anchor there, in order to land and see such beauty; but the water was shallow and I could not anchor unless far from the shore; but the wind was very favorable to reach this cape, where I am now lying at anchor, and which I have named Cape Hermoso, because such it is. So I did not anchor on that neck of land. Looking at this cape, so green and lovely, and all the other things and lands of these islands that are so lovely, I do not know where to go first, and my eyes never get tired of looking at such lovely verdure, so different from ours. I still believe that they have many herbs and many trees which will be of great value in Spain for dyes and as medicinal spices, but I do not recognize them and this gives me a great sorrow. When I arrived here, at this cape, there came from the land the scent of flowers or trees, so delicious and sweet, that it was the most delightful thing in the world. In the morning, before I leave I will go to land to see what there is here at this point. It is not in the village but farther inland, where these men, whom I have with me, say the king is, and that he wears much gold. In the morning I wish to go far enough inland until I find the village and see or talk with this king, who, according to the signs which these men make, rules all these neighboring islands and is clothed and wears on his person much gold, although I do not trust much what they say, both because I do not understand them well and because they are so lacking in gold that any small amount which this king may wear would seem to be much to them. This point here I call Cape Hermoso. I believe that it is an island separated from that of Samoet and there is another small island in between. I make no attempt to examine so much in detail, since I could not do that in 50 years, because I wish to see and discover as much as I can, in order to return to your highnesses in April, if it please Our Lord. It is true that, if I arrive anywhere where there is gold or spices in large quantity, I shall wait until I have collected as much as I am able; and that's why I do nothing but sail to see if I can find it."

Saturday, October 20

"Today, at sunrise, I weighed anchor from the place where I was with the ship, anchored off the southwest point of this island of Samoet, which point I named 'Cape de la Laguna' and which island I named 'Isabella,' in order to steer northeast and east from the southeast and south, where the village and its king were, as I understood from these men whom I have with me. I found the bottom so shallow everywhere that I could not enter or navigate to that point, and saw that, following the route to the southwest, it was a very great detour. Therefore I decided to go back by the same way which I had come from the north-northeast, to the west, and round this island in that direction; and the wind was so light that I never made the entire coast until night, and as it is dangerous to anchor off these islands except in daytime, when it is possible to see where you can anchor, since the bottom varies everywhere, some part being clean and some not, I proceeded to stand off under sail all this Sunday [sic] night. The caravels anchored, because they found themselves near land earlier, and they thought that by making the usual signal, I should go and anchor, but I did not wish to do it."

Sunday, October 21

"At 10 o'clock I arrived here at this 'Cape del Isleo' and anchored, as did the caravels. After having my meal, I went ashore, where there was no village but a single house, in which I found nobody, and I believe they fled in terror, because in the house were all their household goods. I did not allow them to touch anything, and proceeded to examine the island, with these captains and people. If the others, already seen, are very lovely and green and fertile, this is much more so, and has many and very green trees. There are very extensive lagoons, and by them and all around them there are wonderful woods; here and in the whole island all is green and the grass is as that in April in Andalusia. The singing of little birds is such that it seems that man could never wish to leave this place; the flocks of parrots darken the sun; and fowl and small birds are so different and so unlike ours, that it is a marvel. There are, moreover, trees of a thousand types, all with their various fruits and all with marvelous scent. I am the unhappiest man in the world because I do not recognize them, for I am very sure that all are of great value, and I am bringing specimens of them and also of the herbs. As I was walking around one of these lagoons, I saw a snake, which we killed, and I am bringing its skin to your highnesses. When it saw us, it jumped into the lagoon and we followed it, as the water was not very deep, until we killed it with our spears. It is 7 palms in length; I believe that there are many similar in these lagoons. Here I recognized the aloe, and tomorrow I am resolved to have 10 quintals brought to the ship, since they tell me that it is very valuable. Further, going in search of very good water, we went to a village near here, half a league from where I am anchored. When the people heard us, all fled and left their houses and hid their clothing and whatever they had in the undergrowth. I did not allow anything to be taken, even of the value of a pin. Afterward, some of the men among them came toward us and one came quite close. I gave him some hawks' bells and some little glass beads, and he was well satisfied and very happy. And to be more friendly making some request of them, I asked him for water; and after I had returned to the ship, they came to the beach with their gourds full, and were delighted to give it to us; so I ordered to give them another string of small glass beads and they said that they would come back tomorrow. I was anxious to fill here all the ships' casks with water; accordingly, if the weather allows it I shall set out to go around this island, until I can speak with this king and try to see if I can obtain from him the gold which I hear that he wears. After that I wish to leave for another very large island, which I believe must be Cipango, according to the indications that the Indians that I have are giving me; they call it 'Colba' in which they say that there are ships and very many and magnificent sailors; and from this island I intend to go to another which they call 'Bohio' and they also say is very large. The others, which lie between them, I shall see lightly and if I find a quantity of gold or spices, I shall decide what to do. But I am still decided to sail to the mainland and to the city of Quinsay and deliver the letters of your highnesses to the Grand Khan, request a reply and return with it."

Monday, October 22

"I have been waiting here all night and today to see if the king of this place or other persons would bring gold or anything else of importance. There came many people, who were like those of the other islands, just as naked and just as painted, some white, some red, some black, and many other ways. They brought spears and some cotton balls to barter, and here they exchanged them with sailors for bits of glass, broken cups, and pieces of broken clay bowls. Some of them wore some pieces of gold, hanging from the nose, and they gladly exchanged them for a hawk's bell, of the type for a sparrow hawk's leg, and for glass beads; but the quantity is so small that it amounts to nothing. It is true, that laying aside whatever little thing which might be given to them, they still regarded our arrival as a great wonder, and they believed that we had come from heaven. We carried water to the ships from a lagoon which is here, near Cape del Isleo, for so I named it. And in said lagoon, Martín Alonso Pinzón, captain of the *Pinta,* killed another snake like that of yesterday, 7 palms long; and here I ordered to be collected as much aloe as was found."

Tuesday, October 23

"Today I would like to sail to the island of Cuba, which I believe must be Cipango, according to the indications which these people give me concerning its size and riches. I will not delay here any longer or . . . round this island to go to the village, to have a talk with this king or lord, as I had decided, in order not to delay too long, since I see that there is no gold mine here and because to go around these islands, the wind must blow from different directions and it does not blow just as men may wish, and also since it is wise to go where large trade can be found. I say that it is not right to delay, but to go on our way and to discover many lands, until a very profitable . . . land is reached. My impression, however, is that this one is very rich in spices, but I have no knowledge of these matters, which gives me the greatest sorrow in the world, for I see a thousand kinds of trees, each one of which bears fruit after its kind and all as green now as they would be in Spain in the months of May and June, and a thousand kinds of herbs, and also of flowers. And in all this none was recognized but the aloe, of which I have ordered a great quantity to be brought to the ship to take to your highnesses. I have not sailed yet for Cuba because there is no wind, but a dead calm, and it is raining heavily as it did yesterday, without being cold at all. On the contrary during the day it is hot and nights are mild as in May in Andalusia, in Spain."

Wednesday, October 24

"This night, at midnight, I weighed anchor from the island of Isabella, from Cape del Isleo, which is on the north side, where I was anchored, to go to the island of Cuba; of this I hear from these people that it is very large, having much trade, and having in it gold and spices, and great ships and merchants; they showed me that I should steer west by southwest to go there. This I believe because I think that, if it be as all the Indians of these islands and those whom I carry with me in the ships give me to understand by signs, for I do not know their language, it is the island of Cipango, of which marvelous things are told; and in the spheres which I have seen and in the drawings of world maps, it is placed in this region. And so I sailed until daybreak to the west by southwest, and at dawn the wind fell and it rained, and so it was almost all night. I was thus with little wind until after midday, and then it began to blow very lovingly, and I set all my sails on the ship, and two bonnets, and the foresail and spitsail, the mizen, main topsail, and the boat's sail on the poop. So I went on my course until nightfall, when Cape Verde, in the island of Fernandina, which is on the south side in the western part, lay to my northwest, and was 7 leagues away from me. And as the wind blew hard, and I did not know what distance there was to the island of Cuba, and in order not to arrive at night, because all these islands lie in very deep water, so that no bottom can be found beyond two lombard shots' distance, and then it is all patchy, one part being rocky and another sandy, and hence it is impossible to anchor safely, except when it is possible to see, I decided to take in all sail, except the foresail, and to proceed under it. After a short while, the wind became much stronger and I made a considerable distance, at which I felt misgiving, and as there were thick clouds and it was raining, I ordered the foresail to be furled, and that night we scarcely sailed 2 leagues, etc."

Thursday, October 25

After sunrise, until 9 o'clock, he sailed to the west by southwest. They made about 5 leagues. Afterward he changed the course to the west. He went 8 miles an hour, until 1 o'clock in the afternoon, and from then until 3 o'clock, and they sailed about 44 miles. Then they sighted land and it was seven or eight islands in a row, all lying from north to south. They were 5 leagues away from them, etc.

Friday, October 26

He was to the south of said islands. It was everywhere shallow water for 5 or 6 leagues. He anchored about there; the Indians whom he carried with him said that from these islands to Cuba it was a journey of a day and a half for their boats, which are small vessels of a single piece of wood, carrying no sail. These are canoes. From there he set out for Cuba, because from the indications which the Indians made to him concerning its greatness and its gold and pearls, he thought that it was that land, that is to say, Cipango.

Saturday, October 27

They weighed anchor, at sunrise, from those islands, which he called "Islas de Arena" ("Sand Islands"), on account of the little depth of water which there was to the south of them up to a distance of 6 leagues. He made 8 miles an hour to the south-southwest until 1 o'clock and they sailed about 40 miles, and by nightfall they had gone about 28 miles more, on the same course; and before night they saw land. They spent the night on watch while it rained heavily. On Saturday, up to sunset, they went 17 leagues to the south-southwest.

NOTES TO APPENDIX

I. The above translation has been made directly from Father Las Casas's autograph kept at Madrid, as transcribed in "Raccolta di Documenti e Studi Pubblicati dalla R. Commissione Colombiana del Quarto Centenario dala Scoperta dell' America," pt. 1, vol. 1, pp. 15 to 30.

II. Special care has been taken to follow closely Columbus's old Spanish wording. Accordingly, the translator has retained as far as the modern English language allows, the same phrases, idiomatic expressions, equal paragraph divisions, and punctuation employed by the Discoverer.

III. Some Spanish words used by Columbus (because they are archaic Castilian) have today quite a different meaning. In these cases the significance as denoted by the Admiral has been translated into English.

IV. It is my belief that this is a thoroughly dependable translation.

ARMANDO ÁLVAREZ PEDROSO
Havana, May 11, 1956

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MINERALOGICAL STUDIES ON GUATEMALAN JADE

(With Four Plates)

By
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Formerly Head Curator, Department of Geology
United States National Museum
Smithsonian Institution

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INTRODUCTION

Wherever the stone called jade was known to early cultures it was used extensively in the shaping of celts and similar artifacts. In the more advanced civilizations it was also used in objects of ceremony and adornment. The characteristics of the material that probably appealed particularly to the ancient artisan were the toughness of the stone, which permitted him better to exercise his artistic inclinations, and the capacity of the mineral to receive and retain a high and lustrous polish.

The earliest recognized use of jade was by the inhabitants of the neolithic lake dwellings of Europe. Among the forms of jade used as celts during thoses early times are jadeite, nephrite, and chloromelanite, minerals known to occur at a number of localities in that region but sufficiently rare to entail a special knowledge of the stone to enable the artisan to seek it out.

The use of jade in the form of ceremonial celts was widespread in the islands of the Pacific. The occurrence of jade in New Zealand was first reported to the voyager Captain Cook. This form of nephrite jade was called *poonamu* by the Maori aborigines and, in addition to celts, was used by them for ceremonial war clubs and small figurines. Rough nephrite and celts are also known from New Guinea, and celts from New Caledonia, Fiji, and other islands of Oceania.

Jade was widely used in China. The earliest objects are those of the Shang Dynasty (fourteenth to twelfth centuries, B.C.), but the

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[2] Dr. Foshag died in Washington, D. C., on May 21, 1956.

high artistic development of its elaboration presupposes a long period of previous development, probably reaching back into neolithic times. The sources of the earliest jades are unknown but were probably localities in China now forgotten or exhausted. Nephrite jade from Turkestan made its appearance in abundance during the Han Dynasty (206 B.C.-A.D. 220) and continues in use to this day. Jadeite jade from Burma did not come into use in China until the latter part of the eighteenth century.

In America simple nephrite jade celts were found in use by the aborigines of the Amazon River by the explorers of the early sixteenth century, and rough nephrite has been found in Bahía, Brazil. Simple nephrite tools were used by the Indians of the Pacific Northwest and Alaska, who obtained the raw material from the Frasier and other rivers of British Columbia.

Finally there was the widespread and varied use of jade by the indigenous culture of Mesoamerica, in an area extending from Guanajuato, Mexico, to Panamá.

The use of jade by ancient and modern Chinese is widely recognized, owing largely to the fact, perhaps, that this material continues in use to the present day and remains a common article of sale in the stock of many jewelers. As a consequence, people are quite familiar with this material and understand something of its nature and even of the mysticism that surrounds its use. An erroneous notion that jade is known *only* from China is widespread. It is less well known that jade was known and extensively used by the early indigenous cultures of Mesoamerica and that this indigenous American jade is equal in quality and comparable in the artistic merit of workmanship to the finest Asiatic product. The term "jade" is, in fact, of Spanish origin and referred to the American material long before the Asiatic material was known to the Western world.

Our knowledge of Chinese jades is comprehensive, not only for the abundance of material available for study, but also because of the very early accounts of its use and the details of the mysticism associated with it found in early Chinese works. Laufer (1912, p. 8) mentions works in Chinese as early as A.D. 1092. The *Ku yu t'u p'u,* "Illustrated Description of Ancient Jades," was published in 1176, and *Ku yu t'u,* "Ancient Jades Illustrated," by Chu Têh-jun, in A.D. 1341. A huge bibliography has since grown up about this subject, including not only archeological, ethnological, and art studies, but researches in the mineralogy, petrology, and geology of the material.

In contrast to this, the writings relating to American jade are comparatively few. These consist of rather casual mention of jade by the early chroniclers of the Conquest of Mexico (Cortés, Díaz del Castillo, the Anonymous Conqueror, Sahagún, Motilinía, Tezozomoc, and Torquemada) and a few mineralogical studies on archeological jade. The latter have been far too few to fully characterize the mineralogical range of the so-called jades.

Since the earliest known American jades show an extraordinarily high artistic merit, being, in fact, superior in this respect to later American jades, it presupposes a long and ancient artistic development during a civilization or culture of which we are now totally ignorant. When these missing chapters in the history of the indigenous Central American cultures are eventually revealed, it will more than likely be found that the development of the art of jade carving will not only parallel that of China, but be essentially contemporaneous with it. It is already apparent that the artistic zenith in jade carving during the Chou Dynasty of China is contemporaneous with the apogee of hard-stone carving attained by the "Olmecs" about the same time. This does not imply that the two arts are connected in origin and development, but that, by a curious coincidence, the two had their beginnings at about the same time, although differing in design and probably in significance, but comparable in technique and merit.

It is unfortunate that outstanding examples of hard-stone carvings of the early indigenous American cultures do not have a wider representation among the important museums of the world; otherwise their very high artistic merits, gaged even by modern standards, would be widely recognized. The finest of the early examples have a strength and simplicity of line and form not exceeded by any other culture. One need only examine a few of the portrait heads of "Totonacan" or "Olmecan" origin to recognize in them the highest elements of artistic expression. Their simple stylization produces an effect that is, to many students of this type of art, more exciting and exhilarating than the naturalistic forms developed by the Greeks. Like all similar arts, however, the period of early pure art was followed by a period of decadence, in which intricacies and frivolities of design were introduced and naturalistic tendencies became more evident, although some designs of pure line and concept persisted even into Aztec time.

With the final conquest of the indigenous races of Central America by the Spanish and the supplanting of the indigenous cultures and arts by Europeanized forms, the use and knowledge of jade very rapidly disappeared. The sources of supply of jade were soon lost, if they were not already depleted before the arrival of the Spaniards. With this loss of an advanced indigenous art, the folklore associated with it also largely disappeared. So thoroughly was the appreciation of jade eradicated from the indigenous mind that knowledge of the material, its art, and its folklore apparently disappeared from a region where but a a few years previously it was held in the highest esteem —a jewel appropriate to the kings and the gods.

The present study of the mineralogical nature of Mesoamerican jade is based upon the extensive collections of the Instituto de Antropología e Historia de Guatemala. Included in this material are the collections obtained by the Division of Historical Research of the Carnegie Institution of Washington made during their extensive excavations at Kaminaljuyú, Nebaj, San Agustín Acasaguastlán, and Uaxactún. Also included is the Rossbach collection, at Chichicastenango, under the direction of the Instituto. The study was supplemented by an examination of the important Nottebohm and Robles collections.

Mineralogical determinations were made by means of the petrographic microscope using the technique of determining optical properties by the use of immersion liquids. This technique was supplemented by an occasional examination by means of X-ray diffraction patterns. Both of these methods proved to be easy and precise for the identification of the jade minerals.

The program of study was proposed and supervised by Lic. Hugo Cerezo Dardón, Director of the Instituto, whose constant interest and assistance made the study possible. Sr. Antonio Tejeda Fonseca, chief of the section of Museología, similarly cooperated in all ways to expedite the study. Dr. Stephen Borhegyi, then of the staff of the Instituto, permitted me to share his enthusiasm for the treasures of the museum's collections.

Dr. Alfred V. Kidder, chief of the Division of Historical Research of the Carnegie Institution of Washington, was my constant mentor during this study. It would be difficult, at this point, to recognize how much that is contained in this report, and which I now claim for my own, was not actually imbibed from his vast knowledge of Mesoamerican jade. Similarly, Robert Smith and Edward Shook have guided my footsteps along the paths of archeological mineralogy.

I am greatly indebted to Sr. Carl Heinrich Nottebohm, of Guatemala City, and Sr. Vitorines Robles, of Quetzaltenango, for their pleasant reception and their permission to study the interesting jades of their collections.

HISTORY OF THE USE OF JADE

The Spanish explorers first encountered jade during the Crijalva expedition along the coast of Yucatán (1518), as mentioned by Bernal Díaz del Castillo (1632, vol. 1, p. 47). Describing the Indian settlements at the mouth of the Río Grijalva, he wrote:

> Moreover, we wished to give them some of the things we had brought with us. As they understood what was said to them, four of the canoes came near with about thirty Indians in them, and we showed them strings of green beads and small mirrors and blue cut glass beads, and as soon as they saw them they assumed a more friendly manner, for they thought they were *chalchihuites* which they value greatly.

And again (p. 52), in writing of Montezuma's interest in the arrival of the Spaniards, he stated:

> All this news had been brought to him painted on a cloth made of hennequen which is like linen, and as he knew that we were coasting along toward his provinces he sent orders to his governors that if we arrived in their neighborhood with our ships that they should barter gold for our beads, especially the green beads, which are something like their chalchihuites, which they value as highly as emeralds.

An indication of the great value placed by the Aztecs on jade is expressed by Montezuma's words to Cortés upon the presentation of several of these stones in tribute: "I will also give you some very valuable stones, which you will send to him in my name; they are chalchihuites and are not to be given to any one else but only to him, your great Prince. Each stone is worth two loads of gold." (Vol. 2, pp. 136-137.)

There is little specific mention of the use of jade among the Maya in the early Spanish chroniclers, although these people must have known of this material. Some of the regions contiguous to the Mayan area paid tribute in jade to the Aztec conquerors, as, for instance, Kolotlán, Maxtlán, and Tehuantepec (Tezozomoc, 1614, p. 539). In their campaigns of conquest the Aztecs under Montezuma reached as far as Honduras and Nicaragua. In these excursions they passed through Guatemala, collecting tribute; "y pasando adelante, llegaron a la Vera Paz, haciendo estas, y otras cosas semajantes. Y de esta Tierras, les tributaran después Oro, y Plumas Verdes, y otras cosas, que la Tierra daba, y producía, y Piedras, asi de Esmeraldas, como Turquesas, de mucho valor y estima; . . ." (Torquemada, 1613, lib. 2d, cap. 41.)

"Certain precious stones" are mentioned by Gaspar Antonio Chi (1581, p. 231) as being used as money by the natives of Yucatán.

In early colonial times the knowledge of jade persisted as far south as San Salvador, for García de Palacio (1576, *in* Squier, 1860, pp. 51-52) mentions "unos Chalchibites" being found on an island in a lake near Coatán, not far from Santa Ana.

It appears, however, that the Maya made little use of jade at the time of the Spanish Conquest. This apparent lack of appreciation of a stone so highly prized during the classic periods was probably a result of the general decline of the Mayan cultures after the collapse of the Second Empire.

Many of the arts practiced by the Aztecs were acquired by them from the remnants of an earlier culture inhabiting the Valley of Mexico, the culture of a people referred to in the chronicles as Tolteca. The Aztecs attributed to their predecessors many cultural virtues including the development of the lapidary art. Torquemada (1613, lib. la, cap. 14, p. 37) stated, "y dicen de ellos que trageron el Maíz, Algodón, y las demás Semillas, y Legumbres, que ai en esta Tierra; y que fueron grandes Artifices de labrar Oro, y Piedras preciosas, y otras muchos curiosidades." And Sahagún (1530, lib. 10, cap. 29): "Ellos mismos (Las Toltecas) por su gran conocimiento hallaron y descubrieron las piedras preciosas, y las usacron ellos primero, como son las esmeraldas y turquesa fina y piedra azul fina, y todo género de piedras precíosas."

Information on earlier uses of jade depends entirely upon archeological investigations. Such studies have revealed a much wider use of this material. The Maya, during both Early and Middle Classic periods, not only used it freely but were highly skilled in the artistic elaboration of this refractory stone. No finer examples of Mayan-style artistry are known than the magnificant specimens from Nebaj and Kaminaljuyú. Zapotecan and Mixtecan jadework have equally high merit as collections from Monte Albán will show.

Finally, jade has been found in Pre-Classic sites in both Guatemala and Mexico. The discoveries of Shook at Finca Arizona (1945) and of Shook and Kidder at Kaminaljuyú (1952) indicate that the cult of jade was already well established, sources of supply for fine stone readily at hand, and the involved techniques of its lapidary elaboration developed. And if the mysterious "Olmec" culture was contemporary with the "Archaic" or Pre-Classic cultures as discoveries at Tlatilco, Mexico, indicate, the artistic elaboration of jade reached its apogee at a very early period. This Olmec art is so advanced that centuries of development by perhaps still unknown cultures must be postulated to explain its attainment.

Chronological dating, based upon the rate of decay of carbon 14, now indicates that the earliest known use of jade in Mesoamerica dates back to about 1500 B.C. (Libby, 1952, p. 90). Its use by the indigenous cultures of Mesoamerica continued to about A.D. 1600. Monardes in his "Historia Medicinal" (1569) wrote that jades were then no longer readily obtainable, since they had been largely bought up from the caciques and nobles for export to Europe as "piedras de ijada." It then remained in vogue as an ornamental and ceremonial stone among the cultures of Mesoamerica for more than 3,000 years.

NOMENCLATURE

There are no references to jade in mineralogical or pharmacological literature before the discovery of America. Undoubtedly our knowledge of this mineral began with the opening of the New World. The Portuguese explorers of Brazil found a green stone, which they called *amazonstone,* in use among the natives. This term is now restricted to a green variety of microcline, a member of the feldspar group of minerals. Another stone of grayish-green or dark-green color was also encountered, chiefly in the form of celts. This mineral is a variety of actinolite or tremolite, members of the amphibole group of minerals, and is now called *nephrite.*

The Spanish conquerors of Mexico found a precious green stone, somewhat similar in appearance to the two Brazilian stones, being used and highly prized by the Aztecs and other indigenous people of Mesoamerica. The Aztecs called this *chalchihuitl.*

The early Spanish chroniclers frequently referred to the fine green stone from Mexico as emerald. This is not surprising since they knew only the inferior emeralds from Austria and Egypt, which the finest Mesoamerican jade surpassed in color, for the superlatively fine emeralds from Colombia were as yet unknown to them. The very high esteem in which the Aztecs and other indigenous tribes held this stone undoubtedly fostered this error. To the early chroniclers "chalchihuitl" meant "emerald." Thus Torquemada (1613, vol. 2, cap. 45, p. 521), in describing the preparation of the corpse of deceased nobles prior to cremation says, "ponianle en la boca una Piedra fina de esmeralda que los Indios llam chalchihuitl"; Tezozomoc (1598, pp. 375, 434) refers to "esmeraldas y otras muchos generos de piedras chalchihuitl," etc.

The Aztecs, too, had their particular terminology for jade and its varieties. Generically, it was known to them as *chalchihuitl.*

Molina (1585) defines *chalchihuitl* as "esmeralda basta." According to Mena (1927, p. 7) the word "chalchihuitl" is derived from the Nahuatl *xalxihuitl* (*xalli,* sand or jewel; *xihuitl,* herb or herb colored).

Molina also defines *xalli* as a certain arenaceous stone (cierta piedra arenisca), a characterization that might apply to a distinctly granular rock. The term probably means herb-green stone.

Sahagún (1530, lib. 11, cap. 8, p. 3) describes various categories of this stone, as follows:

Quetzalitztli: "son precious de mucho valor, llámanse asi porque *quetzalli* quere decir pluma muy verde, y *etztli* piedra de navaja, la qual es muy pulida y sin mancha ninguna, y estas dos cosas tiene la buena esmeralda que es muy verde, no tiene mancha, y muy pulida y transparente es resplandeciente." It is unlikely that this stone is truly emerald, for no emeralds have yet been found in the Mesoamerican region, either naturally or in archeological sites. The stone referred to is probably the finest quality of emerald-green jade, similar to the Chinese *fei-tsui* or imperial jade. Such fine green and almost transparent jade is found rarely in small objects, usually of Olmec origin. A small pendant of this quality stone is in the Nottebohm collection.

Quetzalchalchihuitl: "es muy verde y tiene manera de chalchihuitl; dícese así porque es muy verde y tiene mancha ninguna, y son transparentes y muy verdes, las que no son tales tienen razas y manchas, y rayas mezceladao!"

Except for the quality of transparency mentioned by Sahagún for quetzalitzli, this description suggests the fine, green, uniformly colored jade that is found among Olmec pieces. No important pieces of this quality stone have, as yet, been encountered in Guatemalan collections.

Chalchihuites: "Son verdes y no transparentes, mezcladas de blanco; úsanlas mucho los principales, trayéndola, en las muñecas, atándolas en hilo y aquello es señal de que as persona noble el que la tral; a los *macequales* no les era lecito traela."

This stone is undoubtedly the common jade of green and white color, such as is found so abundantly at Kaminaljuyú.

Tlilayotic: "Es del género de los chalchihuites, tiene mezcela de negro y verde." Leon (1938, vol. 3, 353) renders this term as malachite, but it is doubtful that this translation is correct. The native lapidary would hardly associate the soft malachite with the hard and tough *chalchihuitl.* Etymologically the word is derived from the Nahuatl *tliltic* (black) and *ayotic* (adjectival form of *ayotl,* gourd), that is to say "dark-green gourd color." This suggests the finer qualities of the jade mineral chloromelanite, as exemplified in the earplug from Uaxactún (3619)[3] of bottle-green color, or some of the forms

[3] These numbers refer to the catalog numbers of the collection of the Instituto de Antropología e Historia de Guatemala.

of diopside-jadeite like the curious serpent-head from Uaxactún (3307) of forest-green color.

Iztacchalchihuitl: "Algunas de estas piedras entre blanco tienan unas vetas verdes o de azul claro, tienen también otros colores entrepuestos con lo blanco, y todas estas piedras tienen virtud contra las enfermedades."

Sahagún (1530, lib. 11, cap. 8, p. 4) classes this stone as jasper. Its etymology (*iztac*, white—*chalchihuitl*) and its description suggest the white forms of jade with little green coloration, such as one finds in the Kaminaljuyú collections. It may also refer to those mixtures of jadeite and albite in which the albite predominates (jadeitic albite).

Xiuhtomoltetl: "Es como chalchihuitl verde y blanco mezclado; es hermosa; Traen esta piedra de hacia *Guatimala* y de *Xoconochoo;* no se hace por acá, hacen de ella cuentas para poner en las muñecas."

Molina defines *xiuhtomolli* as "turquesa, piedra preciosa."

Sahagún (lib. 10, cap. 29, p. 4) also mentions "chalchihuites fingidos" used by the common people to whom the use of jade was denied. This material may have been any one of the lesser stones found in archeological deposits and which show the poorer qualities of workmanship—metadiorite, serpentine, or muscovite.

Monardes (1569) refers to this stone as *piedra de yjada* and appears to have been the first to use this term in print:

> The other stone, which is called piedra de yjada and which appears to be the finest kind of emerald-plasma, tends toward green with a mixture of white, the deepest greens are the best. These are worn in various forms, as the Indians have worn them from ancient times, some like fish, others like bird heads, others like the beak of parrots, also others like round spheres, all perforated for the Indians were accustomed to carry them because of their effect in pains of the side or in the stomach, for which they are supposed to have wonderful effects.

Early writers in Latin (Hernandes, 1615; Clutius, 1627; Bartholinus, 1628; de Laet, 1647, etc.) translated the term "piedra de ijada" into its Latin equivalent "lapis nephriticus." In the French translation of the term it became *pierre l'ejade* or, simply, jade (Buffon, 1749).

To which mineral, the Brazilian or the Mexican, was first ascribed the virtue of alleviating pains in the loins or the kidneys cannot be determined. The Aztecs, as far as the record shows, did not impute any such property to chalchihuitl. A statement by Wittich (1589) that "one can buy such stones for kidney-stones from the Portuguese of Antwerp for sufficient money" suggests that their source was in some Portuguese colony.

Camillus Leonardus (1502), writing immediately before the discovery of Mexico, makes no mention of either name, although he describes about 200 stones used in medicine, including two, *cogolites* and *lyncis,* given as specifics for diseases of the bladder and kidney stones.

In the mid-seventeenth century the nephritic stone of the Orient became known in Europe, while the Mexican stone was soon forgotten, probably because examples of Mexican jade became rare. Within 50 years after the Spanish Conquest of that region Monardes (1569) reported that the stones were rare since they had already been bought up from those caciques and nobles who possessed them. The name "jade" was then transferred from the original Mexican stone to the oriental material to such an extent that some later writers denied the occurrence of true jade in America.

The mineralogical name nephrite was first applied to lapis nephriticus (pierre nephritique) by Werner (1780), but it remained for Damour (1846), investigating the jade of "India," to demonstrate its true mineralogical affinities as a compact variety of the amphibole minerals tremolite and actinolite. In a later study Damour (1863) found that a second mineral, a silicate of aluminum and sodium, was also included in the material called jade. This new mineral species he named *jadeite.* It was not until 1881 that chemical analyses by Damour showed that the Mexican stone was also jadeite. Thus, in a curiously indirect manner, the "piedra de yjada" of the Spaniards became associated with the modern mineralogical species name jadeite.

A list of early Spanish chroniclers and others who referred to jade is given below:

1519	Cortés (inventory): piedras verdes.
1519	Cortés (Merced): chalchihuitl (apocryphal ?).
1530	Pedro Mártir: piedras verdes, esmeralda.
1530	Sahagún: piedra verde preciosa, chalchihuitl, chalchihuites (pl.), quetzalitztli, quetzalchalchihuitl, tlilayotic, esmeralda.
1541	Motolinía: chalchihuitl.
1552	Martín de la Cruz and Juannes Badianus (Badianus MS.): smaragdus, yztacquetzalletztli, quetzalytztli.
1554	López de Cómara: esmeralda.
1565	Monardes: piedra de yjada.
1571	Molina: chalchihuitl.
1576	Garcia de Palacio: chalchibites, chalchivites, piedra de yjada.
1580	Francisco de Casteñada: chalchihuites.
1585	Durán: piedra verde rica.
1590	Acosta: esmeralda, piedra de hyjada.
1598	Tezozomoc: esmeralda, chalchihuitl.
1601–1615	Herrera y Tordesillas: piedra verde rica, chalchibite, chalchihuitl, esmeralda, piedra de yjada.

1609	Boetius de Boodt: osiada, kalsbee, kalssuwyn, siadre.
1612	Vásquez de Espinosa: piedra de ijada.
1613	Torquemada: esmeralda, chalchihuites, piedra verde.
1615	Hernández (Ximenes): lapis nephriticus, ytlibayotea-quetzalitztli.
1632	Díaz del Castillo: chalchihuites.
1644	Boetius de Boodt (French edition): pierre nephritique.
1647	Joannis de Laet: lapido nephritico, iztli-ayotli, quetzal itztli.
1732–1735	Zedler: jade, pierre nephritique, griestein.
1788	Werner: nephrite.
1865	Damour: jadeite.

A mineral closely related to jadeite occupies a mineralogical position intermediate between it and its pyroxene congener, diopside, a silicate of calcium and magnesium. It is appropriately called *diopside-jadeite* to indicate its relationship to these two mineral species. Washington (1922a, pp. 321, 325) proposed the additional names *tuxtlite* and *mayaite* for this mineral, an unjustifiable redundancy of names.

Another closely related mineral has a chemical composition intermediate between jadeite and acmite, a sodium iron silicate, the iron analogue of jadeite, or between jadeite, acmite, and diopside. Because of its characteristic dark-green color it has been named *chloromelanite* (Damour, 1865).

For convenience we may append here the definitions for the mineralogical forms of jade.

Jadeite: A mineral species of the pyroxene group of minerals, essentially a silicate of sodium and aluminum.

Diopside-jadeite: A mineral species of the pyroxene group of minerals, intermediate between jadeite and diopside, essentially a silicate of sodium, calcium, magnesium, and aluminum.

Chloromelanite: A mineral species of the pyroxene group of minerals, intermediate between jadeite and acmite, or jadeite, acmite, and diopside, essentially a silicate of sodium, calcium, magnesium, iron, and aluminum.

Nephrite: A compact variety of the minerals tremolite (calcium magnesium silicate) or actinolite (calcium magnesium iron silicate), mineralogical species of the amphibole group of minerals.

GEOLOGICAL OCCURRENCE

Jadeite has not been found in place in Guatemala [4] or in other parts of Mesoamerica, although there can be no doubt that the archeological material is of an indigenous origin, for it has distinctive characteris-

[4] Since this has been written, fine jadeite of a lichen-green color has been found in situ near Manzanal, Guatemala, by Robert Leslie, Guatemala City.

tics that distinguish it from jades from other sources. Some clue as to its source can be obtained from a mineralogical study of the artifacts and a comparison of this jade with other jadeite occurrences.

In localities where jadeite has been found in situ, it is always closely associated with serpentine rocks and accompanied by the mineral albite in a pure and distinctive form. Thus, at Tawmaw and other nearby localities in Burma, the source of oriental jade, the jadeite forms segregation veins in serpentine. The veins have an outer zone of green chlorite schist and black amphibolite. Immediately adjacent to the jadeite bodies is an enveloping shell of albite that grades successively into jadeitic albite and albitic jadeite to the central mass of relatively pure jadeite (Chibber, 1934, pp. 26-77). Other occurrences of jadeite in Japan (Kawano, 1939; Iwao, 1953) and California (Yoder and Chesterman, 1951) are similarly associated with serpentine and albite. The mineralogical nature of the Guatemala jadeite is exactly similar to the jades of these localities. Particularly significant is the close association of pure albite with the jadeite and the chemical composition of the jadeite, indicating that the geological environment of Guatemala jade is very similar to these other jadeite occurrences. About Tawmaw, and in California, too, glaucophane schist, chlorite schist, and actinolite-zoisite granulite are found in close association with the jadeite-bearing rocks. These same rock types are found among the stone artifacts included in Mesoamerican collections.

Since the characteristic association of jadeite in all the known occurrences is with serpentine bodies intrusive into crystalline rocks, one can reasonably expect that any Mesoamerican occurrence would be similarly situated. Serpentine is an uncommon rock, not widely distributed. Any Mesoamerican area of serpentine, therefore, is a possible source of jadeite.

A small area of serpentine, in part a laminated form called antigorite schist, is known near Tehuitzingo, state of Puebla, Mexico. This occurrence forms a ridge extending from Tlachinola to Tecolutla and Atopoatitlán. The associated crystalline rocks are quartzite, mica schist, and hornblende schist. A cursory exploration of this small area by the writer did not reveal jadeite or any evidence of primitive mining. Some of the serpentine, however, has a distinctive antigoritic character, entirely similar to the antigorite of many Olmec figurines. At the foot of this serpentine ridge is a group of small ancient mounds indicating that the locality was known to an early indigenous population.

A few small occurrences of serpentine are shown near Chimalapa, in southern Chiapas, on Sapper's geological map of Guatemala (Sap-

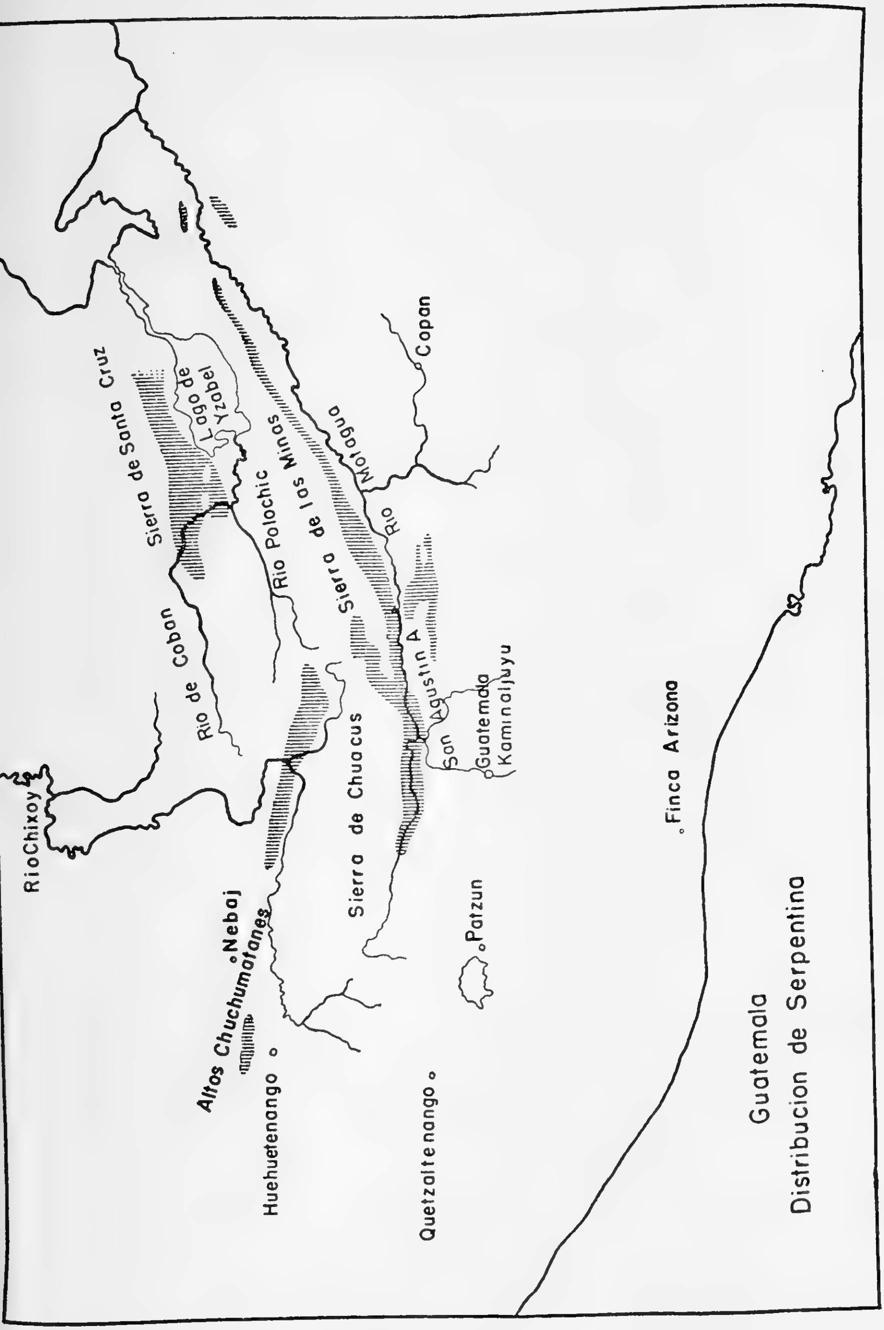

FIG. 1.—Map of Guatemala, showing distribution of serpentine. (After Sapper.)

per, 1937), but nothing is known of the details of the petrology of these masses.

The important occurrences of serpentine are within the confines of Guatemala. A belt of this rock extends along the north slope of the Motagua Valley, including the south slopes of the Sierra de Chuacús and Sierra de las Minas, and a contiguous mass south of the Rio Motagua and east of Sanarate. A second zone lies along the Río Negro, extending from Zacapulas to Santa Rosa, and a third area is found along the western shore of Lake Yzabal, from Estor to Cahabón. These areas are shown on figure 1. There is, finally, a small area exposed on the coast of Guanaja Island.

Pieces of unworked jade recovered by archeological explorations have been in the form of water-worn pebbles. Many of the worked pieces, too, show distinct evidences of having an original pebble or cobble shape. In general, the pieces show only moderate abrasion, indicating that they were not transported far from their original source by the streams. Such unworked pebbles of jade have been recovered in archeological excavations at Kaminaljuyú, San Agustín Acasaguastlán, and Quiriguá. Partially worked pieces of jade or workshop material are not uncommon in Guatemalan sites.

The favorable geology for jade in the Sierra de Chuacús and Sierra de las Minas, as well as the concentration of unworked and partially worked jade materials in sites along and contiguous to the Motagua River Valley, suggests this area as a source of some, if not all, of the Mesoamerican jade.

The beds of the streams draining from these serpentine areas should be carefully examined for pebbles and cobbles of jade. Following such jade pebbles, when encountered, upstream should lead to the actual outcropping of the mineral. Jade pebbles, when wetted, should resemble the polished artifacts in both color and luster.

CHEMICAL PROPERTIES

The mineral jadeite, the principal component of Guatemalan jades, is a sodium aluminum silicate, whose chemical composition is represented by the formula $NaAlSi_2O_6$. As a member of the pyroxene group of minerals the composition of jadeite can be modified by the addition of the molecules of other members of this group, with which the jadeite molecule can mix in any proportion. The commonly associated molecules are those of diopside, $CaMgSi_2O_6$ and acmite $NaFeSi_2O_6$. When mixed with diopside the variety of jadeite is called *diopside-jadeite* or *tuxtlite;* and when mixed with acmite, or diopside and acmite, the variety is called *chloromelanite.* Jadeite and its two varieties, diopside-jadeite and chloromelanite, are found among the jades of Guatemala.

A number of chemical analyses of Mesoamerican jades have been published in scientific literature, but all of them previously reported have been made on samples in which the jadeite was mixed or contaminated with accessory minerals, chiefly albite in varying proportions. The analyses given by Washington (1922a, p. 322) are, for example, mixtures of this kind. Calculations of the composition of the jade mineral contained in such samples can lead to erroneous results or interpretation, particularly where the percentage of the contaminant is high. To best understand the mineralogical nature of jade, and to allow a ready and accurate comparison between specimens, it is desirable to first separate the jade mineral in pure form. This can be accomplished by the use of heavy liquids and electromagnetic separators. The analysis of the pure mineral is more diagnostic and gives a more accurate basis for comparison of the jades with each other. The analyses given below were made upon samples of the purified mineral. Their purity was checked by examining the powder prepared for analysis under the petrographic microscope.

From the material available for analysis, five samples were selected. These cover satisfactorily the range in variation shown by Guatemalan jade. The results of the chemical analyses are given in table 1. For comparison an analysis of Asiatic (Burma) jade and of European chloromelanite are included, as well as the composition of the theoretically pure jadeite and diopside-jadeite (equal proportions of the two molecules).

It is common practice in mineralogy to calculate the chemical composition of a mineral in terms of theoretical pure mineral molecules of the components of a complex series such as pyroxene. These interpretations frequently serve to simplify the comparison of various members of a family. This has been done for the analyses above and the results are shown in table 2.

From a study of the analyses and the molecular composition of the jadeites given in tables 1 and 2 it is apparent that there are three distinct mineralogical varieties included in Guatemalan jades: (1) jadeite with a limited content of diopside (about 10 percent—Nos. 3, 4, 5); (2) diopside-jadeite with a chemical composition almost exactly halfway between its component and members (jadeite 50 percent, diopside 50 percent—Nos. 6, 7), and (3) chloromelanite, or acmitic jadeite (No. 8).

These analyses suggest that there are at least three centers of pro-

TABLE 1.—*Analyses of jadeite*

	1	2	3	4	5	6	7	8	9	10
SiO_2	59.4	59.51	59.35	58.12	58.26	56.28	55.50	57.50	57.39	54.03
TiO_2		0.01	0.18	0.31	0.04	0.03	none		0.44	0.54
Al_2O_3	25.2	24.31	22.18	20.32	22.23	12.18	12.33	12.10	18.93	11.54
Cr_2O_3		0.01		0.01	none	none	none		none	none
Fe_2O_3		0.35	1.15	2.49	0.71	0.85	1.41		4.45	5.62
FeO		0.03	0.32	0.77	0.21	1.28	1.33		0.81	4.09
MnO		0.01	0.01	0.07	0.03	0.13	0.05		0.09	0.05
MgO		0.58	1.77	2.16	2.18	9.02	8.72	9.60	1.92	5.13
CaO		0.77	2.57	3.13	3.72	12.60	12.76	13.40	2.74	11.82
Na_2O	15.4	14.37	12.20	12.43	11.91	6.32	6.94	7.40	12.46	6.81
K_2O		0.02	0.20	0.10	0.40	0.11	0.25		0.11	0.20
H_2O		0.06	0.20	0.16	0.44	1.00	0.30		0.54	0.29
		100.03	100.15	100.07	100.13	99.80	99.59		99.88	100.12
Sp. Gr.			3.356	3.355	3.246	3.196	3.270		3.289	

1. Jadeite; theoretical composition.
2. Jadeite; Burma. E. Zies, analyst, *in* Yoder (1950, p. 229).
3. "Blue-Jade," Mexico. Joseph Fahey, analyst.
4. Jadeite, from large pea-green-colored celt, Guatemala. Joseph Fahey, analyst.
5. Jadeite, from boulder (No. 2078) tomb, Kaminaljuyú, Guatemala. Joseph Fahey, analyst.
6. Diopside-jadeite, rough fragment. Kaminaljuyú, Guatemala. Joseph Fahey, analyst.
7. Diopside-jadeite (tuxtlite), Tuxtla statuette, Mexico. H. S. Washington (1922b, p. 5).
8. Diopside-jadeite; theoretical for $NaAlSi_2O_6$, $CaMgSi_2O_6$.
9. Chloromelanite, from grayish-green celt, Guatemala. Joseph Fahey, analyst.
10. Chloromelanite, Vanelsvdalen, Norway. L. Thomassen, analyst, in Eskola (1921, p. 32).

venience for Guatemalan jade, not necessarily, however, widely separated. The three jadeites Nos. 3, 4, and 5 are remarkably similar to each other in chemical composition, considering their differences in physical appearances, and are, perhaps, derived originally from a circumscribed area. The black jades, or chloromelanite, are a ferrian or acmitic variety of the jadeitic jade and closely related to it. The compositions of the diopside-jadeite (tuxtlite) of the Tuxtla statuette and of the fragment from some workshop material from Kaminaljuyú are so similar that it seems almost certain that their ultimate source was the same.

TABLE 2.—*Molecular composition of jadeites*

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Jadeite	96½	89	89	84	45	45	77	38
Acmite		1		2	2	2	12	16
Diopside	1½	10	12	12	49	49	11	42
Others	2		1	2	4	4		

1. Varieties.
2. Jadeite; Burma.
3. Blue jade; Mexico.
4. Jadeite, pea green; Guatemala.
5. Jadeite, Kaminaljuyú boulder; Guatemala.
6. Diopside-jadeite; Kaminaljuyú, Guatemala.
7. Diopside-jadeite; Tuxtla, Mexico.
8. Chloromelanite; Guatemala.
9. Chloromelanite; Norway.

A comparison of these molecular compositions also shows clearly an appreciable difference in composition between the Burmese jadeite (96½ percent jadeite, 1½ percent diopside) and Mesoamerican jadeite (89 percent jadeite, 10-12 percent diopside). It would also be of interest to point out that there is no equivalent of diopside-jadeite among oriental or any other jade, and that the Mesoamerican chloromelanites differ very appreciably from European chloromelanites. The jadeite of recently discovered occurrences in California show, in turn, appreciable differences in chemical composition from the Mesoamerican materials.

OPTICAL PROPERTIES

Even to a person with only a moderate familiarity with the uses of a petrographic microscope, the identification of jade by optical methods is rapid and easy. To one with experience in petrographic techniques a great deal of useful information can be obtained through the use of this instrument. A minute fragment, or a small amount of powder scraped from a broken edge or a rough corner yields enough material for the necessary observations. A rapid and approximate determination of the mean index of refraction (*n*) of the mineral not only distinguishes jade from other similar materials but also allows the separation of jade into its more specific minerals—jadeite, diopside-jadeite, or chloromelanite.

The mean index of refraction can be determined most easily by comparing the index of refraction of the mineral with that of a liquid of known index. This method is known as the immersion method.[5]

Many minerals (the optically biaxial group) have three distinct indices of refraction, corresponding to the three principle directions in the crystal lattice of the substance. In the jade minerals the lowest index (α) and the highest index (γ) are easily determined. The intermediate index (β) is more difficult to determine. Fortunately no great accuracy in the determination of the indices of refraction is required to distinguish the jade minerals from others with which it is likely to be confused. A determination of the mean index (*n*) suffices to distinguish jadeite and its congeners from other minerals used in the indigenous cultures of Mesoamerica.

To determine the mean index of a refraction of a mineral it is necessary only to crush a small fragment on a glass microscope slide, place a drop of appropriate liquid on the crushed mineral, cover with a cover glass, and observe the grains under the petrographic microscope, using inclined illumination and a moderate magnification. The simplest device to obtain inclined illumination is to introduce the tip of the finger below the condenser of the microscope. This operation casts a shadow over a part of the visible field of the microscope. If the index of refraction of the immersion liquid matches that of the mineral, one edge of the mineral grain appears red, the opposite edge blue.

The indices of refraction for jadeite of known composition from Mesoamerica and jadeite from Burma introduced for comparison are given in table 3.

The variations in the indices of refraction show that the value increases with an increase in the diopside content of the mineral; that is, in the change from jadeite to diopside-jadeite. Unfortunately this change is rather strongly modified by an increase in the iron content of the mineral, as is usual in all minerals where iron is a variable constituent. This is particularly clearly the case in chloromelanite, where a high acmite content raises the indices of refraction to the highest in the jadeite group.

[5] The procedure is described in Larsen, Esper S., and Berman, Harry, The microscopic determination of the non-opaque minerals. U. S. Geol. Surv. Bull. 848, 1934.

The values show, however, that a jade with a mean index of refraction ranging from 1.66 to 1.67 is jadeite, one of 1.68 is either diopside-jadeite or chloromelanite. These latter two can be easily distinguished, under the petrographic microscope, by their birefringence. Diopside-jadeite shows bright interference colors—yellow, green, red—between crossed nicols, while chloromelanite shows birefringence colors in gray, or even of an anomalous blue to brown color change.

From table 5, which gives the optical properties of other minerals used by the early indigenous artisan, and with which jadeite might be confused, it is apparent that the mean index of refraction of jadeite,

TABLE 3.—*Indices of refraction—jadeite composition*

	η	α	γ	*jd.*	*Ac.*	*Di.*	*Others*	*Name* *
1	1.66	1.654	1.667	96		2	2	Jadeite
2	1.66	1.655	1.673	84	2	12	2	Jadeite
3	1.66	1.658	1.672	89	1	10		Jadeite
4	1.67	1.663	1.679	81	1	12	6	Jadeite
5	1.68	1.666	1.688	44½	2½	47	2	Diopside-jadeite
6	1.68	1.668	1.688	45	2	49	4	Diopside-jadeite
7	1.68	1.674	1.690	77	12	11		Chloromelanite

* jd. = jadeite, Ac. = Acmite, Di. = diopside.
1. Jadeite. Burma.
2. Large block, white, mottled pale green, Type III jade. Analysis No. 2. Kaminaljuyú (No. 2078).
3. "Blue-jade," fragment, greenish gray, Type II jade. Analysis No. 3. Mexico.
4. Large celt, pea green. Analysis No. 1. Guatemala.
5. Tuxtla statuette, pale greenish gray. Proc. U. S. Nat. Mus., vol. 60, No. 2409, p. 4, 1922.
6. Fragment, pea green. Analysis No. 5. Kaminaljuyú (B 158).
7. Celt, grayish green. Analysis No. 4. Quetzaltenango.

diopside-jadeite, and chloromelanite are so appreciably different from other minerals likely to be confused with them that a rapid determination of this property should serve to positively differentiate them from all other minerals. In actual practice it was found that a glance at a few grains immersed in an appropriate liquid served to distinguish jadeite and its congeners from other jadelike minerals. The only caution required is to assure that the minute fragment detached for examination is not a grain of albite, a mineral frequently intermixed with jadeite. In the case of jadeitic albite, where a small amount of jadeite is intermixed with albite, the whole field of the microscope slide should be scanned to find the few scattered grains of jadeite that may be present.

More precise determinations of the indices of refraction would yield information from which a reasonably accurate estimate of the chemical composition of the jadeite could be deduced, but such determinations require a more detailed knowledge of the optical properties of minerals and a more refined technique than an archeologist is likely to acquire. Such determination, however, should eventually prove very useful to the archeologist when correlations of the various types of jadeite are required.

Examination by X-rays.—Wherever the appropriate X-ray equipment is available the identification of jade by this means is definite and rapid. The identification depends upon the characteristic pattern of lines that each crystalline mineral yields by the diffraction of a narrow beam of X-rays upon a photographic film. This method has

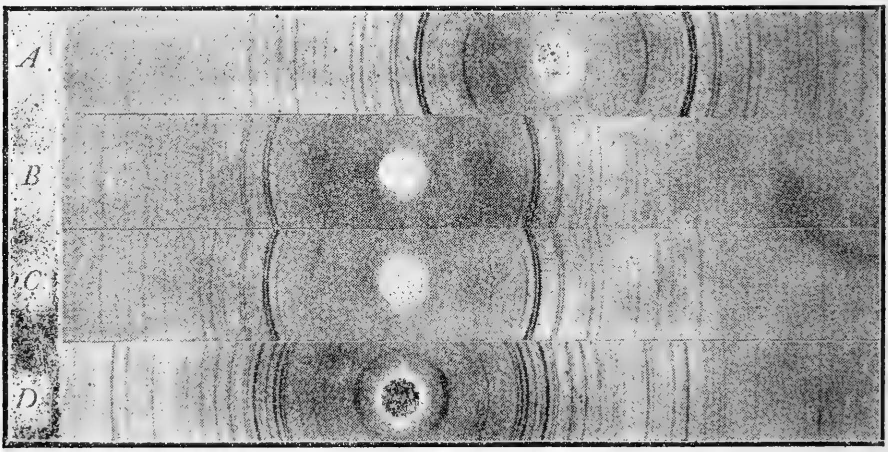

FIG. 2.—X-ray diffraction patterns of jadeite, diopside-jadeite, chloromelanite, and nephrite.

the advantage that a minute amount of powder scraped from a broken edge or from a perforated hole suffices to produce the characteristic pattern of lines of the mineral. The only precaution that must be taken is that the powder be derived from the jadeite itself and not from some extraneous small pocket of albite or other associated mineral. The easiest method for identification is to compare the photographed diffraction lines with a standard pattern of jadeite, diopside-jadeite, or chloromelanite. Closely related minerals, or the congeners of a single mineral series such as the three jade minerals, will have very closely similar patterns of lines, so that they are easily recognizable as related substances. Usually a slight shift in the disposition of the lines is apparent in the patterns of closely related minerals, so that their relationship is easily established and yet their differences are apparent. In figure 2 the X-ray patterns for jadeite, diopside-jadeite, and chloromelanite are shown, together with one of nephrite.

The differences between the jade minerals are readily apparent, while the similarities of the jadeite series are obvious.

JADE TYPES

While the jades of Guatemala show many differing aspects and characteristics, a few distinct types, particularly among the more important objects, are apparent. The finest pieces of raw material were reserved for important objects, but small, stained or otherwise imperfect material was not rejected but found a ready use in lesser objects. Many nondescript and generally unclassifiable varieties are found among the minor objects, such as beads and small crude ornaments.

Seven readily recognizable physical varieties sufficiently characteristic to lend themselves to ready identification were encountered in the collections. In some cases the type was represented by numerous examples, in others specimens were rare but were encountered in collections from widespread localities.

Type I. Jadeite.—One of the most distinctive types, and the variety popularly associated with the term "jade." Color, various shades of apple, grass, or emerald green, frequently mottled white, grayish green, or ash gray. Luster vitreous to pearly. Translucent (rare), semitranslucent to opaque. Fine to medium granular, distinct, although not always apparent on highly polished surfaces. Sometimes a mosaic pattern of grains is distinct.

The usual quality of this type is fine apple green in color, mottled white or gray, and semitranslucent. It is scarcely distinguishable from the green Burmese jade common in our present gem market. The finest quality has a uniform body texture, is translucent and of a rich emerald-green color (Nottebohm collection) and is comparable to the so-called imperial or *Fei-t'sui* jade of China and, like it, is very rare.

Frequently associated minerals with this type of jade are albite in white, sugary-grained nests, and muscovite in rich green plates. The latter frequently appear in the polished surface as apple-green rods.

The abundant jade of Kaminaljuyú, of this type, was used as ornaments, pendants, earplugs, beads, and other forms. Found in Pre-Classic, Early Classic, and Late Classic sites.

Type II. Jadeite.—The so-called "blue" or "Olmec" jade. Color varies from pearl gray through various shades of pallid, greenish gray (mineral gray, gnaphalium gray, tea green, pea green, etc.) to slate, olive, or dark ivy green. Its principal diagnostic characteristics, other than its color, are a textureless body, pearly luster on its polished surface, and chalcedony-like diaphaneity through the edges, or, in the finer quality of the mineral, through the entire stone. A frequent feature is a curdy mottling, or lighter ghostlike patches within the body of the stone. This type of jade, not uncommon in Mexico, Nicaragua, and Costa Rica, has so far seldom been encountered in Guatemala. A small figurine from Kaminaljuyú (3046) is a beautiful example of this stone. Small celts of fine stone are in the Robles and Nottebohm collections. It is a pure jadeite, without accessory minerals. Found in Pre-Classic and Early Classic sites.

Type III. Jadeite.—Color white to pale yellow green, Oural green or light fluorite green. Translucent. Luster vitreous to waxy. Two subtypes may be recognized: (a) granularity distinct to sharp, sometimes in a sharp and distinct pattern of mosaic, coarse angular grains; (b) granularity indistinct on polished surface, the luster on the polished surface waxy. A specimen of rough jade of this type from Manzanal, Motagua Valley, shows the main mass to be of type III (b) with indistinct mosaic grain structure on the polished face, but with well-defined mosaic structure of the weathered surface, and as a zone about the mass, apparently due to exposure and weathering. This type is commonly seen in plaques with Mayan-type faces carved in low relief, particularly from sites in the Quiché. Fine examples are in the Rossbach collection and have been figured by Lothrop (1936, e.g., figs. 58a, 59a, b). Associated minerals are rare and inconspicuous; it sometimes contains a little albite, or sparse spangles of mica. Found in Early Classic and Late Classic sites.

Type IV. Albitic jadeite.—Color dense white or pale ash gray mottled with Hay's green, zinc green, dull yellow green, or sage green. Distinctly granular to structureless on polished surface. Opaque. Luster pearly. Usually as beads (Kaminaljuyú, 3053), sometimes as disks or earplugs (Uaxactún, 4683). Albite usually abundant and intimately mixed with the jadeite. Found in Early Classic and Late Classic sites.

Type V. Diopside-jadeite.—Color, various shades of dark green, Cossack green, Civette green, stone green, leaf green, etc. Structure distinctly granular, prismatic, the prismatic grains usually reticulated, sometimes radiating. Sometimes traversed by fine spider-web cracks (Kaminaljuyú, 3022). Often discolored on the surface to a dark smoky grayish green. Abundant as round or tubular beads and similar minor objects, particularly in collections from the Quiché (Nebaj, 4802). Some small carved pendants are also of this material. Found in Early Classic sites.

Type VI. Jadeite.—Color light gray and green, including tea green, pea green to sage green, and storm gray. Granular, short prismatic to equigranular, distinct. Color and structure uniform. Found as large, well-shaped celts. It contains no apparent accessory minerals.

Type VII. Chloromelanite.—This ferruginous variety of jade is commonly found in Guatemala in the form of celts, although very few examples have been recovered in controlled excavations. Its color is very dark green, dull black to dusky dull green, rarely lighter in color than Russian green. An indistinct mottling is frequently apparent. The dark-green color is often evident only in shallow cracks in the stone. Other dark-colored rocks such as diorite or diabase may be confused with this mineral, but of 269 black celts in the collections of the Instituto de Antropología e Historia de Guatemala examined, 225 of them, or 83 percent, were made of chloromelanite.

Apparently the objects of chloromelanite were of utilitarian nature, celts of various shapes (Kaminaljuyú, 3197; Uaxactún, 483, etc.), chisels, reamers, etc. Some of these tools are shown in plate 2, figure 1. It is interesting to note that chloromelanite celts are still used by Guatemalan potters to polish the pottery before burning. Potters in Chinantla state that they search for these polishing celts in the surrounding hills.

Rarely are objects of high merit carved from this stone. Outstanding exceptions, however, are a "Totonacan" ceremonial celt, carved in the form of a turkey's head (2216), a fine example of artistic carving; an earplug from Uaxactún (3619) in a flawless piece of deepest green material; a monkey figure, simply but effectively carved, with a curious cartouche-like inscription on its base. Several elaborately carved celts in several collections appear to be simple chloromelanite celts with later fraudulent carving.

Chloromelanite has been found in Pre-Classic, Early Classic, and Late Classic sites. Celts in this material are represented in the collections of the Instituto de Antropología e Historia de Guatemala from Chukmuk, Chutex-Tiox, Guatemala (Roosevelt Hospital), Kaminaljuyú, Los Cerritos, Nebaj, San Agustín Acasaguastlán, San Andrés Sajcabajá, Uaxactún, Xa-pom, Zacaleu, and Zacualpa.

It should not be supposed that these jade types are unrelated or from distinct proveniences. Types I and III show frequent gradations into each other (Nebaj, 4753), and less typical examples of types I and V cannot always be readily distinguished. Borderline examples of VI and VII can be found, but are rare.

There are many aspects of jade that cannot be classified, usually among the minor objects. Many of these owe their nondescript character to an impure nature and poor quality of the stone or to surface staining. This classification, however, should prove useful in certain correlations and particularly in their origins when their provenience becomes known.

OTHER MINERALS

Other minerals having some resemblance to jade were used by the indigenous cultures of Guatemala for ornamental objects. The ancient jadeworker must have been aware of the different nature of these stones from true jade because of their differences in workability. Usually these stones were used only in minor objects in Guatemala, such as beads or small simple pendants, and usually, too, the lapidary did not expend his best efforts on these materials. Notable exceptions to this rule are the fine steatite vase from Kaminaljuyú (2718) and the muscovite figure from Uaxactún (921).

Among Mexican cultures, other stones than jade were sometimes used for important pieces. Among these one can mention fine Olmec figurines in serpentine and remarkable Aztec work in diorite, metadiorite, aplite, and rock crystal.

Actinolite.—A calcium, magnesium, iron silicate, a member of the amphibole group of minerals. When actinolite is compactly reticulated and tough it is called nephrite. The mineral found in archeological collections in Guatemala consists of a rather loose aggregate of parallel, splintery grains, is often loosely coherent and does not take a good polish, and should not be classed as nephrite. The color varies from sage green, pea green, andover green to deep grayish olive and is frequently stained. Fracture hackly, cleavage distinct, breaking into needlelike prisms. Index of refraction, 1.635. Specific gravity 2.94. Hardness, variable owing to its loosely coherent character, 3-5. Silky luster on the cleavages of the individual grains. The common type of artifact in actinolite is in the form of "button" beads (Nebaj, 4811, 4813). It has been found as beads at Chalchitán, Paraíso, and Quetzaltenango.

Albite.—This member of the feldspar group of minerals is usually white but in Guatemalan artifacts it is frequently green (tea green, dark bluish glaucous, pea green, andover green) by included jadeite or hornblende. It shows a strong tendency to absorb stain, either burial or smoke, so that it is colored superficially gray, brown, or black. Much of the albite shows a granularity resembling that of jadeite, and it is sometimes difficult to distinguish these two minerals with the unaided eye. If a small fragment is crushed between two slips of glass, albite breaks readily with a characteristic crackle, while jadeite is much tougher and resists crushing.

Albite is a common associate of jadeite. In its natural occurrence one would expect that the outer portions of jadeite bodies would be rimmed with albite and that intermediate zones would consist of varying proportions of albite and jadeite. Many fine jade pieces show nests or veinlets of albite. All degrees of mixture can be found among objects in the collections. One form is essentially albite containing dispersed jadeite. In thin section, under the microscope, the material consists of a mosaic of clear, untwinned albite grains containing scattered, etched, ragged prisms of jadeite ($n=1.665$). Albite of similar appearance contains needles of green hornblende in place of jadeite rods. For the mixture of jadeite in albite the term *jadeitic albite* is suggested.

The most important object in jadeitic albite is the Miraflores headpiece from Mound E-III-3, Kaminaljuyú (Shook and Kidder, 1952, p. 115, fig. 81). This object, embellished with 31 pieces, shows several types of albite. The pale-green elements are of jadeitic albite, the dark-green pieces hornblendic albite.

Several other objects of jadeitic albite have been found at Kaminaljuyú, a broken celt and a broken pendant. Beads of this material are sometimes encountered in collections. It seems to have been widely used but seldom in important pieces.

It is interesting to note here the occurrence of jadeitic and hornblendic albite with jadeite at Manzanal, discovered by Robert Leslie. In general appearance and microscopic character they are exactly like the jadeitic albites found as artifacts in Guatemalan collections.

Beryl.—The only mention of beryl in use by the early indigenous populations is a reference by Antonio de Herrera (1601-1615):

> Esmaltan, engasten i labren Esmeraldas, Turquesas, i otras Piedras, i agujereaban Perlas; pero no tan bien como en Europa. Labran el Cristal, mui primamente, i hacen viriles grandes i pequeños, dentro de los quales melen Imagenes entalladas de Madera, tan pequeñas, que en el espacio de una figuran un Christo en Cruz, con San Juan, i Nuestra Señora a los lados, i la Magdalena al pie, i en la misma Madera, en la otra parte, otras figuras de manera, que en el viril hace dos haces, que si no se viese cada día, parece cosa imposible.

The Robles collection, Quetzaltenango, contains three rough pieces of beryl (aquamarine) recovered from a tomb near Salcajá. The color ranges from pale aquamarine blue to pale aquamarine green. All three pieces are broken fragments without crystal faces. This is the only reported find of archeological aquamarine in America.

Beryl has a hardness of $7\frac{1}{2}$ to 8, or greater than that of quartz. The primitive lapidary would find it an extremely refractory stone to work, and it could be fashioned only with other beryl or some still harder stone.

Chlorite.—This soft mineral of dark-green color and pronounced scaly texture was not used in objects of artistic quality. It is a soft material, owing to its scaly structure, and is easily whittled into shape. Most of the *camahuiles,* or crudely carved triangular figurines, of the Quiché are of this material. Except for these *camahuiles* only a few crude beads of this mineral were found.

Glaucophane.—This mineral was found but once, as a broken celt without known locality. It is mixed with albite and chlorite. The color is black, slightly mottled pale greenish gray. The mineral is easily identified under the petrographic microscope by its pleochroism, the color changing, upon rotation of the mineral between crossed nicols, from pale buff to pale lavender or blue. The principal significance of this mineral is its geological association with jadeite, both minerals found about the peripheries of serpentine bodies.

Jasper.—Two forms of this aphanitic variety of quartz have been encountered in Guatemalan collections. One is a compact stone of green color, usually more grayish in tone than the common green shades of jade. Among the various shades of color may be mentioned bice green, deep dull yellow green, stone green, and bluish-gray green. An apple-green form, resembling chrysoprase, has been found at Uaxactún (8741). Sahagún (lib. 11, cap. 8) mentions a form of green jasper which was called xoxouhquitecpatl by the Aztecs, "Hay una manera de pedernales verdes que se llaman *xoxouhquitecpatl* (xoxouhqui=green, tecpatl=jasper) que tiran a chalchihuites; los lapidarios los llaman tecélic; porque son blandos de labrar; tienen pintas de azul claro."

A second form is chalcedonic silica impregnated with a green chloritic mineral which gives it a green color. This form is almost always associated with crystalline calcite, which weathers out, leaving the highly polished jasper in high relief in a deeply etched soft brown matrix.

Both the jasper and the jasper-calcite mixture are so distinctive that it is likely that each had a single source of origin.

Jasper is fairly widespread as minor objects but not in abundance. It has been found at Uaxactún, Kaminaljuyú, Nebaj, the Quiché, and about Quetzaltenango. A full-face figure of Quiché type in this stone is in the Nottebohm collection.

Metadiorite.—This material is a rock, rather than a mineral, and petrologically would be termed albite-zoisite-actinolite-muscovite granulite. Since, however, it is a metamorphic rock derived from diorite, a simpler designation, metadiorite, would be appropriate.

This distinctive material has peculiar significance for archeological studies since it is easily recognized and has a wide distribution in Mesoamerica. It is abundant in the form of beads and figurines in the state of Guerrero, Mexico, which seems to be the center of its dispersal, but with what culture it is associated is still unknown. It is perhaps the "chalchihuitl fingida" referred to by Sahagún as a material used by the common people, chalchihuitl being restricted to gods and nobles. This characteristic rock is also encountered in Guatemalan sites but it is rare. All sites at which extensive excavations have been carried out have yielded a few artifacts of this material, from Piedras Negras and Uaxactún in the Petén to the Pacific Coast, including Kaminaljuyú, San Agustín Acasaguastlán, Quetzaltenango, and the Quiché.

The stone is mottled green, with small areas of dark cress-green, meadow-green, or cassock-green color in a white to glaucous-green ground. When freshly broken it has a fine saccharoidal fracture, which sometimes shows the glint of small mica flakes. Its specific gravity varies from 3.07 to 3.20, depending upon the relative proportions of its various constituents. It takes a good polish, but not as well as does jade. It is frequently mistaken for and classified as jade.

In Guatemala metadiorite has been recognized only in the form of beads (Kaminaljuyú, 3072; Nebaj, 4740) or crude earplugs (Kaminaljuyú, 2501, 2502, 2503, 2543, and one in the Nottebohm collection).

Microcline, variety amazonstone.—This is one of the feldspar group of minerals which shows various colors of green or pale blue, including such hues as light blue green, lumiere blue, glaucous green, dark bluish glaucous, or light blue green, also waxy white and ash gray. Its luster is duller than that of jade. Particularly diagnostic of this mineral is a coarse, well-defined cleavage. A cross-hatched pattern of color, the result of an internal twinning of the mineral, is also diagnostic when observed.

Amazonstone is rare but fairly widespread. Its distribution and use suggest that it was prized, but rarely available. Cleavage plates, either in their natural state or polished and used as thin beads or small pendants, have been encountered. Its most common use was as small beads, often in combination with jade beads of similar size and shape (Nebaj, 4769). A crystal of characteristic natural habit was drilled for use as a pendant (Rossbach collection). A small bead of this stone was also found at Piedras Negras. It is widespread but rare in Mexico.

The Aztec *xiuitl,* which Sahagún (lib. 11, cap. 18, p. 279) describes as "turquesas bajas; estas turquesas son hendidas y manchadas, no son recias, algunas de ellas son cuadradas y otras de otras figuras," is almost certainly amazonstone. It was used in mosaics, for which its ready cleavage made it easily adaptable (Monte Albán). Cleavage flakes, perforated for stringing, have been found in Querrero. A group of natural crystals ("son cuadradas," that is, in the form of crystals), perforated for use as a pendant is in the National Museum of Mexico.

Broken natural crystals showing the crystal faces of the prism (110) and of the base (001) and the distinct cleavage are in the Rossbach collection at Chichicastenango.

The decided similarity in color of much of the amazonstone to turquoise would easily lead to a confusion of these two minerals. The irregular coloration, mentioned by Sahagún, is frequently evident in the natural mineral and is commonly observed in the Middle American material. A characteristic feature often observed in the Mesoamerican material is a cross-hatched color marking due to crystallographic twinning.

Muscovite.—This mineral, a silicate of potassium and aluminum, is an important member of the mica group. It is best known in the form of isinglass, a platy transparent mineral that can be readily split into thin plates or sheets. The variety found among the artifacts is a fine-scaly compact form called *sericite* or a fine-scaly green form known as *fuchsite*. These two forms grade into each other.

Sericite is made up of minute to small scales. Often these scales have a more or less parallel orientation so that an artifact of this material will show a silky sheen or pearly luster in certain directions. The scaly nature of the mineral may not be readily apparent on a polished surface, but can be readily recognized on a broken face. The scaly nature of the stone may also manifest itself in scattered small silvery reflections.

The color of sericite varies from light olive gray to pale yellow-green, kildare green, bice green, and similar shades. When the mineral is well compacted, it shows a waxy translucency especially when wetted. It has a hardness of 2½, and cannot be scratched with the fingernail, which will serve to distinguish it from steatite. Density 2.80-2.90. Its mean index of refraction is 1.595.

"Shoe button" beads are commonly of this mineral (Nebaj, 4767, 4783), also round beads, rondels, and simple pendant forms. Figurines or elaborate carvings in this material are seldom encountered. A notable exception is a carved figure from Uaxactún (921) described by Kidder (1947, pp. 47-48). The sides of this figure show the silky sheen of the minute orientated scales of the mineral.

Prehnite.—This mineral is a silicate of lime and alumina, sometimes found among the jades of Mexico, but not yet found in Guatemala. Its general appearance is very similar to jade type III. In color it is pale green. A common diagnostic characteristic is the presence of small metallic flakes of native copper embedded in the mineral. This metal may be oxidized on the surface of the object to green malachite. When this green crust is scraped off the metallic copper below is revealed. Another diagnostic criterion is the frequent presence of small cavities with characteristic crystals of prehnite. The mineral takes and retains a high polish. Beads are common in some parts of Mexico. Fine figurines have also been found. Although found widely distributed as worked objects, its peculiar association with native copper suggests a very limited occurrence, probably in an area of old basaltic rocks.

Serpentine.—This is a common mineral in Guatemala, making up large parts of the Sierra de Las Minas, Chuacús, and Santa Cruz. It is now extensively used in the manufacture of fraudulent antiquities to be sold to tourists at Chichicastenango and other centers. There are three principal varieties: common serpentine, antigorite, and precious serpentine, or williamsite.

Serpentine, common.—Ordinary serpentine is a rather dull, lusterless material usually of various shades of dull gray green. Some of the more pleasing colors are olive green, calla green, cedar green, ivy green, grape green, or lime green, also bone brown to black. It is structureless and shows no granularity. The stone usually takes only a poor polish. Its use is confined largely to beads and to poorly executed figurines, except in Mexico where Olmec figures of high artistic merit are found in this material. A "long-nose" is in the Nottebohm collection. Numerous beads of this mineral, from the Quiché, are in the Rossbach collection, being among the most common materials among the lesser bead forms.

Serpentine, variety antigorite.—This variety of serpentine is characterized by a distinct fissile structure. It can be split easily into thin irregular plates. Usually the objects made of this variety of serpentine are crudely done, except the fine Olmec figurines of Mexico, which are sometimes in this variety of serpentine. Antigorite, similar in all respects to that of many Olmec pieces, is found in abundance at Cerro Palón, near Tehuitzingo, state of Puebla, Mexico. Very few objects of this material have been found in Guatemala.

Three thin plates (5112), part of a large mosaic disk, show the fissile character of antigorite. Their provenience is unknown.

Serpentine, variety williamsite.—The precious variety of serpentine, williamsite, is sometimes difficult to distinguish from jade. It is, however, very rare. A cylinder, 8½ cm. long and 1½ cm. in diameter, of a somewhat grayish oil-green color, translucent and with a waxy luster, is in the Robles collection. The material of this cylinder resembles the Chinese *yu-yen* stone, a variety of serpentine much used to imitate the nephrite jade from Turkestan.

Talc, variety steatite or soapstone.—This stone can be easily identified by its softness and slippery or greasy feel. It is readily scratched by the fingernail. It is never of fine green color but shows dingy shades of gray, greenish gray, buff, brown, or red to black. It does not take a good polish. It is fairly abundant in the Quiché and many poorly worked beads are in the Rossbach collection. A finely worked vase of waxy luster and gray color is from Kaminaljuyú (2718). A few beads are in the collections from Nebaj. A string of beads from Zacualpa (1121) includes many steatite beads. Among the miscellaneous small beads from the Quiché, steatite is the most common material. A few small flares and spindle whorls in this material were found in the Rossbach collection. A string of unusually long, tubular, well-worked beads of this stone are in the Nottebohm collection.

Turquoise.—In contrast to the important use that the Aztecs and other Mexican cultures made of turquoise, especially in the form of elaborate mosaics, the almost complete absence of this mineral in the Guatemalan collections is noteworthy. The only turquoise recovered is in the form of some very small concretionary masses and small mosaic plates of a pale robin's-egg blue and cobalt green to a very pale buff color from Nebaj.

Zoisite.—A calcium aluminum silicate, an important mineral constituent of metadiorite, but also found in pure masses. Three distinct varieties were found in Guatemalan artifacts: (1) A translucent stone closely resembling jadeite of type III but showing little apparent granularity. Its color is usually mottled, Paris green and white, or Paris green and light buff. Under the petrographic microscope it appears black under crossed nicols. Index of refraction 1.725; specific gravity 3.07; hardness 5½-6½. Tough and hard to crush. It was rarely used as small pendants (Nottebohm collection), or as beads. (2) A mottled stone resembling jade of type I, but the color an opaque dense white with included areas of meadow-green pyroxene. Index of refraction 1.725; specific gravity variable. Takes only a fair polish. This form of zoisite is usually found in small irregular beads, apparently small pebbles little modified from their original shape. (3) Dense opaque greenish or bluish mineral resembling a poor grade of amazonstone, frequently containing irregular lenses of smoky-gray albite. Color mytho green to dark bluish glaucous. Index of refraction 1.705, with medium low birefringence; hardness $5\frac{1}{2}$-$6\frac{1}{2}$. Usually in the form of tubular or barrel-shaped beads.

Zoisite has been found in collections from Kaminaljuyú, Patzún, Quiché, and Quetzaltenango.

Artifacts of these minor minerals are found only in small numbers in the tombs rich in fine jade (Kaminaljuyú, Nebaj). At Uaxactún, where jade objects were scarcer and of poorer quality, the proportion of these lesser stones increased. These materials seemed to have been abundantly used in the Quiché. A lot of miscellaneous beads in the Rossbach collection (700 in 9 strands) showed the following percentages: steatite 30, serpentine 29, jade 13, tremolite 10, zoisite 5, muscovite 5, miscellaneous (chlorite, jasper, shell, microcline, unidentified) 4, marble 3, albite 1.

Very probably these minor stones will be found in all important archeological sites where comprehensive collections will be available. Their distribution, as far as they have been collected to date, is as follows:

Actinolite-tremolite: Chalchitán, Nebaj, Paraíso, Quiché, Salcajá.
Albite: Kaminaljuyú, Nebaj, Patzún, Quiché, Quetzaltenango, San Agustín Acasaguastlán, Uaxactún.
Amazonstone: Nebaj, Piedras Negras, Quetzaltenango, Quiché, Paraíso.
Jasper: Kaminaljuyú, Paraíso, Piedras Negras, San Agustín Acasaguastlán.
Metadiorite: Asunción Mitla, Kaminaljuyú, Nebaj, Patzún, Piedras Negras, Quiché, Uaxactún.
Muscovite (including fuchsite): Cadenas, Kaminaljuyú, Nebaj, Paraíso, Patzún, Quetzaltenango, Quiché, San Agustín Acasaguastlán, Zacalena, Zacualpa.
Serpentine: Kaminaljuyú, Nebaj, Patzún, Quetzaltenango, Quiché.
Steatite: Kaminaljuyú, Nebaj, Patzún, Quetzaltenango, Quiché, Zacualpa.
Ziosite: Kaminaljuyú, Quetzaltenango, Quiché, Patzún.

PHYSICAL PROPERTIES OF JADEITE AND JADELIKE MINERALS

The usual method of distinguishing jadeite and differentiating it from minerals of similar appearance is by the determination of certain physical properties, particularly specific gravity and hardness. There are also minor characteristics of color, luster, fracture, and texture that are frequently diagnostic. A brief familiarity with these characteristics will be a great help in recognizing the various minerals, but cannot be used as positive determinative criteria. The physical properties of these minerals are brought together in table 4.

More precise identification of the mineral species can be made by determining the mean index of refraction of the mineral. These are given in table 5.

TABLE 4.—*Identification of jadelike minerals*

Sp. gr.	*Color*	*Grain*	*Hd.*	*Use*	*Mineral*	*Remarks*
2.50-2.60	Microcline to sulfate green; methyl blue	Coarse, well-defined cleavage, sometimes in monoclinic crystals	6-6½	Beads, small earplugs, mosaic plates, sometimes unworked crystals used as pendants	Microcline (amazonstone)	Rather rare. Opaque
2.50-2.80	Grayish green to greenish gray, dark green to black, rarely cobalt to zinc green	Massive, without visible grain; laminated	2.5-4	Beads, pendants, figurines, mosaics	Serpentine: luster dull, frequently mottled, common serpentine; laminated, smooth feel, variety antigorite; translucent with fine texture and color, variety precious serpentine	Common. Frequently used in falsification
2.60-2.65	White, ash gray, dark to smoky gray, yellowish oil green, calla green, cedar green	Distinctly granular, sugary texture, brittle	6-6½	Beads common; figurines rare	Albite. (Green colors due to amphibole inclusions, dark gray to brown colors to staining)	Fairly common. More brittle than jade
2.60-2.65	Winter green, stone green	No apparent grain; sometimes veined white, or mixed with calcite	7	Beads, small pendants	Jasper	Rare
2.60-2.90	Oural green to Paris green, Kildare green	Distinctly granular	6-6½	Beads, pendants, figurines	Jadeitic-albite (a mixture of jadeite and albite)	Common

2.70-2.80	Gray, greenish gray, buff brown, red	No apparent grain, smooth feel. Easily scratched by fingernail	1-2	Beads, rarely pendants, vases	Talc (steatite or soapstone)	Fairly common
2.80-2.90	Gendre, Paris, olivene, Niagara or glaucous green; pearl gray. Pearly luster.	Fine to coarse scaly	2½	"Shoe-button" beads, rondels, vases (rare), figurines	Muscovite: fine scaly variety sericite, green variety fuchsite	Fairly common
2.80-3.00	Very pale green to Paris green	Coarse grained, sometimes reticulated. Small included flakes of copper common	6-6½	Beads common; figures rare	Prehnite	Not found in Guatemala
2.90-3.05	Pea green, sage green	Columnar, aggregate of rather loosely coherent needles	3-5	Elliptical beads, button beads	Actinolite	Rare
2.90-3.10	Fluorite green, bice green, Killarney green	Medium to coarse granular, reticulated prismatic	6-7	All forms, including celts	Albitic-jadeite. Mixture of albite and jadeite in about equal proportion	Common

TABLE 4.—*Identification of jadelike minerals*—continued

Sp. gr.	*Color*	*Grain*	*Hd.*	*Use*	*Mineral*	*Remarks*
3.00-3.20	Bice, forest olivene, sage and Niagara green, etain blue, speckled dark green on light ground	Granular	$5\frac{1}{2}$-$6\frac{1}{2}$	Beads, earplugs, figurines, etc.	Metadiorite	Rare in Guatemala, common in Mexico
3.00-3.35	White, oriental gray, shamrock green, grayish olive, fluorite green, white mottled green	Dense, grain not apparent	$5\frac{1}{2}$-$6\frac{1}{2}$	Small beads; small pendants rare	Zoisite: (a) translucent variety clouded green in gray or brownish ground; (b) opaque variety white mottled green	Very rare
3.10-3.35	Oural green to Killarney green, pale fluorite green to Shamrock green, white	Medium to coarse grain, mosaic grain, reticulated prismatic grain	6-$6\frac{1}{2}$	All forms including celts and mosaics	Jadeite (many variations)	Abundant
3.35-3.45	Elm green, Varleys green, blackish green	Granular indistinctly reticulated prismatic, tough	6-$6\frac{1}{2}$	Celts abundant, tools, figures; earplugs rare	Chloromelanite	Abundant

TABLE 5.—*Optical properties of jade and other minerals*

	Name	*n*	*Interference colors*	*Shape of grain*	*Remarks*
1.	Serpentine	1.500	Gray	Hackly irregular	Felted structure pronounced
2.	Microcline	1.525	Gray to yellow	Flat	Flat grains, frequently cloudy
3.	Albite	1.530	Gray to yellow	Conchoidal	Clear glassy grains
4.	Jasper	1.545	Gray to yellow	Irregular	Mosaic of minute grains
5.	Talc (steatite)	1.565	Gray	Irregular	Very soft, soapy feel
6.	Muscovite	1.595-		Flaky	Felted scaly plates
		1.600	Gray	Splintery	A mixture of 3, 6, and 12
7.	Metadiorite		Gray	Splintery	Pleochroism in blue or violet colors strong
8.	Glaucophane	1.630	Gray	Irregular	Bright red, yellow, and green interference colors
9.	Prehnite	1.630	Bright	Splintery needles	
10.	Tremolite	1.635	Bright	and rods	
11.	Jadeite	1.660	Medium	Splintery	Light gray to bright interference colors
12.	Chloromelanite	1.680	Gray	Splintery	Anomalous slate-blue and brown interference colors
13.	Zoisite	1.705	Gray to dark	Angular	Anomalous interference colors
14.	Zoisite	1.725	Black	Conchoidal	Almost isotropic

In the foregoing table the mean index is given as the average value of the lowest index (α) and the highest index (γ). The interference colors are those colors shown by crushed grains when the nicol prisms of the petrographic microscope are in crossed position. These colors are a measure of the birefringence or the difference between the lowest index of refraction (α) and the highest (γ), and have diagnostic value.

LOCAL CHARACTERISTICS

When the probably limited occurrences of jadeite in nature in Mesoamerica and the wide distribution of the material as artifacts over an extensive region are considered, the pronounced local mineralogical character of the jade collections is rather striking. Kidder, Jennings, and Shook (1946, p. 105) have already noted this variation in the kinds of jade from different Guatemalan sites. The collections from Kaminaljuyú, for example, are strikingly different from those of the Quiché. On the other hand, the wide distribution of many of the minor varieties of hard stones, apparently similarly dispersed from a single limited area, is also noteworthy. The unique metadiorite, for instance, so common as artifacts in the state of Guerrero, Mexico, has been found in almost all the Guatemalan collections. At the present time we can only call attention to this erratic distribution of jade, without indicating what vagaries of trade have brought it about.

There is no indication at present of any pronounced temporal variation in the varieties of jade. The principal types of stone have been found in Archaic or Middle Culture collections, through the Classic to materials of the historical epoch. The largest collection of Archaic (Miraflores) jade material is that recovered at Finca Arizona, and described by Shook (1945), and now in the Petrilli collection. This includes both bright-green jade (type I) and "blue" jade (type II). Jade of these two types was also found sparingly at the Archaic site at Tlatilco, Mexico. Collections of jade from Archaic sites, however, are too meager to show the possible range in all its varieties.

The possible exception to the long use of all types of jade may be the so-called "blue jade" (type II) commonly found in Olmec objects, and which may be confined to Archaic and Early Classic cultures, or if used in later cultures, may have been derived, secondarily, from Olmec sources.

Only a few examples of chloromelanite have been recovered in controlled excavations, and so its distribution cannot be satisfactorily delimited, although it appears to be abundant and widespread. This mineral has been found in Archaic or Pre-Classic sites, as well as

Early and Late Classic material, and celts of this material, recovered from archeological sites, are still used by present-day potters in Guatemala.

The minor stones seem to have a time range similar to that of jade, although the collections are too meager to completely determine their distribution. Albite, for instance, was used in Pre-Classic (Miraflores, Kaminaljuyú) Early Classic (Uaxactún) and Late Classic (Nebaj, Uaxactún).

Some of the local characteristics of the hard stones used will be given in the following notes:

Uaxactún.—Uaxactún is situated in the low, densely forested area in northern Petén. Geologically this region is a coastal plain made up of sedimentary rocks of Tertiary age, and not likely to contain deposits of jade. Extensive excavations were undertaken here by the Carnegie Institution of Washington, the results of which have been reported by Riketson and Riketson (1937). The artifacts recovered during these excavations have been described by Kidder (1947).

Considering the number of graves encountered during these excavations and the lavish offerings that they contained, the amount of jade recovered was small, and the quality of the material was poor. That a lack of appreciation of this stone was not the cause of this paucity of material is indicated by the careful re-use of material, such as the adaption of almost insignificant fragments of rich colored mineral, and of sliced beads in mosaics (447, 449). The mural painting uncovered in edifice B-XIII by the Carnegie Institution indicates a simple use of ornaments, earplugs, nose ornaments, necklaces, and belts of beads.

The jades of Uaxactún are a rather heterogenous lot, with no important pieces of fine stone. Most abundant is the pale green jadeite (type III), chiefly in the form of large and small beads, but none of the flat, carved faces commonly observed in such jade from sites in the Quiché.

Diopside-jadeite of various shades of green, such as sage green, dark ivy green and stone green, is second in quantity, and was used chiefly as very thin mosaic plates (461), or large coarse mosaic elements (8807). A curious serpent head in four articulated parts (455) is in this stone. This material was rarely used as beads.

Fine green jade (type I) was highly prized but apparently was rare. Its principal use was in mosaics (447, 449) where it is obviously re-used material, salvaged from beads and earplugs, or cabachons cut from small, even tiny fragments.

The mottled ash-gray to dark grayish-green jade (type IV) has its best representation in a perforated disk (445). Several other specimens of similar material are included in the collection.

A rich chloromelanite earplug in very dark-green, finely textured material (469) is an outstanding object in this stone.

Albite is in unusually large proportion in the Uaxactún collection. In one example, a broken earplug of sea-green color (496), the workmanship is unusually good for one of the lesser stones. Jasper is represented by a fine green bead (466), some small chrysoprase green plates (8741), a poor chert pendant, and a calcitic jasper bead. Metadiorite, muscovite, and fuchsite are also represented in the collection.

A large seated idol of compact, finely scaly muscovite, Niagara green in color, is the most important object in this material now known. It has been described by Morley (1946, p. 926) as the largest known jade figure. The scaly texture of the stone is evident on the sides of the head, nose, arm, and thighs.

The predominance of pale green jade (type III), the generally poor quality of the material, and the rather heterogenous character of the jade are suggestive of material from Quiché sites.

Piedras Negras.—A small collection of stones from this site is of minor importance. It contains small objects or beads of jade (types I, III, and V), as well as jasper, metadiorite, and amazonstone.

San Agustín Acasaguastlán.—Numerous archeological sites are situated in the Motagua River Valley. This region is geologically favorable for the occurrence of jadeite since a large part of the north slope of this valley is occupied by serpentine, the important rock associated with jadeite.

The material available for study was the collection made by A. L. Smith during excavations in 1940 and described by Smith and Kidder (1943). The collection contains no outstanding jade object, although it was reported that many burials were encountered in the exploration of the site. The jades showed a wide variety including beads of fine emerald and apple-green color (type I), pale green (type III), and pea green (type V). Other material includes albite, muscovite, fuchsite, green jasper, and calcitic jasper.

The collection includes an unusually large proportion of rough and partially worked material, including a workshop lot (1762) containing 11 roughed-out beads and similar material. There is also included in the collection a stream-worn pebble of muscovite of fine color (1664), a polished earplug core (1763), and two rough partially worked pieces (1674, 1679). This large proportion of workshop material suggests that the San Agustín Acasaguastlán area was a center of a jade-working industry.

Kaminaljuyú.—Rich collections of jade have been recovered in excavations at this site in the outskirts of Guatemala City (Kidder, Jennings, and Shook, 1946; Kidder, 1949). The area lies within the volcanic ash deposits immediately associated with the volcanoes to the west, but crystalline rocks, including serpentine, are exposed only a short distance to the north.

The Kaminaljuyú jade objects are characterized by fine-quality stone and good polish. None of the other Guatemalan collections compares with the Kaminaljuyú material in its large proportion of fine stone. Particularly striking are the large numbers of objects of fine apple-green to emerald-green jadeite (type I). The pale-green jade (type III) is also better colored and more limpid than similar jade from other sites. The single example of "blue" jade (type II), a small figurine pendant (3046), is of unusualy fine quality, rare even among Olmec examples.

Fine apple-green jadeite, similar in appearance to the green jadeite from Burma, makes up one-half of the jades of the collection. The pale-green jade (type III) makes up about 20 percent of the collection. This material is vitreous in luster, and sometimes shows such a coarse and distinct granularity that it has a striking mosaic structure. The jade of type III, common in collections from the Quiché, is similar, but has a waxy rather than vitreous luster and rarely shows the distinct granularity of the Kaminaljuyú stone. This latter variety is lacking in Kaminaljuyú collections.

Jade of type IV, a dense white stone mottled with greenish-gray color is represented by six examples, the most characteristic of which is a string of 56 beads (3053), 53 of which are of this type of jade.

Of the stones other than jade, muscovite—usually the bright green form, fuchsite—is the most abundant. Two rich green vases of scaly fuchsite (4720, 4721) are, perhaps, the finest examples of this material yet found. Metadiorite is represented by six objects, four of which are crude earplugs (2501-3, 2543) of similar material. A bead is exactly similar to the metadiorite so abundant as beads in Guerrero, Mexico. A string of 16 beads (3072) contains a number of structureless zoisite beads, pale apple green in color, streaked with gray granular albite. This material, too, is abundant among beads from Guerrero.

Except for two small beads, steatite is represented only by a beautiful vase of pale greenish-gray color carved with a figure of Tlaloc, and shows traces of cinnabar powder. This is the finest example of Mesoamerican work in steatite known.

Other materials from Kaminaljuyú are serpentine, jasper, and calcite-jasper.

The jades of the Kaminaljuyú collections are distinct from other Guatemalan collections in the large proportion of high quality of both the bright-green and the pale sea-green stone, the important objects in fuchsite and steatite, and the low proportion of the lesser stones. Kidder, Jennings and Shook (1946) have called attention to the similarity of the Kaminaljuyú jade to that of Copán, Petén, and British Honduras, and its distinct quality from the Quiché stone.

Finca Arizona.—A small collection of jade was recovered from burials in mounds at Finca Arizona, on the Pacific coastal plain near San José. This collection, now in the Petrilli collection, was not seen, but the descriptions of the objects by Shook (1945) suggest definitely characteristic material of type I and type II jade. The collection is interesting in that it represents the best collection of Archaic (Miraflores) jade yet found.

Patzún-Godínez (Nottebohm collection).—The Nottebohm collection consists mainly of objects originating in the vicinity of Patzún and Godínez, situated in the volcanic area lying immediately east of Lake Atitlán. The material is undocumented except for its general provenience. No systematic excavations have been undertaken in this region. Some of the specimens in the collection may be from other areas.

The most abundantly represented jade in this collection is the pale-green variety showing little granularity on the polished surface (type III, b). Eighty-five percent of the important objects are in this type of jade. There are 11 fine examples of the Quiché type of carved face, all but 2 of which are in type III jade. The exception is carved from a jade so similar in its peculiarities to a long bead from El Sitio, in the collection of the Instituto de Antropología e Historia de Guatemala that these two pieces may well have been cut from the same rough material. Still another Quiché carved face is in calcite-jasper, the only important object in this material I have encountered. A small carved Quiché face is in porcellanous white and green zoisite.

The gray, even-grained jade (type VI) is well represented in this collection by celts and other objects. A rather crudely executed figure of a fish, 14 x 5½ cm., was obviously adapted from a pebble, with part of the original surface still evident. There is also a large, roughly tabular mass of this type of jade, essentially a rough piece, but partly shaped by pecking and grinding.

Several examples of jade type II are included, the most interesting of which is a flat peltoid pebble shaped into a celt by grinding two flat faces upon it to form the bit (pl. 3, fig. 2, *c*). A small highly polished and well-formed celt $3\frac{1}{2}$ cm. long is greenish gray in color and has a translucent, evenly textured chalcedony-like body.

Chloromelanite is represented by two large celts, one with a face carved on its face (which may be recent work) and two small well-shaped and highly polished celts of tooth size. These two small "celts" and two similar ones in pale ash-gray jade in this collection appear to be unique.

Several specimens in this collection show well the association of two different types or aspects of jade in a single object, indicating that jades of different appearance need not necessarily have distinct provenience. There is, for example, a carving in pale sea-green, waxy jade (type III, b) which grades into compact gray jade (type VI).

In addition to jade, the collection contains objects in serpentine, jasper, zoisite, steatite, albite, muscovite, calcite-jasper, and metadiorite. Of particular interest among these lesser stones is a "long-nose" face in serpentine, similar to one from Nebaj (4742); a second "long-nose" in albite; and a crude earplug in metadiorite exactly similar in workmanship and material to four in the Kaminaljuyú collection (2501-3). Also unusual among collections is a string of 17 very long, well-polished steatite beads.

In stone, the Patzún-Godínez material shows strong affinities to general collections from the Quiché. This is especially true of the relative abundance of the pale sea-green jade (type III). In this respect the collection is similar to the jades recovered at Zacualpa.

Quiché (Rossbach collection).—The Rossbach collection was gathered together by the former parochial priest, Father Rossbach, of Chichecastenango, and is now housed in a small public museum in that town. Except for a small collection from Zacualpa the collection consists of minor objects presented to him by members of his and neighboring parishes. Presumably the specimens are derived largely from sites in the Department of Quiché.

The Quiché material, as illustrated by the material in this collection, shows a wide variety of jade, usually of poor quality, and an abundance of lesser stones. It should be considered, perhaps, not as characteristic of the materials of the area, but of the variety of stones used in minor objects.

The small objects of jade are usually of nondescript quality. Impure and discolored stone is common, and much of it appears altered and stained subsequent to working. Of the distinctive and recognizable types, the pale-green variety (type III) is most abundant. Fine apple- to emerald-green stone is rare. The collection contains many pebble-shaped pieces, crudely carved into full or profile face pendants by straight or curved line incisions, with shallow drilled indentations to represent the eyes. Numerous small earplugs, varying from flat to cupped forms, are largely in jade, but a few in jasper, albite, and fuchsite are also represented.

A great variety of beads are included in the collection. Nine strands, including about 700 individual beads, gave the following percentages of stone varieties: Steaite 31 percent; serpentine 27 percent; jade 14 percent; actinolite 10 percent; zoisite 5 percent; muscovite 2 percent; miscellaneous 7 percent. Among the miscellaneous materials are marble, jasper, calcite-jasper, metadiorite, and amazonstone.

A stone not found in other sites is a granular white marble streaked or mottled grayish green or bright green by fuchsite. Some of the larger objects in this material are undoubtedly fraudulent work but some of the small objects appear authentic.

Within the Department of Quiché are areas of serpentine rocks in which some of the jade from this area may have its origin.

Nebaj.—The Nebaj collection includes more than 100 specimens, many of them of unusual artistic merit. Among the objects are three plaques, collected by A. L. Smith and described by Smith and Kidder (1951; 4733, 4734, and 4735), outstanding objects of Mayan art. The plaque (4733; Smith and Kidder's fig. 59b) is the finest example of Mayan jade carving as yet discovered. Other striking examples of Mayan jadework are a string-cut example of jade (4760; Smith and Kidder's fig. 52f); a jade skull with inset earplugs (4764; Smith and Kidder's fig. 56); a long squarish bead 13 x 3 cm. drilled longitudinally, a remarkable example of drilling (4802; Smith and Kidder's fig. 58c).

While the jade of this collection is in general of high-quality material, few of the larger and important pieces fall within the recognized types, differing in texture and frequently in color from the commoner types I and III. I have pointed out, however, in a description of the jade types, that only a part of the material can be divided into reasonably clear-cut categories, and that much fine jade has individual physical characteristics that separate it from other jade. The variation in the varieties of jade from Nebaj is in contrast with Kaminaljuyú jade where a strong similarity of the material runs through the collection.

Lapidary techniques are quite varied, ranging from the involved techniques of the large plaques to objects ornamented with simple grooved lines and incised circles. The details are adequately described in Smith and Kidder's report.

Minor objects, in addition to those of jade, include a wide variety of materials: serpentine, muscovite, amazonstone, actinolite, steatite, metadiorite, jasper, jasper-calcite, marble, and albite.

The Early Classic material from Nebaj includes jade, types I, III, and IV, muscovite, jasper, amazonstone, rock crystal; Late Classic, jade types I, III, IV, and V, muscovite, jasper, jasper-calcite, amazonstone, albite, metadiorite, and serpentine. Differences in this list are probably due to the larger number of Late than Early Classic pieces.

It is interesting to note that the single "long-nose" figure (4742) is of a light, fine-grained serpentine, as are most of the few other "long-nose" faces known.

Zacualpa.—In the Rossbach collection at Chichicastenango are a number of specimens that can be identified as some of the material described by Lothrop (1936) from Zacualpa. These pieces are carvings characteristic of this area and which Lothrop has classified as Oaxacan, Pipil, and Quiché styles of decoration.

Fine green stones, like the jade of Kaminaljuyú, are absent in this small collection. The pale-green stone without distinct granularity (type III, b), which is not represented in the Kaminaljuyú jades, is the common type.

Zoisite, actinolite, muscovite, and steatite have been found at Zacualpa as beads. A string of beads (1121) contains 34 beads of jadeite, 57 of zoisite, 63 of steatite, and 14 of muscovite.

Quetzaltenango Valley (Robles collection).—Of the major pieces in the Robles collection, most of which came from the vicinity of Quetzaltenango, the jades are, for the most part, types not distinctly classifiable. Of the 99 major pieces, 25 percent belong to the pale-green granular jade (type III, a), 12 percent to the nongranular pale-green jade (type III, b), 6 percent to the gray celt jade (type VI), and 2 percent "blue" jade (type II). Fifty-two percent of the specimens cannot be readily assigned to any type of jade. Also included among the stone objects, chiefly as beads, are steatite (38 pieces), jasper (27), serpentine (23), zoisite (21), albite (9), amazonstone (5), and miscellaneous (13).

Three small broken fragments of aquamarine, pale blue to pale green in color, are the only examples of this mineral found in Guatemalan collections.

In the large percentage of pale-green jade (type III) and the large proportion of miscellaneous stones among the minor objects, this collection has strong similarities to the collections from the Quiché. The number of pieces of celt jade (type VI) suggests the collections from Patzún-Godínez.

Among the noteworthy examples of stone is a cylindrical rod of precious serpentine 8½ cm. long. This serpentine resembles the finest quality of the Chinese "yu yen" stone, a fine green, evenly textured serpentine. A monkey head in black chloromelanite, 4 cm. high and 4½ cm. across, well carved in simple design and with a curious cartouche-like inscription on its base, is one of the few well-carved figures in this type of jade. Among examples in type VI jade are two carved pendants. This type of jade is usually restricted to long, narrow well-made celts. It is probable that these pendants are late fraudulent carvings made from early celts.

Paraíso.—A small collection of 21 pieces came from Paraíso and are in the Robles collection. It contains jades of miscellaneous aspect, including objects in jade types I and III. Also included are beads or minor objects of actinolite, amazonstone, calcite-jasper, and muscovite. This small lot is similar to the materials common in the Quiché material.

Zacaleu.—A small collection of minor objects from Zacaleu consists of small beads of green jade (type I) and pale-green jade (type III). Serpentine, fuchsite, and metadiorite are also included. The few minor specimens in the collection show a strong affinity to the Kaminaljuyú jades in mineral character.

LAPIDARY TECHNIQUES

The Mesoamerican lapidary was an artisan of the highest skill, well acquainted with the virtues of the various stones with which he had to deal. Sahagún (1530, lib. 10, cap. 7) has given us the attributes of the lapidary:

> El lapidario está bien enseñado y examinado en su oficio, buen conocedor de piedras, las cuales para labrarlas quítales la raza, córtales y las junta, o pega con otras sutilmente con el betún, para hacer obra de mosaico.
>
> El buen lapidario artificiosamente labra y inventa labores, sutilmente esculpiendo y puliendo muy bien las piedras con sus instrumentos que usa en su oficio.
>
> El mal lapidario suele ser torpe o bronco, no sabe pulir sin que echar a perder las piedras, labrándolas atolondronadas o desiguales, o quebrándolas, o haciéndolas pedazos.

Seler (1890) has reproduced and translated a portion of Sahagún's original Nahuatl text relating to the art of the lapidary as practiced by the Aztecs at the time of the Spanish conquest, and now preserved in the archives of the Academy of History, Madrid. His rendition is not always clear as to the lapidary techniques employed. I present here a new translation in which the interpretations are more in conformity with lapidary practices and principles. Definitions were taken from the dictionary of Molina (1585) and grammatical construction from the grammars of Molina (1585) and Garibay (1940). The Nahuatl text can be found in Seler, and in Saville (1922).

1. The master lapidary (1)[6] cuts rock crystal, amethyst, *chalchihuitl* [common jade] (2), and quetzalitztli [fine jade] (3) with an abrasive (4) and hard copper.
2. And he scrapes it with a trimmed flint (5).
3. And he perforates it and drills it with a small metal tube (6).
4. Then he carefully smooths it, polishes it, gives it luster (7) and so prepares it.
5. He polishes it (8) in [or with] wood (9) so that it shines.
6. Or the lapidary polishes it with bamboo (9) and so prepares it.
7. And in the same manner the amethyst is prepared.
8. First he breaks it into pieces (10) and trims it with [a] copper [instrument] because he works only the good red material.
9. To prepare it in this manner it is not necessary to break it with [a] copper [instrument].
10. And then he grinds it and smooths it and makes it shine, and polishes it with wood, using the polisher with which they clean and prepare it.
11. And the stone called *eztecpatl* (11) [bloodstone] is very hard and is not easily cut with the abrasive.
12. And it is broken by striking with a stone.
13. Also the flawed stone which is no good is thrown away (12) and is not polished.
14. They select and seek only the good [stone], the good [stone] they polish, the blood-colored [stone] and the well-spotted [stone, i.e., the bloodstone].
15. It is ground then upon a very hard stone (13) that comes from the country of the Matlatzincatl.
16. It is good for this purpose for the bloodstone is as hard as the stone and they grind each other.
17. Then it is smoothed with abrasive and polished with emery (14).
18. And then it is prepared and polished with bamboo.
19. And in this manner they make it sparkle and give it the brilliance of the sun.
20. And that [stone] called vitzitziltecpatl [hummingbird stone, opal] (15) resembles that bird.
21. When finished it is as if painted, white and green and like fire, similar to a star and like a rainbow.

[6] Numbers in parentheses refer to notes following this section.

22. It is ground and polished only with sand.
23. And that [stone] called *xiuhtomolli* [turquoise] is not hard, emery is not used to grind it or to smooth it or to polish it, but worked with bamboo it is made to shine like the sun and to reflect light.
24. And the *teoxihuitl* [precious turquoise] is not very hard.
25. In the same manner it is polished and cleaned with fine sand, and the good [stone] is given the brilliance of the sun with a turquoise polisher.

NOTES

(1) *"Tlateque tulteca," "tlatecque tulteca."* The Aztecs attributed to the Toltecs a mastery of many of the arts. "Y dicen de ellos, que trageron el Maíz, Algodón, y las demás Semillas, Legumbres, que ai en esta Tierra; y que fueron grandes Artifices, de labrar Oro, y Piedras preciosas, y otras muchas curiosidades" (Torquemada, 1613, lib. 1ª, cap. 14.). For this reason master craftsmen or artists were referred to as "tulteca"; "Eran poco Guerreros, y más dados al Arte de Labrar Piedras (que esto quiere decidr Tulteca, como ya hemos dicho), que á otro Arte alguno."

(2) *"Chalchihuitl," "esmeralda baja"* (Molina); "son verdes y no transparentes, mezcladas de blanco" (Sahagún); ordinary jade.

(3) *"Quetzalitztli," "esmeralda"* (Molina); "las esmeraldas que se llamen quetzalitztli" (Sahagún, lib. 11, cap. 8); fine jade.

(4) *"Teoxalli," "teuxalli"* = esmeril (Molina); "los Lapidarios cortaban, y labraban las Piedras preciosas, con cierta arena, que ellos sabían, aunque aora la cortan con Esmeril, y hacían de ellas las figuras, que querian" (Torquemada, 1613, pt. 2D., lib. 13, cap. 34). "El Esmeril se hace en las provincias de *Anáhuac* y *Tototepec,* son unas pedrezuelas pequeñuelas; unas son coloradas y otras, etc., y los lapidarios las muelen, y con la arena limpian y pulen las piedras preciosas. Una manera de margagita que sale del metal, cuando se lavan después de molidos; otra manera de margagita negra que se hace en muchos partes; otra manera de esmeril de pedernales molidos, son unos pedernales o piedras recias que se hacen hacia *Huaxtepec,* en los arroyos, traídas por acá, muélenlas y con aquellas debastan las piedras preciosas, para después purificarlas con el otro esmeril arriba dicho" (Sahagún, libro 11, cap. 1q).

(5) *"Tecpatl tlatetzotzontli"* = "pedernal martillado" (Molina); probably a jasper tool fashioned by flaking.

(6) *"Tepuztlacopintli"* = "cañuto de estaño horador piedras preciosas" (Molina, *vide cañuto*). The use of metal tubes for drilling may have been a Spanish introduction. It is unlikely that the Aztecs used the metal tin extensively. "Antes que viniesen los españoles a esta tierra nadie se curaba de la plata, ni del plomo; buscaban solamente el oro en los arroyos . . . ." (Sahagún). Lothrop (1952, p. 14) describes an ornamented disk of tin from the *cenote* of Chichén-Itzá. Holmes (1897) describes the leg bone of a large bird used as a drill in a Mexican travertine ("onyx") object from Chalco, Mexico. Hollow bamboo rods, used in conjunction with an abrasive, would serve well for perforating.

(7) *"Temetzuia."* Molina defines this term as "pegar o soldar con plomo." Seler translates it "to give a matt finish." It probably signifies "to give a leadlike luster." Jade, when well polished, has a pearly luster that may be compared to that of lead. This metal was probably unknown to the Aztecs before the advent of the Spaniards (see note 6).

(8) *"Pepetlaca, tonameyotia, tlanextia, cuecueyoca."* All have the same connotation—to sparkle, to glitter. Their combined use here, and in other passages, is an example of the redundancy of terms commonly used by the Aztecs.

(9) *"Ytech quahuitl," "anozo quetzalótatl."* A hard wood or bamboo, used with an abrasive, is an efficient means of polishing stones, and yields a surface showing the characteristic features of the indigenous polish. "El que vende espejos es de los lapidarios, porque también corta sutilmente piedras del espejo, y las raspa con el instrumento que llaman *teuxalli,* y las asierra con un betún hecho de estiercol de murciélegos, y púlelos en unas cañas macizas que se llaman quetzalótatl" (Sahagún, lib. 10, cap. 24). "El que vende piedras preciosas, o es lapidario, es de esta propiedad, que sabe labrar sutilmente las piedras preciosas y pulirlas para hacer relucir, y algunas las pule con la caña maciza que llam *métatl;* y algunas lima, y algunas adelgaza" (Sahagún, lib. 10, cap. 16).

(10) *"Molena,"* etc., "amollentar la tierra" (Molina). "Cuando los que conocen las piedras hallan alguna piedra preciosa dentro de ella, primeramente la quiebran, y sacan la piedra preciosa de donde está, y luego la debastan, y después la raspan, y después la limpian para que resplandeza, y después la esmeran sobre una caña mazica" (Sahagún, lib. 11, cap. 8).

(11) *"Eztecpatl"*; *eztli* = sangre, *tecpatl* = pedernal; *eztetl* = piedra de sangre (Molina). Varieties of jasper, including bloodstone in the form of pendants or the so-called "pulidores" have been found in the Valley of Mexico and other localities.

(12) *"Itepetlayo"; tepeua* = "echar algo por el suelo" (Molina), that is, to discard. "Las piedras preciosas no se hallan asi como están ahora, en poder de los que las tienen, o que las venden, asi hermosas y pulidas y resplandecientes, más antes se crían en unas piedras toscas que no tienen ninguna apariencia ni hermosura, que están por esos campos, o en los pueblos; las traen de acá, para allá, y otras tales piedras muchas veces tienen dentro de sí piedras preciosas, no grandes sino pequeñitos; algunas las tienen en el medio, otras en las orillas o en las costados" (Sahagún, lib. 11, cap. 8).

(13) *"Ytech tetl cenca tlaquauac"* = "junta a una piedra muy dura." Sahagún (lib. 10, cap. 8) defines *teuxalli* as an instrument for grinding gems, "las raspa con el instrumento que llam teuxalli." Molina calls this stone *teuxalli,* "piedra arenisca como molejón parar amorar herramienta." Two stone objects, one in the collection of the Instituto de Antropología e Historia de Guatemala and one in the Robles collection, are grooved in such a manner as to suggest their use in grinding stones in the manner here indicated. Drucker (1952, p. 146) describes saws of a gritty stone from La Venta.

(14) *"Ezmellil"* = esmeril. The use of esmeril was probably introduced by the Spanish, for no deposits of this nature are known in Mesoamerica. "Los Lapidarios cortaban y labraban las Piedras preciosas, con cierta arena,

que ellos sabían, aunque aora la cortan con Esmeril, y hacien de ellos las figuras que querian (Torquemada, 1613, pt. 2D, lib. 13, cap. 34).

(15) *"Vitzitziltecpatl,"* "hummingbird jasper." Seler apparently confuses this stone with *huitzitziltetl*. Sahagún says of the latter, "hállase esta piedra a las orillas de la mar entre la Arena." Its occurrence suggests the operculum of a conch. The description of *vitzitziltecpatl* suggests precious opal. This stone occurs in several places in Mexico and has been encountered in some archeological sites.

Undoubtedly the lapidary techniques used by the Aztecs, and described by Sahagún were derived from, and were essentially the same as, those used by earlier cultures, but they had undergone some changes with time. Copper instruments were a late introduction, for this metal appears to have been unknown to the earliest cultures. Bird bones or bamboo stems were probably the forerunner of the copper tube. The use of emery was a very late introduction by the Spaniards as noted by Torquemada.

Essentially the lapidary process of the Aztecs was carried out somewhat in the following manner:

The raw material was not always suitable for lapidary use, but frequently was broken, trimmed, and the suitable material selected, the worthless stone being rejected. The selected material was shaped with a trimmed hard stone, or rubbed down into shape upon a selected hard stone suitable for this purpose. It was ground, smoothed, and then polished, using either wood or bamboo and an appropriate abrasive.

In spite of the primitive means to which the lapidary was restricted, he was able to achieve results of the highest merit in the elaboration of such refractory materials as jade and other hard stones. Except for the few details given us by Sahagún and Torquemada, the early techniques can only be inferred from the evidence yielded by worked and partially worked objects found at archeological sites. Collections recovered from the Motagua River Valley and vicinity appear to be exceptionally rich in unworked jade and workshop material, suggesting that this region was an important jadeworking center. Interesting workshop lots have been found at Kaminaljuyú (Kidder, Jennings and Shook, 1946), San Agustín Acasaguastlán (Smith and Kidder, 1943), and Uaxactún (Kidder, 1947).

Workshop lots in the collections of the Instituto de Antropología e Historia de Guatemala are as follows:

Kaminaljuyú (3077): Lot of small pebbles, sawed pieces, and earplug cores. The pebbles are of type III jade, and are angular with worn edges. The earplug cores are almost pure white jadeite. From Tomb I, Mound A.

Kaminaljuyú (B-158): Lot of broken pieces of jade and many small fragments, rough unfinished jade bead disks apparently salvaged from other material, crystal or quartz; rock containing plates of specular hematite, perhaps used as source of hematite for polishing rouge.

Uaxactún (8736): Rough ground pieces of jade (for mosaic); sawed beads (for mosaics like Uaxactún mosaic earplug 3294); broken beads of albite and metadiorite.

San Agustín Acasaguastlán (1762): 6 bead blanks of jade; bead blank of jasper; 3 tubular bead blanks of jade, sawed; rough pebble of jade, partly drilled; small earplug core; small jade tool; 2 roughed-out small jade pendants; 2 finished but crude jasper pendants; miscellaneous roughed-out and broken pieces; rough pebble of jasper; rough piece of chalcedony; small quartz crystal.

In addition to rough mineral pieces, a number of examples of reworked objects or of salvage material were encountered, indicating that jade of fine quality was highly prized and probably rare. Such examples are polished earplug cores (San Agustín Acasaguastlán, 1763), small earplug made from an earplug core (Kaminaljuyú, 2965), sliced jade beads used in mosaics (Uaxactún, 3293, 3294), sawed and broken beads reworked (Uaxactún, 8736).

The jadeworking techniques have been described by Kidder, Jennings, and Shook (1946, pp. 118-124) in detail. A few additional observations will be given here.

The specimens in Guatemalan collections show evidence of pecking, grinding, rasping, sawing, drilling, reaming, polishing, incising, graving, and string sawing.

Abrasives.—According to Torquemada (1613, pt. 2D, lib. 13, cap. 14), the lapidaries "cortaban y labraban las Piedras preciosas, con cietar arena, que ellos sabían." The hardness of jade, 6-7 on the scale of hardness of Mohs, requires an abrasive of equal or greater hardness to cut or polish it. Sahagún (lib. 11, cap. 10) describes the abrasive used by the Aztecs as follows:

> El esmeril se hace en las provincias de Anáhuac y Tototepec, son unas pedrezuelas pequeñuelas; unas son colorados y otras, etc., y los lapidarios las muelen, y con la arena limpian y pulen las piedras preciosas. Una manera de margagita que sale del metal, cuando se lavan después de molidos; otra manera de margagita negra que se hace en muchos partes; otra manera de arena que sale de los espejos cuando se pulen, o se labran, otra manera de esmeril de pedernales molidos, son unos pedernales o piedras recias que se hacen hacia Huaxtepec, en los arroyos, traídas por acá, muélenlas y con aquellas desbasten las piedras preciosas, para después purificarlas con el otro esmeril arriba dicho.

The red stones mentioned in the above list may be garnet (hd. $6\frac{1}{2}$-$7\frac{1}{2}$) or rouge (hd. $6\frac{1}{2}$-7). *Margagita* or pyrite has a hardness of $6\frac{1}{2}$ and was much used for mirrors. *Margagita negra* is probably specular hematite, a material found in tombs at Kaminaljuyú. This material, when finely ground, is the familiar polishing powder known as polishing rouge. Pedernal, or *piedra recia,* is quartz (hd. 7) or any hard stone which, when crushed into a fine sand or powder, would serve its purpose.

Garnet is widely used as an abrasive today, its sharp lune-shaped fracture making it particularly useful for the dressing of iron and steel objects. Hematite as rouge is also widely used as a polishing medium in present-day lapidary practice. Flint, as ground flint, tripoli, or other forms of fine-grained silica, are also useful in modern lapidary techniques. Esmeril, as such, was a Spanish introduction into Mesoamerican lapidary techniques, as stated by Torquemada.

Crushed jade itself can also be used as a cutting, grinding, and polishing medium. In this connection it is interesting to note the find of crushed jadeite in the jadeworkers' tomb at Kaminaljuyú described by Kidder, Jennings, and Shook (1946, pp. 85, 120, fig. 3a). This material, probably contained in a small sack or pouch, consists of crushed angular jadeite fragments of medium to coarse size (maximum grain size, 3 mm.) mixed with specular hematite, feldspar, quartz, augite, hornblende, olivene, muscovite, biotite, magnetite, a few grains of cinnabar, rock fragments of andesite, and mica schist. Of these minerals the feldspar, quartz, augite, hornblende, olivene, biotite, and magnetite are normal constituents of the volcanic ash that covers the region about Kaminaljuyú. The clean nature of this sand suggests that it was derived from the bottom of arroyos, or was washed free of accompanying clay and slimes. The jadeite, specular hematite, muscovite, and mica schist are foreign to the area. Cinnabar is also foreign to this area, but is probably an accidental contaminant, as it has no lapidary value, although it was frequently used as a pigment for painting jade objects. In the workshop material (B-158) broken fragments of jade were found, as well as a rock fragment containing specular hematite. Material such as this sand could serve satisfactorily for sawing, grinding, and polishing jade when used with a metal or wooden instrument.

Abrasives harder than jadeite or quartz sand, such as corundum or emery, were probably unknown to the Mesoamerican lapidaries. Beryl (hardness 8) is a useful abrasive and was known to the indigenous inhabitants of the region, but it is a rare mineral and very local in its distribution. The small fragments of this mineral in the Robles collection show no evidence of having been used either as a tool or as an abrasive.

Pecking.—The technique of pecking with a round or blunt stone tool was commonly used in the elaboration of round beads and celts. The rounded balls of jade from which earplug pairs were cut were shaped by pecking. Unfinished examples of such objects often show the percussion marks of the pecking instrument, as, for example, some of the bead blanks shown in plate 2, figure 2, and the earplug blank in plate 4, figure 1, *b*. Many celts show the percussion scars on the poll and sides, and light percussion "ghosts" below the polish of the face (pl. 3, fig. 2, *b*). This operation seems to be confined to the lesser qualities of jade and was not observed in the fine green-colored stone, where the percussion "ghosts" would detract from the beauty of the material.

A number of chloromelanite tools, some of them broken, show rounded and scarred surfaces, suggesting their use as percussion instruments. The durability and toughness of chloromelanite makes it a suitable stone for this purpose.

Pecking was also used for delineating designs upon polished surfaces, as on thick mosaic plaques. Such designs were sometimes produced by pecking since they show a rough pitting and a lack of sharpness at the edges. The features of the lines suggest, however, that the percussion was accomplished by means of a pointed instrument carefully placed and then struck with another object. In this manner better control of the design could be obtained than by simple pecking.

Grinding.—Grinding as a means of pre-forming an object in jade would, with the means available to the ancient lapidary, be a tedious and laborious process. While some objects show evidences of grinding, this technique does not appear to have been widely used. Pecking and sawing appear to have served the lapidary better. It was used, however, on rough stone where the piece already had an acceptable shape and needed only slight modification. In the process of grinding, the jade object was probably rubbed upon the stone grinder. Two flat stones with wide grooves, one in the collection of the Instituto de Antropología, the other in the Robles collection, were perhaps used as grinding stones.

Several objects in Guatemalan collections show distinct evidence of this technique. A celt in the Nottebohm collection was obviously ground from an appropriately shaped pebble (pl. 3, fig. 2, *c*). Another specimen in this collection is a large, essentially rough mass of jade (pl. 3, fig. 2, *a*), but shows abundant traces of pecking and grinding. Coarse mosaic plates were usually shaped by grinding and modified by rasping. Blanks for tubular beads were often shaped by grinding, after sawing.

Striations on the face of flat earplugs and the general flatness of the flares indicate that grinding was used in the shaping of the flare. Grinding was also used to square off the stem and to smooth the edges of the flare. Striations also suggest that the flaring type of earplug was fashioned and smoothed by grinding, after the preliminary sawing to shape, to impart a smooth surface preparatory to polishing.

Large, heavy beads were frequently ground at each end to eliminate irregular or ragged edges.

Undoubtedly, grinding was used extensively where minor modifications of shape were required in the elaboration of the design.

Rasping.—The technique of rasping is not greatly different from that of grinding, although a different tool was probably required. In the operation of rasping a comparatively narrow filelike tool was applied to the stone, the rasped surface yielding a number of small striated facets, while in grinding the object was frequently applied to the stone, yielding a single broad surface. The only objects in which rasping appears to have been used extensively are small mosaic plates, the purpose of the operation being to reduce the mosaic wafers to an appropriate thickness. The striated character of the rasped surface indicates that the tool offered a medium-grained, unpolished surface of hard stone. Such a tool may have been similar to the "texalli" of the Aztecs, defined by Molina as "piedra arenisca como molejón para amorar herramienta."

Sawing.—This technique was commonly used whereby larger pieces of jade were cut into slabs or thin wafers for further elaboration. Many of the larger plaques show the saw cuts on the back of the object. The sawing was usually accomplished first from one side, then the other, and the slab then broken, leaving a rough septum between the two cuts. In very thin waferlike sections, as for mosaic plates, the cut may continue through the stone to obviate possible breakage. The large jade boulder from Kaminaljuyú shows a number of broad saw cuts where pieces were removed for working. By applying a straightedge to some of these cuts they were found to be entirely straight or very slightly concave. Remnants of the cut groove indicate that the cutting edge of the instrument was hardly more than a millimeter thick. The three fine Nebaj plaques (4733, 4734, 4735) showed the original sawed surface on the back and the cuts are likewise entirely straight. A metal tool, as of copper, used in conjunction with crushed jade or sand would serve admirably for this purpose. Trials with the thin axlike copper objects, sometimes identified as money, were found to be efficient saws when used with abrasive, but these celtlike objects do not show the wear that such a use would undoubtedly induce. Lacking such a metal tool, a hard wood or bamboo saw would serve. Convex cuts, such as would result in string or cord sawing, were not encountered.

Sawing in this manner was a rather ancient accomplishment, for it is shown by some of the mosaic pieces from a Miraflores headdress from Kaminaljuyú.

In addition to the use in the sawing of plaques, this technique was widely used in the pre-forming of long tubular beads. Several bead blanks roughed out by sawing were encountered in the collections (pl. 3, fig. 1), and such beads as the 12-cm.-long one from Nebaj were pre-formed in this manner.

Sawing was an essential process in pre-forming both the flat and flaring types of earplugs (pl. 4, fig. 1, *b*). Sawed earplug blanks of both types are known. The cutting groove indicates a cutting edge of the saw about a millimeter in thickness.

Mosaic plates were also sawed in a similar manner. Some of these jade mosaic plates are only ½ mm. or less in thickness. A small plate from Kaminaljuyú 1 x ½ x .05 cm., consisting of a single grain of fine green jadeite and with marked cleavage cracks, shows distinct marks of sawing, and demonstrates the precision and care with which fine-quality material was treated.

Although sawing was frequently employed in the elaboration of fine ceremonial celts in "blue" jadeite in Olmec examples, this technique does not appear to have been used in the more utilitarian celts of the Guatemalan area.

Sawing techniques were also used in some of the decorative elements of figurines and pendants. Earplug flares are sometimes notched by sawing (Nebaj).

Thin mosaic plates from Uaxactún were divided by sawing. The cut indicates a sawing edge of about 1½ mm. in thickness.

Drilling.—Amazing examples of drilling are sometimes found in Mesoamerican artifacts, and a wide variety of drills were used. Small or thin objects were usually single-drilled, that is, from one side only, to yield a small conical hole. Larger objects were double-drilled, first from one side, then the other, to yield a biconical hole. Large objects were similarly drilled, the meeting of the two holes, unless reamed out, shows a thin broken septum.

Both solid and tubular drills were used. The solid drills were used chiefly for drilling beads and for the small cup-shaped depressions frequently used as elements of design, as in the corners of mouths of faces, and in headdress design (pl. 4, fig. 2, *b*). Such drills may have been jade-tipped rods, the four figures shown (pl. 1, fig. 1, *b, c, e, f*) being, perhaps, such jade points. Large blunt drills were used in larger cup-shaped depressions and in rings or ringlike beads. By using jade drill points no abrasive is required, sufficient dust being generated by the friction of the two stones to act as a satisfactory abrasive.

Some remarkable examples of drilling are found in the Guatemalan collections. The fine Nebaj plaque (4733) was drilled transversely for suspension for its entire width of 14 cm. A long bead from Nebaj was drilled for a length of 12 cm. Both objects were double-drilled, first from one side, then the other, to meet so perfectly in the middle of the stone that the join is hardly perceptible.

Hollow drills were widely used (pl. 4, fig. 1, *b, c*). The resultant core could be used for small objects. These hollow drills sometimes had a diameter of 3 cm. or more. Drill grooves in the cores indicate that the cutting edge of the tool had a thickness of about a millimeter. These hollow drills were probably of reed or bamboo (the Aztec *quetzalotatl*) or bird bones (Holmes, 1897, pp. 304-309). Sahagún mentions tubes of metal (*teputztlacopintli*), used for drilling precious stones, but these are probably a late introduction into the lapidary techniques, perhaps by the Spaniards.

In order that such drills should be effective, an abrasive must be applied to the cutting edge. For soft stone any hard-rock powder would be suitable, but for jade some hard mineral such as crushed jadeite or fine quartz sand would serve the purpose.

Large hollow drills were used principally in the elaboration of earplugs. The inner diameter of the stem was almost always prepared in this manner. In the earplug blank with its accompanying core (3068, pl. 4, fig. 1, *b*) the stone was drilled from the sawed side to the bottom of the hemispherical mass and the core tapped free. The core is slightly tapering, $1\frac{3}{4}$ cm. at the top, $2\frac{3}{8}$ cm. at the bottom. A remnant of the cutting groove at the bottom of the core indicates a cutting edge of the drill $1\frac{3}{8}$ mm. wide. The drilled hole is $2\frac{1}{4}$ cm. wide at the top, and 2 cm. wide at the bottom. An earplug from Nebaj (4782) shows further evidences of the use of large drills. The central hole was drilled first from the flat face of the earplug blank, then from the rear. A circular septum indicates where the two drill holes met. A second, and larger drill, $1\frac{3}{4}$ cm. inside diameter, was now used to drill the cylindrical stem to a length of $1\frac{1}{2}$ cm. A circular groove at the base of the stem indicates that this drill had a cutting edge 1 mm. in thickness. This earplug was completed by sawing the back of the flare by horizontal cuts, polishing the stone and reaming the throat.

Certain elaborately pierced designs may have been produced by drilling a series of contiguous holes, which could then be joined by grinding to form a flowing design. Such a technique was used by the Olmec lapidaries.

A few measurements of the dimensions of hollow drills were made upon the circular elements of designs and show a range from an inside diameter of 1 to 6.5 mm. and with a thickness of the drill from $\frac{3}{8}$ to $1\frac{1}{2}$ mm. The ratio of interior diameter to thickness of the drill walls is usually about 5-6:1, but occasionally one varied widely from this ratio.

A drilling technique appears to have been used to produce shallow cup-shaped earplug flares (Nebaj, Uaxactún). The instrument used appears to have been a thick, blunt drill producing a shallow depression, which could then be polished. In the case of the Nebaj flares the diameter of the tool was 20 mm., and in the broken Uaxactún flare 8 mm. This technique could be classified as grinding, except that a rotating tool was probably used.

Conically pointed drills were also used to perforate beads or to drill holes in pendants for suspension, but to judge by the septa remaining in biconically drilled holes, the blunt drill was preferred.

Beads were sometimes first drilled on both sides with a blunt, solid drill to form two cup-shaped depressions, and the perforation then completed by a smaller, more cylindrical drill to yield a small hole.

Reaming.—Drilled holes were frequently smoothed by reaming. This is particularly common in the stem and throat of earplugs (Kidder, Jennings, and Shook, 1946, fig. 145, *a, b*). The flaring throat of some earplugs may well have been produced by reaming. The neatly beveled edge of the horizontally flared earplugs was certainly produced in this manner. Large beads were sometimes reamed after drilling to yield a widely tapering hole.

Several stone tools in chloromelanite, appropriate for reaming, were encountered in Guatemalan collections. Plate 1, figure 2, *e,* is almost certainly a reamer and fits well the reamed throat of some of the earplugs. Plate 1, figure 2, *a,* would also serve such a use, while figure 2, *c,* seems to be a reaming tool of general utility. It should be noted that reamers such as those illustrated are also suitable, through shape and hardness, for use as polishers.

Polishing.—The polished surfaces of Mesoamerican jades show characteristics different from those on modern lap-polished surfaces.

Under the microscope or a hand lens one can see that the eminences are polished but that the intergrain depressions are rough. The reflections from a polished surface are a pattern of brilliant spots separated by an irregular anastamosing network of dull areas. Such a surface would result from fine grinding with a hard tool. In modern polishing with a felt lap and an appropriate polishing powder, the entire surface is polished, since the soft felt penetrates the intergrain fissures to produce a smoothed and polished valley. The result is a completely polished surface with a microscopically undulating surface. In addition, the "pull" of a felt lap leaves a series of minute orientated ridges not shown by fine grinding or polishing with a hard surface. The distinctive surface features should serve to distinguish authentic Mesoamerican polishing from modern lap polishing.

Probably the early jade polishing was accomplished with jade polishing tools. Experiments by the writer have shown that small jade celts, such as are shown in plate 1, figure 2, *d, f,* are efficacious in polishing a properly prepared jade surface. The resultant polish shows the same characters as the authentic Mesoamerican polish. There is no evidence that a polishing powder was used other than the dust developed by the abrasion of the celt upon the jade surface being polished.

A similar polished surface can be obtained easily and quickly by polishing a smoothly ground surface with the outer surface of a bamboo rod, using an appropriate abrasive. A hard wood surface would also serve this purpose but is less efficacious than bamboo. Polished surfaces on obsidian or rock crystal produced in this manner show characters different from the polished surface of jade, because of their lack of granularity.

Incising.—A simple pattern of fine incised lines, without further modification, is sometimes found upon unimportant objects. Such incising was perhaps accomplished by edged jade tools like that shown in plate 1, figure 1, *d,* or fine jade points.

Another manner of incising was by means of tubular drills. Circular elements, as for eyes, and lune-shaped curves, made by holding the drill at an angle, as for the nose or mouth, are frequent in the Mayan heads of the Quiché region. Other decorative elements, such as representation of earplugs, circles on cheeks or foreheads of figures, or simply random circles on flat surfaces are also encountered. Deeper and more intricate graving forms the basic technique in the more elaborate carvings. This was done with abrasive tools to form a deep groove. Frequently the eyes, nose, and mouth of faces are produced by this means, as well as head bands and the delineation of the headdress.

Such incising can be accomplished with sharp-bitted celts of jadeite or chloromelanite. Finer detail can be performed with finely pointed jadeite rods, such as one from Mexico in the collections of the U. S. National Museum. Large celts, such as the one shown on plate 1, figure 2, *f,* would serve for roughing out the larger elements of some designs.

String sawing.—A specimen from Nebaj (4760) representing a turkey (?) shows large commalike elements in the design which may have been produced by string sawing. The design begins at a drilled hole and continues in a tapering commalike pattern. The cut has been polished, thereby obliterating any marks of the tool used. A flat bead from Kaminaljuyú representing a parrot's head in profile shows a single such element to delineate the bird's beak. In a small serpent figure, also from Kaminaljuyú, the long slitlike mouth is probably by the same technique. Certain straight elements, as the mouth or headband lines in effigies, may have been made by string sawing, but there are no clearly diagnostic criteria to prove this.

Superb examples of string sawing in jade, and similar to the specimen from Nebaj, from Costa Rica, are in the Bliss collection, National Gallery of Art, Washington, D. C.

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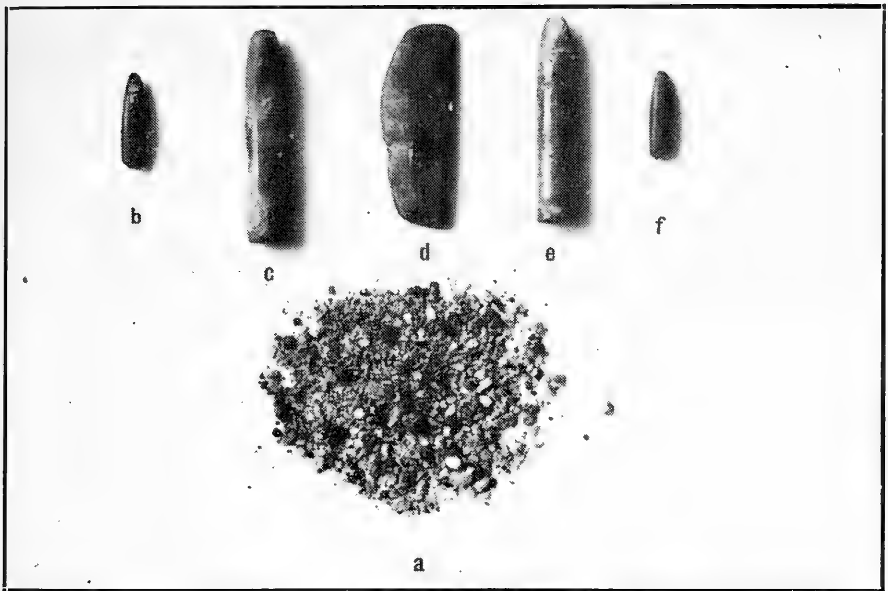
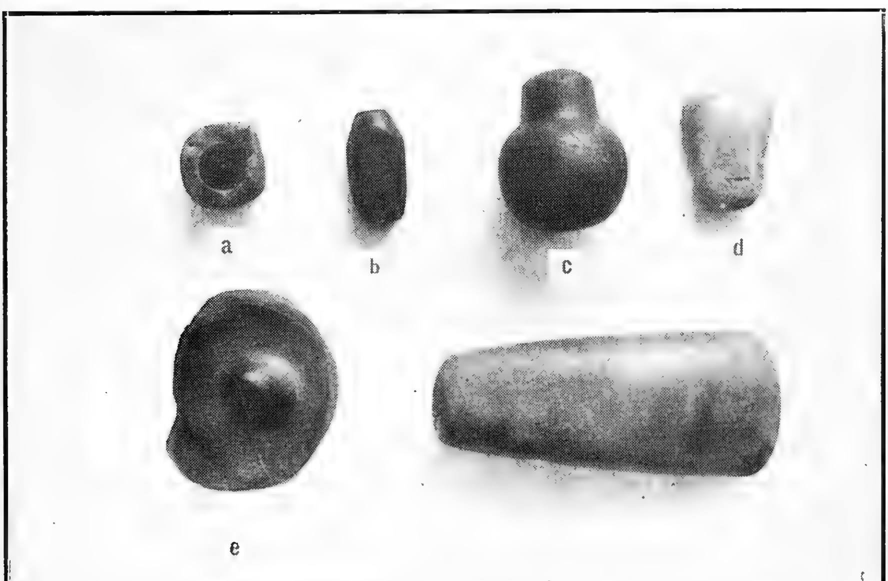
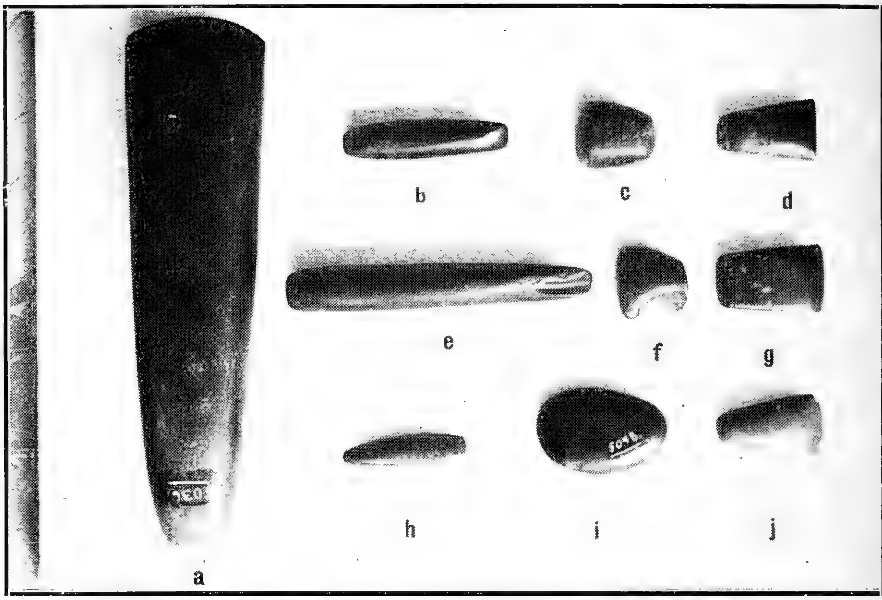
PLATES



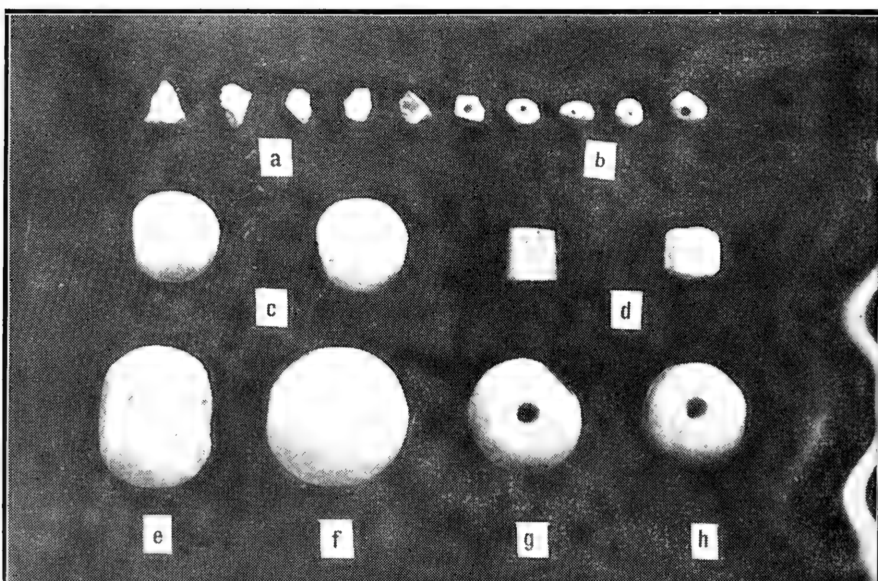
1. Jade-working tools. *a,* Crushed jadeite abrasive, Kaminaljuyú; *b, f,* jadeite drill points(?), San Agustín Acasaguastlán; *c, e,* jadeite drills(?); *d,* jadeite graver(?), San Agustín Acasaguastlán (natural size).



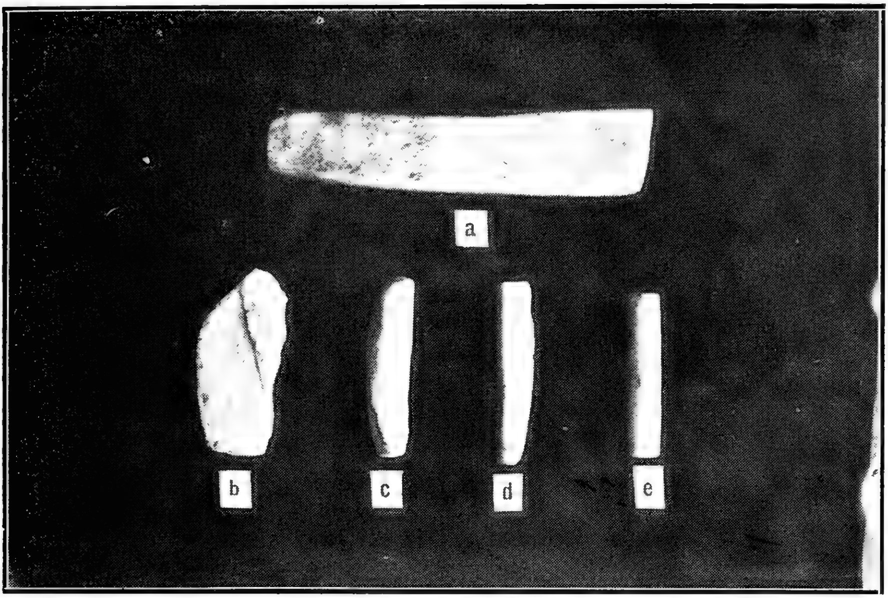
2. Jade-working tools. *a,* Jade, drilled hole with central pointed core, Nottebohm collection; *b,* chloromelanite reamer, Nottebohm collection; *c,* chloromelanite reamer and polisher(?), Nottebohm collection; *d,* jadeite polishing celt (5041); *e,* earplug reamer, Kaminaljuyú; *f,* large jadeite polishing celt (5039), 14 cm. long. (See footnote 3, p. 8, for explanation of numbers in parentheses.)



1. Chloromelanite tools, polishers, polishing celts, gravers, and percussion tools. *b*, *c*, *j*, 1458; *g*, 5041; *h*, 5042; *i*, 5048; *e*, Chichecastenango, 6594; *a*, *f*, no numbers. *e* is 14 cm. long.

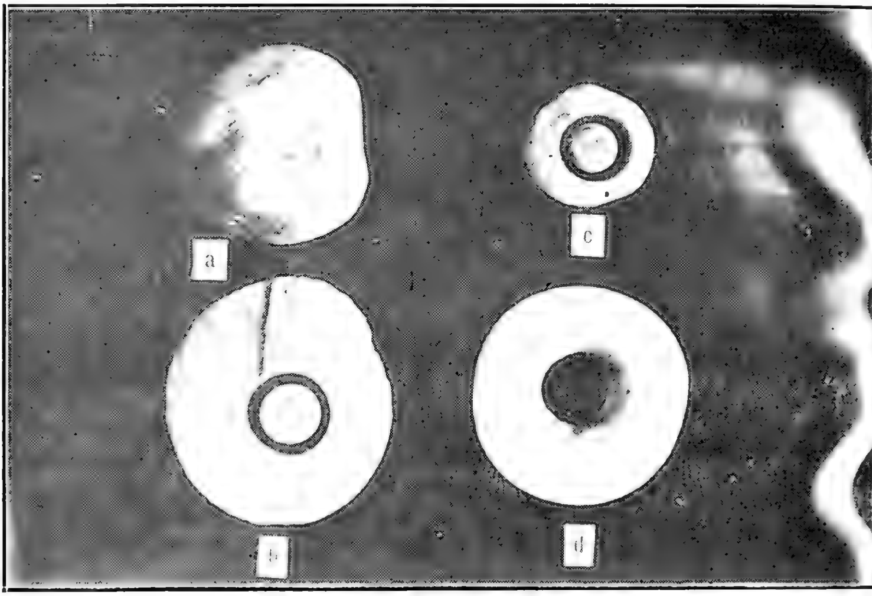


2. Jade-working techniques. *a*, Small jadeite fragments for small beads, Kaminaljuyú; *b*, small beads made from *a*; *c*, jadeite bead blanks, pecked round but not polished or drilled (3077), Kaminaljuyú; *d*, bead blanks; *e*, *f*, cylindrical roughed-out jadeite bead blanks (1765), San Agustín Acasaguastlán; *g*, jadeite bead, drilled but unpolished (2908), Kaminaljuyú; *h*, finished jadeite bead (2955), Kaminaljuyú. (Natural size.)

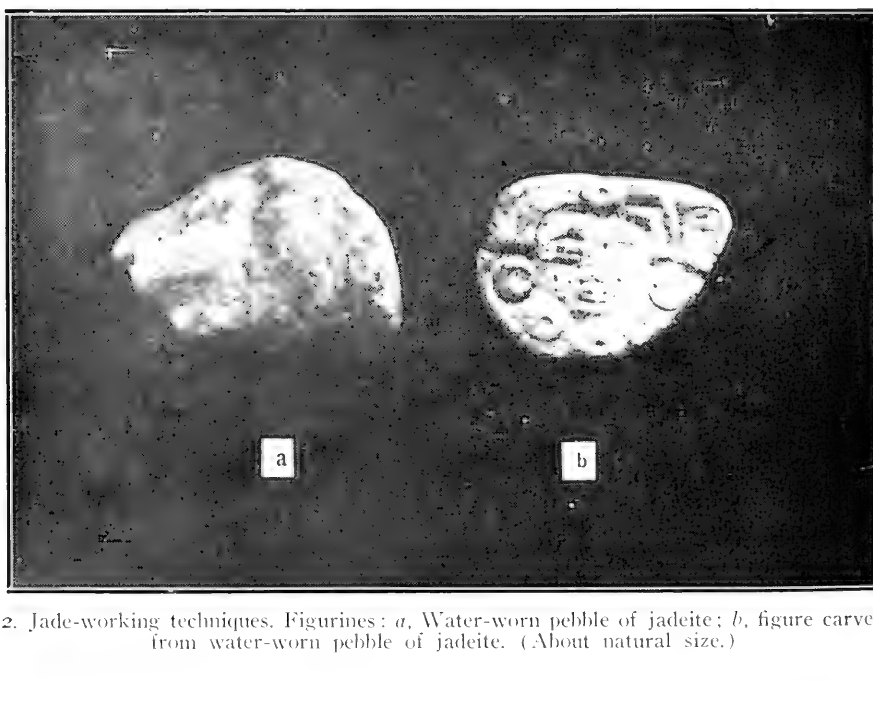


1. Jade-working techniques. *a*, Large jadeite bead (4802), 13 cm. long, made by sawing, polishing, and drilling; *b*, sawed jadeite bead blank (3077), Kaminaljuyú; *c*, sawed and shaped but not drilled jadeite bead blank (3027), Kaminaljuyú; *d*, completed jadeite bead, sawed and rounded (4745), Nebaj.

2. Jade-working techniques. *a*, Jadeite used in celts, partly shaped by pecking and grinding, Nottebohm collection; *b*, jadeite celt, like *a*; the white spots are percussion scars, the celt well polished; Nottebohm collection; *c*, a flat pebble of jadeite ground into a celt; the sides and poll are unworked pebble surface, the front and bit are shaped and polished; Nottebohm collection. The large jade block is 17 cm. maximum length.



1. Jade-working techniques. Earplugs: *a*, Jadeite pebble (3146), such as is used in the forming of earplugs; *b*, jadeite, pecked round, sawed, and drilled (3608), Kaminaljuyú; *c*, shaped and drilled block of jadeite (5116), an earplug blank(?); *d*, finished earplug of jadeite (5003). *a*, *b*, and *d* are all in the same type of jade. (About ½ natural size.)



2. Jade-working techniques. Figurines: *a*, Water-worn pebble of jadeite; *b*, figure carved from water-worn pebble of jadeite. (About natural size.)

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A REVISED INTERPRETATION OF THE EXTERNAL REPRODUCTIVE ORGANS OF MALE INSECTS

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CONTENTS

A REVISED INTERPRETATION OF THE EXTERNAL REPRODUCTIVE ORGANS OF MALE INSECTS

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INTRODUCTION

There is nothing in taxonomic biology so hard to eradicate as a dead idea embalmed in a traditional nomenclature. This observation applies particularly to the study of the external genital organs of male insects. The great diversity in structural detail of the genitalia gives these organs a value for the identification of insect species almost equal to that of fingerprints for the identification of human individuals. On the other hand, the very structural diversity of the organs makes it difficult to understand their fundamental nature and the homologies of their parts. Consequently in taxonomic descriptions of the genitalia there is such a lack of uniformity in concepts of homology and in the adopted terminology that one specialist hardly knows what the other is talking about. Those who are interested in current nomenclatural systems used by taxonomic specialists are referred to the "Taxonomist's Glossary of Genitalia in Insects," edited by S. L. Tuxen (1956).

When homologies cannot be determined by comparative anatomy alone we must have recourse to ontogeny. Fortunately something of the development of the genitalia is now known in most of the major orders of insects. On the basis of this scattered information the writer has attempted in the following discussions to analyze the subject anew in the hope of arriving at a better understanding of the fundamental structure and the homologies of the genitalia, from which a uniform terminology might be devised.

The development of the external genital organs has been described in Thysanura by Lindsay (1939), and Qadri (1949); in Orthoptera by Else (1934), Roonwal (1937), and Qadri (1940); in Hemiptera by Christophers and Cragg (1922), Pruthi (1925a), George (1928), Metcalfe (1932b), Rawat (1939), and Qadri (1949); in Coleoptera by Kerschner (1913), Pruthi (1924), Metcalfe (1932a), and Srivastava (1953); in Siphonaptera by Sharif (1937); in Trichoptera by

Zander (1901); in Lepidoptera by Zander (1903), Mehta (1933), and Rakshpal (1944); in Diptera by Christophers (1922), Christophers and Barraud (1926), and Abul-Nsar (1950); in Hymenoptera by Michaëlis (1900), Zander (1900), Tiegs (1922), Snodgrass (1941), and D'Rosario (1942).

In all these insect orders the definitive genital structure, whether simple or complex, is derived from a pair of small ectodermal outgrowths (fig. 1 A, *PhL*), which appear on the nymph or larva, and may be termed the *primary phallic lobes* (*phallos,* emblem of generation). The terminal ampullae (*Amp*) of the vasa deferentia (*Vd*) are commonly observed to lie partly within the lobes. In the Ephemeroptera (B) the primary lobes become a pair of penes (*Pen*); in Thysanura they unite to form a simple median penis. In the higher orders, from Orthoptera to Hymenoptera, each primary lobe divides into two secondary lobes (C), or *phallomeres,* which may be designated *mesomeres* (*Mmr*) and *parameres* (*Pmr*). Between the bases of the mesomeres an ectodermal ingrowth forms the *ductus ejaculatorius* (*Dej*), the opening of which is the *gonopore* (*Gpr*). The ampullae unite with the inner end of the duct and are carried inward with its further growth. In the Orthoptera the four phallomeres develop into organs of various types. In the higher orders the mesomeres become hollowed on their opposed surfaces and unite with each other to form the tubular median organ known as the *aedeagus* (D, *Aed*). The lumen of the aedeagus is thus not a continuation of that of the ejaculatory duct, but a newly formed extension of the genital passage, which may be distinguished as the *endophallus* (*Enph*); its opening at the end of the aedeagus is the *phallotreme* (*Phtr*). The endophallus with the gonopore at its inner end (F, *Gpr*) is usually eversible from the aedeagus (I), bringing the gonopore to its tip.

The parameres elongate and usually become the principal genital claspers of the adult. If they are not completely separated from the aedeagus (E) the three parts are supported on a common *phallobase* (*Phb*). Usually, however, the parameres retain only a narrow basal connection with the aedeagus (F), and they may be so far displaced laterally (G, H) as to appear to be independent appendages of the ninth segment.

Inasmuch as the name "paramere" has been given to so many different parts of the adult genital structure, some writers contend that the term is thereby rendered meaningless and should be discarded. This verdict, however, is equivalent to denying a true claimant his rights because of impostors. The term *paramere* was coined by Verhoeff (1893), and by him was specifically given to the lateral genital

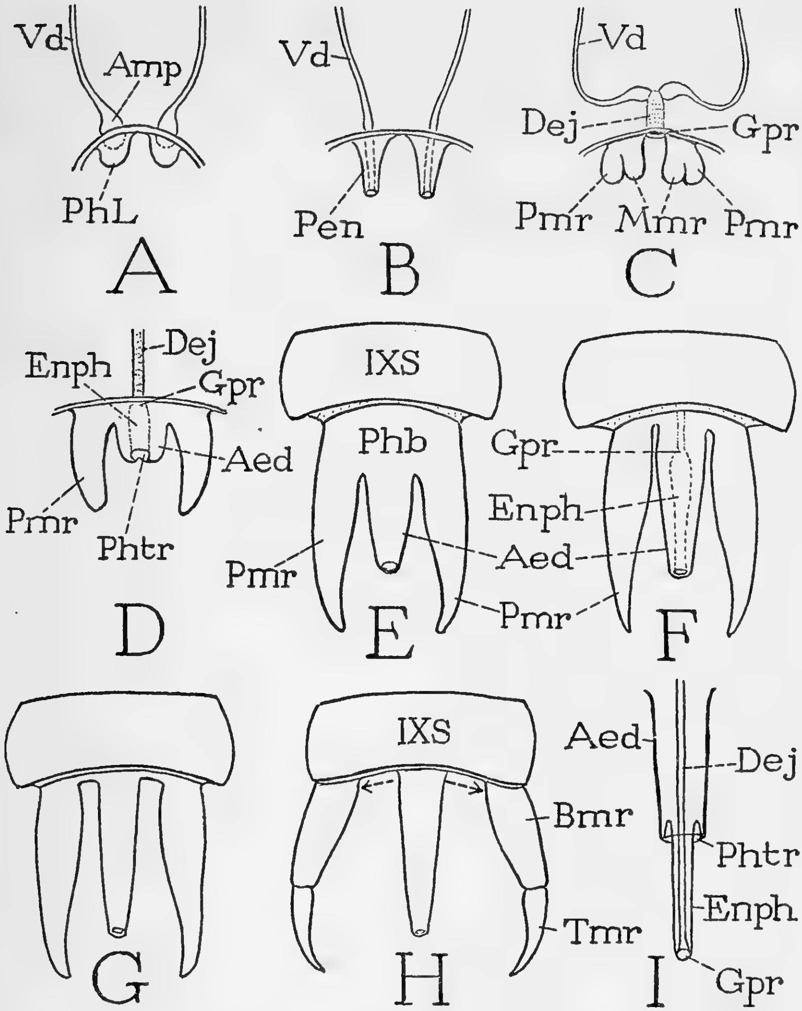

FIG. 1.—Diagrams illustrating the common origin and various types of development of the phallic organs.

A, the primary phallic lobes (*PhL*) invaded by the ampullae (*Amp*) of the vasa deferentia (*Vd*). B, penes of Ephemeroptera, giving exit to the genital ducts. C, the usual division of the phallic lobes into mesomeres (*Mmr*) and parameres (*Pmr*); ejaculatory duct (*Dej*) developed between the mesomeres, opening through the gonopore (*Gpr*). D, mesomeres united to form the aedeagus (*Aed*); aedeagal lumen, or endophallus (*Enph*), opening through the phallotreme (*Phtr*). E, aedeagus and parameres not completely separated from common phallobase (*Phb*). F, aedeagus and parameres with only narrow basal connections. G, parameres removed from aedeagus. H, parameres more widely displaced from aedeagus on margin of ninth abdominal sternum (*IXS*), divided into basimeres (*Bmr*) and telomeres (*Tmr*). I, aedeagus with endophallus everted, bringing the gonopore to its tip.

lobes of Coleoptera. These lobes have been shown to be derived from the lateral branches of the primary phallic rudiments. Structures of other insects having the same origin, therefore, are legitimately parameres (side parts) regardless of what they may be called by taxonomists.

Because of their community of origin, the parameres and the aedeagus are primarily closely associated at their bases, and this condition where it occurs in the adult (fig. 1 E, F) should be a relatively primitive one. Generally the phallic organs lie close behind the ninth abdominal sternum (E, *IXS*), or before the margin of its anteriorly reflected posterior part. To better serve their clasping function, however, the parameres tend to move away from the aedeagus along the sternal margin (G), and in many of the higher insects they have come to have a lateral position on the ninth segment (H), where they are commonly mistaken for ninth-segment appendages. Gustafson (1950) says, "There is a strong tendency for the gonapophyses (parameres) of the male to fuse with the phallus." Considering the common origin of the parameres and the "phallus" (aedeagus), however, the facts should be stated in the reverse—the parameres have a tendency to separate from the aedeagus. Finally, in the higher orders, the parameres may become two-segmented by a secondary constriction dividing each clasper into a proximal *basimere* (H, *Bmr*) and a distal *telomere* (*Tmr*). The telomeres have been called also *harpagones* (sing. *harpágo,* a grappling hook).

Inasmuch as the parameres and the aedeagus are developed from a single pair of primary genital lobes, the three parts together are here termed the *phallus,* or *phallic organs,* though the name "phallus" is sometimes given to the aedeagus alone. The phallic organs serve the dual function of *copulation* and *intromission.*

Specific examples of the development and the adult structure of the phallic organs will be given in subsequent parts of this paper. While the aedeagus and parameres are almost constant parts of the adult genital apparatus, either or both may be absent, and many secondary accessory parts appear that have little relation in the different orders. These secondary structures must be given specific names in taxonomy. Finally, there may be processes and lobes of various kinds developed on the eighth, ninth, and tenth abdominal segments that appear to serve some function in copulation, in which even the cerci of the eleventh segment may be involved. All these structures together with the true genitalia are often termed collectively the *terminalia.*

In the Thysanura the penis lies between a pair of stylus-bearing plates which probably are correctly regarded as the coxae of former ninth-segment limbs. In some species of Machilidae endite processes arise from the inner basal angles of the coxal plates and embrace the penis (fig. 2 G, *Endt*). In the Ephemeroptera the coxae are united in a plate behind the ninth sternum (fig. 3 A, *Cx*) and the styli (*Sty*) are usually developed into long clasping organs. Distinct coxal plates and styli are again found in the orthopteroid *Grylloblata* (fig. 5 A), but where styli are present in other insects the coxae are united with the sternum. The occurrence of coxal plates and styli in these three groups of insects has furnished a basis for most theories on the homologies of the genital structures in the other insects.

The stylus-bearing plates are commonly called "coxites" by students of the genitalia, but, if the plates are supposed to be the coxae of former limbs, why the addition of *ite,* a biological suffix meaning "a part of"? "Coxopodite," on the other hand, is a perfectly good compound, meaning the "coxal part of a leg," but it is unnecessary. The fact, already noted, that the parameres of the adult insect very commonly have a lateral position on the ninth sternum has led quite naturally, from a study of adult anatomy, to the current interpretation of the parameres as being the coxal plates of the ninth segment, termed "gonocoxites." That they are often two-segmented strengthens this concept because the distal segments then are "gonostyli." However, this interpretation entirely ignores the development of the parameres from lateral branches of the primary phallic lobes, and the fact that they thus have a common origin with the aedeagus. In spite of this, the theory of the coxal nature of the parameres survives by hypothetical manipulation of certan facts concerning the aedeagus.

The aedeagus of the adult insect may be either wholly membranous or entirely sclerotic, but in some cases the sclerotization takes the form of lateral plates or rods in the aedeagal wall, which are called "penis valves," though nothing about them suggests a valvular nature. According to the theory that the parameres are the coxal plates of the ninth segment, the aedeagus must have a connection with these plates. The "penis valves," therefore, are supposed to be derived from endite processes of the coxal plates, such as are present in some species of *Machilis* (fig. 2 G, *Endt*). As this theory is elaborated and diagrammed by Michener (1944), the endites are assumed to unite with a primitive median penis to form the aedeagus, and thus become the "penis valves" of this organ. But here theory assumes priority over facts. The coxal endites of Machilidae are not united with the penis, they are not present in other male thysanurans, nor are there corresponding structures in other male insects. The so-called "penis valves" are well developed in Hymenoptera (fig. 15, *r*), but they are clearly seen to be only lateral sclerotizations of the otherwise membranous aedeagus. The penis of Thysanura is formed by the union of two rudiments entirely comparable to the phallic lobes of other insects that give rise to both the aedeagus and the parameres. The same rudiments in the mayflies develop directly into a pair of penes having no connection with the coxal plate of the ninth segment. There is no convincing anatomical evidence, therefore, that the parameres are ninth-segment coxae, or that the aedeagus has any relation to the latter.

The next question that comes up is: do the phallic organs belong to the ninth or the tenth segment of the abdomen? Most writers refer them to the ninth, but there is sufficient evidence in the lower insects to warrant the belief that primarily the phallic rudiments are developed on the tenth segment. Their origin at least in part on the tenth segment has been observed by Roonwal (1937) in *Locusta,* by Qadri (1940, 1949) in Orthoptera and Hemiptera, by Sharif (1937) in Siphonaptera, and by Tiegs (1922) in the chalcid *Nasonia.* Else (1934) claimed to have traced the phallic rudiments from the appendage buds of the tenth abdominal segment in the embryo of *Melanoplus.* In nymphal insects the rudiments are described as formed in the genital chamber just behind, or above, the ninth abdominal sternum, but in holometabolous larvae they may appear to be actually on the venter of the ninth segment, in which a sternal plate has not yet been formed. Embryological studies on Thysanura and Orthoptera have shown that the vasa deferentia first extend into the tenth segment, on which presumably were the primitive male genital openings. The forward looping of the vasa deferentia in adult Orthoptera from beneath the long cercal nerves of the eleventh segment, as they are carried forward by the ejaculatory duct, is highly suggestive, as the writer (1937) has shown, that the vasa deferentia primarily ended in the tenth segment. The fact that the phallic organs get their musculature from the ninth segment might be taken as evidence that they belong to this segment. Since, however, the tenth sternum is commonly much reduced, it is possible that the phallic musculature is derived from the original intersegmental muscles between the ninth and tenth sterna.

Writers who have taken it for granted that the phallic organs represent a pair of segmental limbs point out that they cannot be appendages of the tenth abdominal segment, because in lepidopterous and tenthredinid larvae the limbs of this segment are present as prolegs, and two pairs of appendages cannot be developed on one segment. However, numerous reasons have been given by Hinton (1955) for believing that the prolegs are secondary organs adapting the long-bodied larvae for crawling and climbing. He shows that neither in their structure nor in their musculature do the prolegs have any likeness to thoracic legs, and concludes that they are new locomotor organs developed on the site of the disappeared embryonic leg vestiges. Now we must consider the question as to whether or not the phallic organs themselves represent a pair of legs.

A proper interpretation of the nature of the adult genital organs could be deduced only from a knowledge of what the organs were in the primitive ancestors of the insects, but this we do not know. In the minds of most entomologists, or at least in their writings on the insect male genitalia, there seems to be little question that the phallic organs are specially modified segmental appendages of the ninth or the tenth abdominal segment. Some go so far even as to see in the dual branching of the primary lobes a retention of a supposedly biramous limb structure. Among the arthropods, however, the biramous limb is a crustacean specialty, and it is too much to believe that it should occur among the insects only in the male genital appendages. This theory would have to assume that the endopodites unite to form the aedeagus, and it does not account for the undivided penes of the mayflies. Generalization can be stretched to the breaking point.

Only one writer, Else (1934) in his study of *Melanoplus,* has claimed to have observed the derivation of the phallic rudiments from abdominal appendage buds of the embryo, specifically those of the tenth segment. Wheeler (1893), on the other hand, said the tenth-segment limb buds on the embryo of *Xiphidium* gradually become smaller and finally disappear. Most observations on the origin of the phallic rudiments show that the buds usually appear first on the nymph or the larva, and often in the later instars. The post-embryonic appearance of the phallic rudiments, therefore, suggests that they are not equivalent to the transient limb vestiges on the abdomen of the embryo.

Michener (1944) has reasonably said: "That the copulatory organs are new structures seems far less probable than that they are derived from pre-existing structures." His further contention, however, that the pre-existing structures were segmental limbs would assume that there is no alternative. Are we to imagine that before these limbs were modified into genital organs the male insects used a pair of legs for the discharge of the sperm? If so, where were the gonopores in relation to these legs? Among other modern arthropods, as in *Limulus,* the pycnogonids, and many of the crustaceans and diplopods, the gonopores are on the limb bases, and usually open through a pair of penes. In some of the crustaceans and diplopods the penes are on the sternum between the legs, and the two may be united in a single median penis. In the insects typical paired penes are present in the Ephemeroptera. Hence it would seem quite probable that the primitive male insects should have had a pair of penes on the genital segment, and that the oviducts of the female opened separately, as they still do in the Ephemeroptera. A logical deduction, therefore, is that the paired phallic rudiments of modern insects represent a pair of primitive penes. A penis origin of the phallic lobes is further suggested by the fact that the terminal ampullae of the vasa deferentia usually lie partly within these lobes (fig. 1 A). Though in the higher insects the genital ducts do not open through the phallic lobes, in the Ephemeroptera and those Dermaptera that have paired penes the ducts discharge individually through the latter, and therefore primarily must have opened through the primitive penis lobes. In insects that have a median ejaculatory duct developed between the phallic lobes, the mesodermal ampullae withdraw from the lobes and open into this secondary ectodermal outlet (fig. 1 C).

Admittedly it is difficult to imagine that from a pair of simple penes could have been evolved the large and complex genital organs of the higher insects. Yet, whatever the primary phallic rudiments may be, they do develop into all the variety and complexity of the mature genitalia.

It is true that in some arthropods in which the female has a sperm receptacle the actual intromission of the sperm by the male is accomplished by a pair of legs, but these legs are not those of the segment bearing the genital openings or penes. In most of the malacostracan crustaceans, for example, the male genital outlets are on the last thoracic segment, but the sperm is received by the modified first two abdominal appendages (pleopods) and by them introduced into the receptacle of the female. Likewise in the diplopods the penes are on the third body segment, and the intromittent appendages are usually one or both pairs of modified legs on the seventh segment. In these cases the male practices what amounts to artificial insemination, as does the male spider with his pedipalps. This method of insemination has no counterpart among the insects.

The concept of a penis origin of the phallic lobes leads to a much broader generalization than does the idea that they represent a pair of segmental limbs. We may then correlate the organs of sperm emission in all the arthropods, whether they are penes on the leg bases, paired or single penes on the venter of the genital segment, or the variously developed phallic organs of most insects. To this may be added the fact that the phallic organs in their early development never have the structure of a leg, and it is only in their higher evolution that they suggest anything of a leg nature. On the contrary, the mouth parts of insects, which unquestionably are remodeled legs, always show in their structure or development their leg origin, and the leg structure is most evident in the lower orders.

The frequent occurrence of the genital apertures on the coxae of a pair of legs among the arthropods may perhaps be traced back to the Onychophora, in which the nephridia open at the mesal sides of the leg bases. The genital ducts are merely a particular pair of nephridial ducts (coelomoducts) that have come to serve as gonoducts. Where penes occur, they are secondary ectodermal outgrowths around the mouths of the ducts. It is quite reasonable, therefore, to suppose that in the early arthropod ancestors of the insects the penes were on the bases of a pair of legs. That these legs are represented by the parameres, however, seems very improbable, since each phallic rudiment becomes a penis in the mayflies, and parameres are lateral branches of the primary lobes developed principally in the higher insects. In their simplest functional form the phallic lobes are penes not associated with appendages, each of which is penetrated by an ectodermal duct that connects with the terminal ampulla of a vas deferens.

Many of the lower invertebrates that are permanently aquatic discharge the reproductive elements freely into the water, where union between the ova and spermatozoa takes place. This method of propagation would not be practicable with land animals, and most of the arthropods have improved on it by the development of sperm receptacles in the female and intromittent organs in the male. By this device the inseminated female can fertilize the eggs whenever the eggs are mature, a method particularly favorable for life on land. Since, however, most Crustacea have sperm receptacles and intromittent organs, it is probable that the ancestors of the terrestrial arthropods were thus equipped before they left the water, but the great diversity in the segmental position of the genital openings and the spermatheca in different arthropod groups would indicate that the organs have been separately developed and not derived from a common ancestor. In *Limulus* and the arachnids the genital ducts in both sexes open consistently on the eighth body segment, from which fact it might be inferred that the same was true of the trilobites. By contrast, the gonopores of the mandibulate arthropods are on different segments in the several classes and even within a single class, so we have no evidence as to what may have been the primitive position of the genital outlets in these arthropods.

The manner by which the diversity in position of the genital outlets came about in the evolution of the early arthropods is difficult to understand. Gustafson (1950) has proposed as an explanation that "it seems most probable that the primitive ancestors of the Arthropoda possessed paired gonads, gonoducts and gonopores in nearly every segment of the body," and that differences in the position of the outlets resulted from "segmental localization" of the gonads. This idea is a rather extravagant assumption, and embryogeny gives no support to any such theory. Multiple segmental gonads with separate nephridial outlets might have been present in some remote worm progenitor of the arthropods, but among modern forms multiple gonopores occur only in some of the aberrant pycnogonids, and even the Onychophora have a single genital opening. It is hardly to be supposed, therefore, that the early arthropods themselves had more than one pair of genital outlets. Still it is difficult to account for the later differentiation in the segmental position of the gonopores.

From the work of Tiegs (1940, 1947) on the progoneate Symphyla and Pauropoda it appears that functional genital ducts may be secondary ectodermal ingrowths that connect with the gonads, while the primary, posterior mesodermal ducts degenerate. Yet we cannot invoke secondary duct-formation of this kind as a general explanation of the differing positions of the gonopores, because the ectodermal ducts are usually connected with mesodermal ducts. It is possible, however, that during the anamorphic development of the early arthropods, by mutations and selection, different coelomic ducts were utilized as genital outlets. In this connection it is significant that in the chilopods the genital opening is always on the last body segment regardless of the number of segments in the adult centipede, showing that the genital segment is not *numerically* determined as such in development. Among the geophilid centipedes the number of body segments differs in different species, and even between individuals of the same species.

As the several modern groups of arthropods became differentiated, a single fixed position of the genital outlets would not be convenient for all types of body structure. For a crustacean swimming with its abdomen the gonopores are best situated on the thorax, while with the arachnids the genital outlet is quite appropriate on the anterior part of the abdomen, and with the centipedes and insects the posterior part of the body serves best for copulatory purposes. The progoneate modern myriapods, however, seem to have found the opisthogoneate condition of their ancestors unsatisfactory and developed new, ectodermal genital outlets on the anterior part of the body. Even here, the segment of the gonopores in Symphyla is not the same as in Pauropoda and Diplopoda.

External fertilization of the eggs is still prevalent even among those arthropods in which the females have sperm receptacles. The female crayfish, for example, discharges her eggs on the venter of the thorax while she lies on her back, and the eggs are inseminated as they flow backward over the orifice of the spermatheca. In the insects the spermatheca and the oviduct open into a genital chamber, but this chamber is merely an outside space partly enclosed by the sternal plate beneath it. The eggs discharged from the oviduct are here fertilized from the spermatheca. The "uterus" of most viviparous insects is an enlargement of the genital chamber and is thus anatomically equivalent to the incubation pouch of a marsupial. In only a few insects are the eggs inseminated in the ovaries or in the haemocoele. The discharge of spermatozoa into a genital chamber or directly into a spermatheca involves possession by the male of efficient organs of copulation and intromission, and with such organs the insects are more amply provided than are any of the other arthropods.

The great structural diversity in the male genitalia of insects is the delight of taxonomists, the despair of morphologists. In the following sections of this paper, however, an attempt will be made to show that the parts of the male genital apparatus in all the principal orders of insects can be uniformly interpreted and named as here proposed, if the known facts of their development are given priority over theoretical generalizations.

I. PROTURA, COLLEMBOLA, DIPLURA

The genital equipment of these entognathous hexapods offers nothing that contributes to an understanding of the genitalia in Thysanura and Pterygota. The complex male genital organ of Protura arises between the eleventh and twelfth abdominal segments and clearly can have no homologue in the other hexapods. In the Collembola the genital opening is on the posterior part of the fifth abdominal segment, but external genitalia are absent. In the male dipluran *Heterojapyx* there is a genital pouch behind the eighth sternum, which contains in its dorsal wall a small plate, apparently the ninth sternum, bearing a pair of styluslike processes. Immediately behind this plate is the simple genital opening. Though the Collembola are the oldest hexapods known in the geological record, having been found in the middle Devonian, they are certainly not ancestral to the other orders.

They are an early offshoot from the hexapod line, which proved to be so successful that the Collembola have continued to the present time with few evolutionary changes.

II. THYSANURA

Inasmuch as the thysanurans are more closely related to the winged insects than are any of the other apterygote hexapods, it is reasonable to suppose that they should give us a reliable picture of the basic structure of the insect male genitalia, and most theories on the nature of the genital organs take their start from the Thysanura. However, it is well known that appearances are sometimes deceptive, and that apparent likeness is not always evidence of homology.

In most thysanuran species there is a pair of large, triangular stylus-bearing plates on the under side of the ninth abdominal segment (fig. 2 F, *IXCx*). These plates presumably are coxal remnants of former appendages, as are similar plates on the preceding segments, in which there may be a small sternal plate at their bases. Between the bases of the ninth-segment coxal plates arises a small median genital outlet tube, commonly called the penis, though functionally it is not an intromittent organ.

Sweetman (1938) has described the elaborate courting maneuvers of the sexes of *Thermobia domestica,* after which the male deposits a spermatophore on the surface in front of the female. Then, after being touched as a signal by the male, the female walks over the spermatophore until her genital region comes in contact with it. The spermatophore adheres to the female, but soon she turns around and bites it, and finally eats it. The fate of the contained spermatozoa is not recorded. Most remarkable is the mating behavior of *Machilis,* as described by Sturm (1952). The participants first meet head to head. Then the male attaches nearby a thread extruded from the penis, and with the female turns through a half circle until the female is parallel to the thread with her ovipositor directed toward the attachment point. Now the male discharges several droplets of sperm on the thread, which the female attempts to take into her ovipositor with the assistance of the male, who reaches back with one of his antennae, loads it with sperm from the thread, and delivers it to the ovipositor of the female. After insemination is thus accomplished, the female departs. The whole performance lasts about five minutes.

In some species of Machilidae the penis is closely flanked by a pair of endite processes (fig. 2 G, *Endt*) from the mesal basal angles of the coxal plates. From this simple structure in the Thysanura has been evolved the theory that the coxal plates become the lateral genital claspers (parameres) of the higher insects, and that the aedeagus has been formed by the union of the coxal endites with a primitive median penis. Unfortunately, the known facts of the development of the genital organs do not substantiate this interpretation.

The thysanuran penis is double in its origin, being formed in nymphal instars by the union of two primary lobes entirely comparable with the phallic rudiments of other insects. In *Machilis,* as described

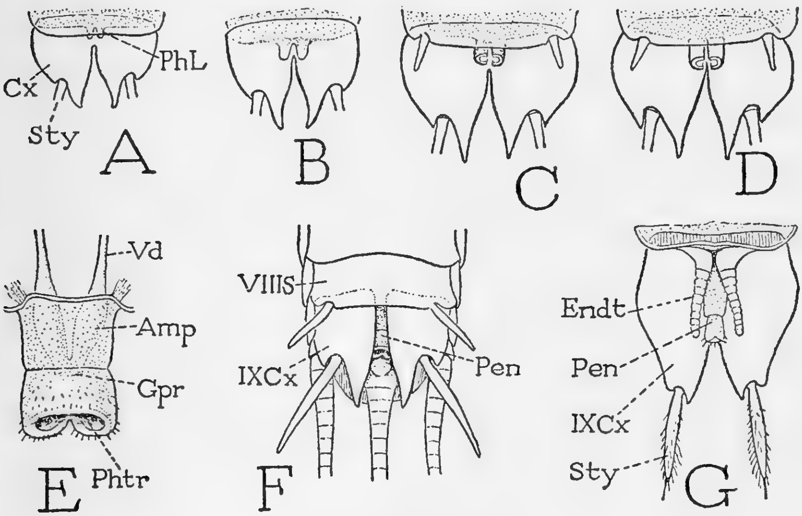

FIG. 2.—Thysanura.

A-D, *Ctenolepisma longicaudata* Esch., developmental stages of the penis (from Lindsay, 1939). E. *Ctenolepisma urbana* Slabaugh, mature penis. F, same, end of abdomen, ventral. G, *Machilis variabilis* Say, ninth-segment coxal plates and penis, dorsal.

by Qadri (1940), the penis rudiments are present in the genital cavity of very young nymphs and develop independently of the ninth-segment appendages. In *Ctenolepisma,* according to Lindsay (1939), the penis rudiments appear first on the eighth instar as a pair of small lobes on the intersegmental membrane at the base of the cleft between the coxal plates of the ninth abdominal segment (fig. 2 A, *PhL*). In the tenth instar (B) the rudiments have increased in size, in the eleventh and twelfth instars (C, D) their opposed surfaces are concave, and finally the two lobes unite to form the tubular organ of the adult (E). The mature penis appears to be divided into a proximal and a distal section, but since the ampullae (*Amp*) of the vasa deferentia (*Vd*) open into the base of the distal section (*Gpr*), the latter alone is the true penis, the proximal part being a secondary outgrowth of the genital chamber wall. The very short undivided terminal part of the exit passage is said by Qadri (1953) to be formed as a shallow depression between the bases of the primary penis lobes, and therefore represents the ejaculatory duct. In an immature instar the ampullae end blindly, and just behind each is a penis bud. This relation of the ducts to the penis rudiments suggests that the latter were primitively a pair of penes.

In its ontogenetic development the thysanuran penis has no relation to the ninth-segment coxal plates, and the endites of the latter are not united with it. The independence of the penis in its origin from ninth-segment structures, Qadri notes, obviously assigns the penis lobes to the tenth segment, and this conclusion is supported by the observation of Heymons (1897) that the embryonic male genital ducts in *Lepisma* end in the tenth abdominal segment, where presumably they opened to the exterior through a pair of primitive penes. The penis rudiments of Thysanura do not divide to form parameres as do the phallic lobes in most of the higher insects, but the double origin of the penis clearly identifies the thysanuran organ with the aedeagus of the other insects.

The coxal plates and styli of the ninth segment are not known to have any genital function. The abdominal styli, unlike the coxal styli of the thorax, are musculated and perhaps may be remnants of telopodites; they serve to support the abdomen and are active in locomotion. The coxal endites of the ninth segment of *Machilis* are male homologues of the second gonopophyses, or valvae, of the female ovipositor. In some species the first gonopophyses are represented in the male by a pair of small endites on the eighth segment.

III. EPHEMEROPTERA

The mayflies characteristically have a pair of long clasping styli (fig. 3 A, *Sty*) arising ventrally from a transverse plate (*Cx*) behind the ninth abdominal sternum. The styli are movable by muscles (*smcl*) from the supporting plate, which fact identifies the plate as the fused coxae of the ninth segment. An enlarged basal joint of the stylus, therefore, cannot be mistaken for the coxal plate. In some forms (C) evidence of the dual nature of the plate is retained. The styli are usually long, curved, jointed arms by which the male securely grasps the abdomen of the female during mating, but they may be relatively simple (G), and in some species they are typically styliform (E).

Also characteristic of the mayflies is the presence of a pair of penes (fig. 3 A, B, C, F, *Pen*) giving exit individually to paired genital ducts. The penes arise from two small, transverse plates (B, *XS*) or a single plate (D) in the membrane between the ninth sternum and

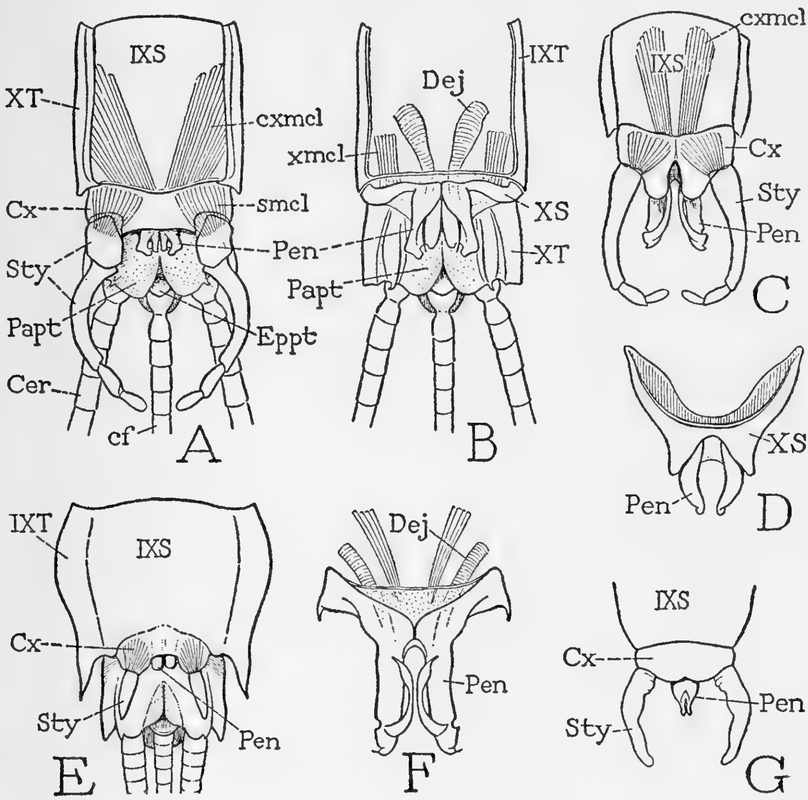

FIG. 3.—Ephemeroptera.

A, *Ephemera simulans* Walker, end of abdomen, ventral. B, same, coxal plates removed, exposing tenth sternal plates bearing penes. C, *Blasturus nebulosus* Walker, end of abdomen, ventral. D, *Habrophlebiodes betteni* (Needham), tenth sternum and penes. E, *Oniscigaster distans* Eaton, larva, end of abdomen, ventral. F, *Campsurus decoloratus* (Hagen), tenth sternum and penes. G, *Trichorythrodes fallax* Traver, end of abdomen and single penis, ventral.

the paraprocts, as may be seen by removal of the underlying coxal plate (B). These plates evidently represent the tenth abdominal sternum, since muscles from the ninth sternum are attached on them (B, *xmcl*). The complete independence of the penis plates and the penes from the coxal plate of the ninth segment is quite out of harmony with the idea expressed by some writers that the penes are "endopodites" or "gonapophyses" of the ninth-segment appendages; or, more briefly said, the theory is not in harmony with the facts.

In some species the penes are armed with processes of various shapes (fig. 3 F), and the usual two penes may be united at their bases or combined in a single organ (G), but the ducts remain separate. The structure and musculature of the mayfly penes in seven genera have been described by Levy (1948), who says that the penes of *Siphlonurus* have muscles arising on the ninth sternum; in four other genera there are only muscles that lie entirely within the penes, which probably flex them mesally, while in *Ephemera* and *Blasturus* there are no penis muscles.

The larval penes are merely a pair of short simple lobes projecting from above the coxal plate of the ninth segment (fig. 3 E, *pen*). According to Qadri (1940) the penes are developed in the young larva from a pair of outgrowths in the genital chamber behind the ninth sternum. The rudiments do not divide during their growth, and the various processes or hooks that may be developed on them have no likeness to the parameres of higher insects. The ephemerid penes are the most primitive male genital organs of the insects, and since it is hardly to be questioned that they are homologues of the primary phallic lobes of other insects, the inference is clear that the latter were originally a pair of penes. The Ephemeroptera in no way suggest that the insect male genitalia took their origin from a pair of legs. The penes are ectodermal outgrowths on the venter of the tenth abdominal segment containing the ends of the genital ducts. As such, they have exact counterparts in various other arthropods as shown in the Introduction.

IV. DERMAPTERA

The Dermaptera have no styli or appendages of any kind on the ninth abdominal segment. The genital equipment of the male is either a pair of penes with individual ducts, or a single organ containing both ducts or only one duct. The presence of paired penes would appear to be the more primitive condition within the order, but the females of all species have only a single genital opening.

Paired penes are characteristic of the Labiduroidea. In *Anisolabis maritima* (fig. 4 E) each organ consists of a long basal stalk bearing two apical lobes. The mesal lobe (*Mmr*) is a hollow continuation of the stalk giving exit to the contained duct. The lateral lobe (*Pmr*) appears as a sclerotized appendage of the stalk. The two penes are

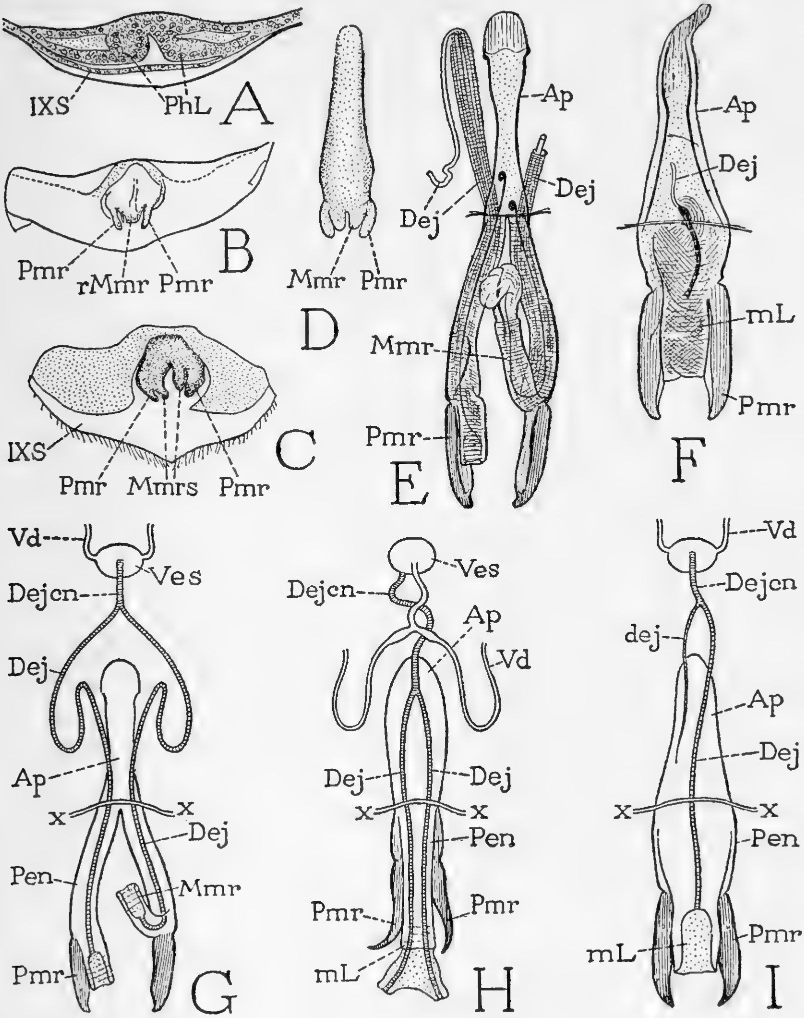

FIG. 4.—Dermaptera.

A, *Forficula auricularia* L., transverse section through primary phallic lobes of first-instar nymph (from Qadri, 1940). B, same, genitalia of full-grown nymph (from Qadri, 1940). C, *Hemimerus hanseni* Sharp, genitalia of nymph (from Qadri, 1940). D, *Anisolabis maritima* (Gené), genital organ of last-instar nymph. E, same, genital organ of adult. F, *Forficula auricularia* L., genital organ of adult. G, *Anisolabis maritima* (Gené), diagram of double penes and ducts. H, *Hemimerus hanseni* Sharp, diagram of single genital organ with two ducts. I, *Forficula auricularia* L., diagram of single genital organ with one functional duct.

united at their bases in a large, internal apodemal plate (*Ap*) on which the phallic muscles are attached. The long ejaculatory ducts of the penes (G, *Dej*) unite in a short common duct (*Dejcn*), which joins a vesicle (*Ves*) that receives the two vasa deferentia (*Vd*). Neither the intromittent organ nor the exit system of the adult, therefore, is strictly double as in Ephemeroptera. In the last nymphal stage of *Anisolabis* the genital organ is an elongate structure (D) divided only at its distal end into median and lateral lobes. These lobes, however, are entirely comparable to the mesomeres and parameres of higher insects, so that there can be little question that the mesal lobes of the adult organ (E, G, *Mmr*) are the persisting mesomeres and the lateral lobes (*Pmr*) the parameres. In *Forficula* Qadri (1940) has shown that the single phallic organ of the adult (I) arises from a pair of typical phallic rudiments in the first-instar nymph (A, *PhL*), which later (B) unite at their bases and divide distally into mesomeres and parameres. The adult male organ of Dermaptera, therefore, is double in its origin, and its rudiments are comparable to the penes of Ephemeroptera. Phallic parameres make their first appearance in the Dermaptera.

Hemimerus talpoides has a single genital organ (fig. 4 H) with two parameres, but the mesomeres are united in a common median lobe (*mL*) comparable to the aedeagus of the higher insects, except in that it gives exit to the two primary ducts. In the nymphal organ of *Hemimerus* (C), as shown by Qadri (1940), the phallic lobes are broadly fused at their bases and divided distally into mesomeres and parameres. Clearly the median lobe of the mature organ of *Hemimerus* is formed by the union of the mesomeres.

The phallic organ of *Forficula* (fig. 4 F) resembles that of *Hemimerus* (H) in that it has a single median lobe, but one duct (I, *dej*) is abortive, the other (*Dej*) alone remaining as the functional genital outlet. According to Qadri the median phallic lobe of *Forficula* is formed mainly from the right mesomere of the nymph (B), the left one being reduced and practically obliterated. In both *Hemimerus* (H) and *Forficula* (I), as in *Anisolabis* (E, G), the base of the external part of the genital organ is produced into a large apodemal plate (*Ap*). The adult organ of *Forficula* (F, I) has a close resemblance to the nymphal organ of *Anisolabis* (D), and it is apparent that the apodeme of the adult organ is merely an extension of the undivided base of the nymphal organ (B, C).

If the separate openings of the ejaculatory ducts on the phallic mesomeres in Dermaptera has any phylogenetic significance, it must mean that primitively the ducts opened through the primary phallic lobes themselves, and that these lobes represent a pair of primitive penes such as those of the Ephemeroptera. On the other hand, the development of parameres at lateral branches of the phallic rudiments appears to relate the penis rudiments of the Dermaptera to the primary phallic lobes of the higher insects.

The evolution of a single phallic organ from a pair of primary rudiments in the Dermaptera, however, does not parallel the phallic development in the higher insects from a pair of similar rudiments. The mesomeres of the Dermaptera are penetrated individually by ectodermal exit ducts, which Qadri (1940) says are formed in *Forficula* during the second nymphal instar. The two ducts unite in a short common duct that joins the vesicle of the earlier-formed vasa deferentia. Where the two mesomeres are united, the median lobe thus formed contains the ends of both ducts, or only one functional duct if the other is reduced. In the development of the higher insects, on the other hand, the phallic lobes are never penetrated by ducts; the common ejaculatory duct is formed as an ectodermal ingrowth between the bases of the lobes, and, when the latter unite to form an aedeagus, the duct discharges through the aedeagal lumen. It is only in their earliest stage of development, therefore, that the phallic organs give evidence of their common origin from a pair of genital lobes, which in the mayflies still function as individual penes.

V. ISOPTERA, EMBIOPTERA, ZORAPTERA, PLECOPTERA, PSOCOPTERA

The members of these orders offer little of interest in a general study of the male genitalia. Ninth-segment styli are present in most of the Isoptera, but if the termites ever had phallic organs they have been greatly reduced or entirely suppressed. In a few species of Isoptera and Embioptera the ejaculatory duct opens on a small penis, but in neither order are parameres present. The Zoraptera have a small tripartite genital organ, with the genital opening on the base of the median prong. The Embioptera are characterized by the division of the ninth abdominal tergum into asymmetrical plates of various forms, and the presence of mesal lobes on the bases of the cerci.

The Plecoptera have no styli or appendages of any kind on the ninth abdominal sternum. The ejaculatory duct discharges through a long, probably eversible endophallic sac, which opens either directly to the exterior or on a small penis. In *Chloroperla,* according to Qadri (1940), the penis is formed from a pair of small outgrowths in the anterior end of the genital chamber between the ninth and tenth abdominal sterna, and each rudiment divides into a dorsal and a ventral lobe as in Orthoptera.

In the Psocoptera there is a variously developed median genital organ, or aedeagus, and a pair of lateral arms on each side, generally termed the outer and inner parameres (see Badonnel, 1956, and Klier, 1956). The inner parameres are probably branches of the outer parameres, but since, so far as the writer knows, the development of the organs has not been studied, we cannot be sure of their homologies. Badonnel (1934), however, observes that since the parameres and the aedeagus are branches of the same trunk, they may be considered as lobes having a common origin. A full account of the internal and external genital organs of male Psocoptera, mating of the sexes, and insemination of the female by a spermatophore is given by Klier (1956).

VI. ORTHOPTERA

Among the orthopteroid insects ninth-segment styli occur in the males of Grylloblattidae, Blattidae, Mantidae, and Tettigoniidae. In the last three families the styli arise directly from the margin of the sternal plate, which presumably is a coxosternum. In *Grylloblatta* (fig. 5 A), however, the styli (*Sty*) are carried on large, asymmetrical coxal plates (*Cx*) movably articulated on the ninth sternum. According to Walker (1943) the coxal plates are strongly musculated, but the styli have no muscles. There can be no question here that the coxal plates and styli are ninth-segment appendages corresponding with the coxal plates and styli of the ninth abdominal segment in Thysanura; they have no anatomical relation to the phallic organs.

The genital equipment of *Grylloblatta* consists of two soft lobes at the sides of the gonopore (fig. 5 B). The short right lobe, or right phallomere (*rPhm*), has several irregular plates in its dorsal wall; the left lobe (*lPhm*) is a long, twisted, saclike structure. The rudiments of these organs in the nymph are shown by Walker (1922) to be a pair of low, rounded lobes (C, *PhL*) behind the ninth sternum. Since the adult organs are developed directly from these primary lobes, which evidently represent the phallic rudiments of other insects, the adult lobes are not equivalent to parameres, and are here termed simply *phallomeres* (phallic parts).

The phallic organs of the Orthoptera in general present a great diversity of structure characteristic of the different families. From the studies of Qadri (1940) on the development of the genitalia in Blattidae, Tettigoniidae, and Acrididae, and the observations of other

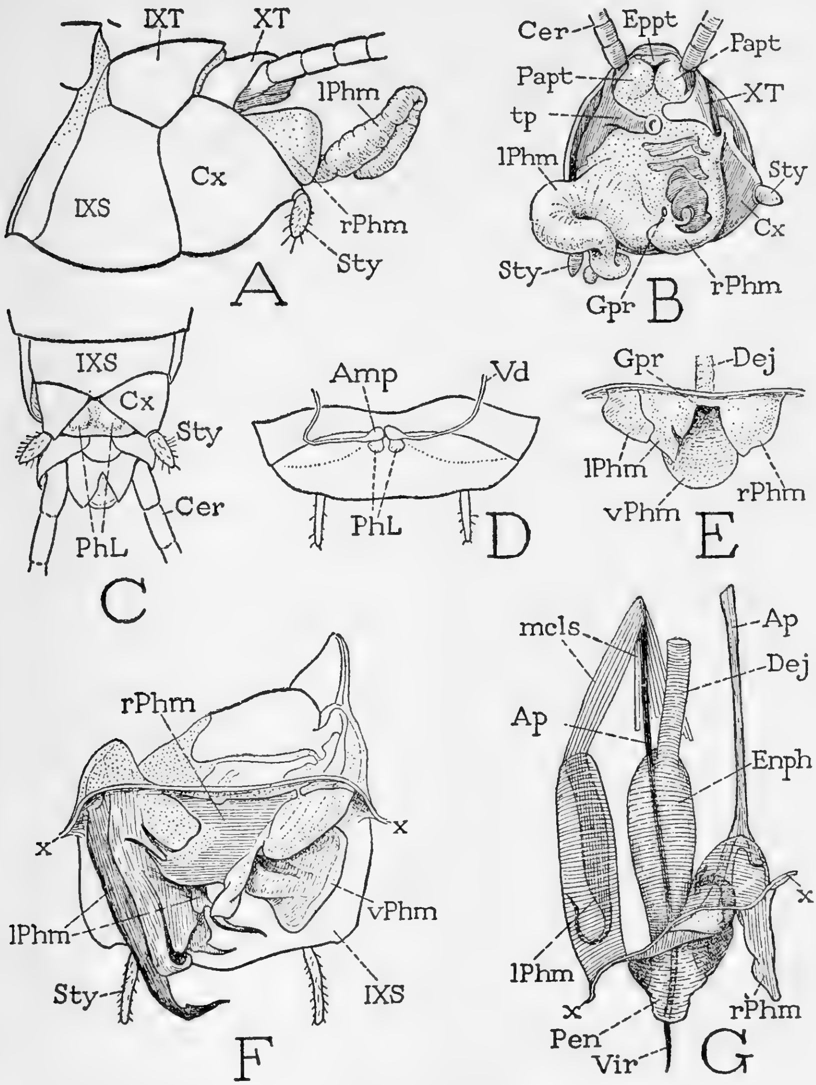

FIG. 5.—Orthoptera.

A, *Grylloblatta campodeiformis* Walker, end of abdomen, left (from Walker, 1922). B, same, end of abdomen with mature genital structures, posterior (from sketch by Walker). C, same, end of abdomen of half-grown male nymph (from Walker, 1922). D, *Periplaneta americana* (L.), primary phallic lobes of second-instar male nymph (from Qadri, 1940). E, same, genitalia of later nymphal instar. F, *Blatta orientalis* L., male genitalia of adult, dorsal. G, *Blattella germanica* (L.), male genitalia of adult, dorsal.

writers, it is probable that in all the orthopteroid insects the external genital organs arise from a single pair of primary rudiments. The primitive phallic lobes as generally seen in the nymph lie behind the ninth abdominal sternum and thus appear to belong to the tenth segment. Though Else (1934) claimed to have traced them from the appendage buds on the tenth segment of the embryo in *Melanoplus,* his observation has not been verified. In a former paper on the structure of the adult organs of Orthoptera, the writer (1937) failed to observe their origins in the earliest instars.

The two primary phallic lobes, according to Qadri in the families studied by him, split horizontally into four secondary lobes, two dorsal and two ventral. These four phallomeres either remain as lobes surrounding the gonopore, or they become variously combined and elaborated into complex genital structures. A relatively simple condition is retained in the Mantidae and among the Blattidae in *Blatta* and *Periplaneta.* In *Periplaneta* Qadri says the primary genital rudiments (fig. 5 D, *PhL*) are present in the base of the genital chamber in the newly hatched nymph. Later the primary lobes divide horizontally into four parts, which are at first dorsal and ventral, but the two lobes on the left unite (E), and finally in the adult of both *Periplaneta* and *Blatta* (F) they form a highly complex composite left phallomere (*lPhm*). The right dorsal phallomere (*rPhm*), armed with a hook and spines, overlaps the left phallomere, and with its base are associated a complex of plates in the wall of the genital chamber. These phallomeres serve as copulatory organs. The right ventral phallomere (*vPhm*) remains as a simple lobe beneath the gonopore, and probably manipulates the spermatophore. This type of genital apparatus undergoes many modifications in other blattid genera.

A quite different type of genital structure is found in the genera *Blattella, Supella, Ectobius,* and *Leucophaea.* Here there are present only two, asymmetrical phallomeres (fig. 5 G) sunken into pouches at the sides of a short, membranous median penis (*Pen*), through which opens an endophallic sac (*Enph*). In *Leucophaea maderae,* van Wyk (1952) says the left phallomere is first formed in the fourth-instar nymph as a lobelike outgrowth of the genital chamber wall above the ninth sternum; the rudiment of the right phallomere appears in the sixth instar. The membranous median penis is formed "by an evagination of the genital chamber wall around the mouth of the ductus ejaculatorius," and "could not be identified in the nymphal stages." It is interesting to note that in this group of blattids the genitalia resemble those of *Grylloblatta* in that there is only one pair of phallomeres, apparently developed directly from phallic lobes of the nymph.

The development of the genital organs in the Orthoptera from a single pair of rudiments leaves no doubt that in their origin the genitalia of Orthoptera are homologous with those of other insects. In their later growth, however, they follow special lines of development, giving rise to adult structures having no counterparts in other orders. The primary phallic lobes may develop directly into a pair of phallomeres, and though more commonly each divides into two parts, the resulting four phallomeres never form a typical aedeagus and parameres. The Orthoptera are genitalic individualists.

VII. HEMIPTERA (RHYNCHOTA)

It is difficult to give an intelligible general account of the male genitalia in this order because of their apparent differences in different groups. The genital parts have consequently been variously interpreted and named by taxonomists according to what particular theory of homology is accepted. That the structural differences in the organs are more apparent than real, however, can be deduced from comparative studies of selected forms and from what is known of the development of the organs.

In most of the Homoptera a pair of parameres is more or less closely associated with the aedeagus, and the three parts are developed from a pair of typical phallic rudiments. The primary phallic lobes are said by Qadri (1949) to be visible from the very onset of postembryonic development. They arise behind the ninth abdominal sternum, are innervated from the tenth-segment ganglion, and therefore must belong to the tenth segment. Other writers have commonly referred the phallic organs of the Homoptera to the ninth segment of the abdomen, and some regard them as derivations of ninth-segment appendages; but these writers have given no evidence in support of theories that are not in accord with the facts of development.

The ninth abdominal sternum of some Homoptera bears a pair of lobes of various length, called "subgenital plates." Pruthi (1925a), after showing that the aedeagus and the parameres develop from one pair of primary lobes and the subgenital plates from an entirely distinct pair, says: "The subgenital plates seem to be the coxites of the ninth sternum; and both the aedeagus and the parameres, derived from a primitive single pair of appendages, correspond to the endopodites." To discredit any such idea as this, we have only to refer back to the Thysanura to see that the phallic rudiments have no connection with the ninth-segment coxal plates, which latter are supposed to be represented in the homopteron by the subgenital plates. There is little evidence that the subgenital plates are other than mere lobes of the ninth sternum, though they may be flexibly attached on the latter. If they are ninth-segment appendages, then the common interpretation that the parameres are "coxites" becomes untenable.

A relatively simple condition of the homopterous genitalia, in which the parameres are closely associated with the base of the aedeagus, is seen in the Indian cicadellid *Idiocerus atkinsoni,* described by Pruthi (1925b). The aedeagus (fig. 6 B, *Aed*) is a long slender organ, for most of its length adnate on the dorsal wall of the genital chamber; proximally it is supported on a median basal plate (*BP*). The two long, divergent parameres (*Pmr*) are articulated on the basal plate of the aedeagus, which appears to serve as a fulcrum for their movement by muscles attached on basal apodemal arms (*Ap*). In addition to these phallic organs there is a pair of long narrow subgenital lobes (A, *sgl*) flexibly attached on the ventral arc of the ninth sternum (*IXS*).

The development of the genitalia of *Idiocerus* has been shown by Pruthi (1925b) to proceed in the usual manner from a pair of primary phallic rudiments ("paramere" lobes) that divide and eventually form the aedeagus and parameres. The subgenital plates are outgrowths from the ninth abdominal sternum. Metcalfe (1932b) likewise describes the origin of the aedeagus and parameres in the cercopid *Philaenus spumarius* from a pair of ectodermal outgrowths that appear in an early nymphal stage at the sides of the gonopore (fig. 6 J, *PhL*). At a later stage (K) each primary lobe divides into two secondary lobes, mesomeres (*Mmr*) and parameres (*Pmr*), and still later the mesomeres unite to form the aedeagus. Both Pruthi and Metcalfe contend that the phallic lobes and the subgenital plates pertain to the ninth segment, and conclude that they represent respectively the "telopodites" and "coxites" of this segment. Qadri (1949), on the other hand, regards the phallic lobes of Hemiptera as belonging to the tenth segment, and as having thus no relation to the subgenital plates of the ninth segment. Since there is no concrete evidence of any anatomical relation of the phallic rudiments with the subgenital plates or other appendages of the ninth segment, we may accept the developmental facts as described by these writers, and pass over their theoretical interpretations.

Since the aedeagus and parameres are developed from common rudiments, a close association of the three parts, as in *Idiocerus* (fig.

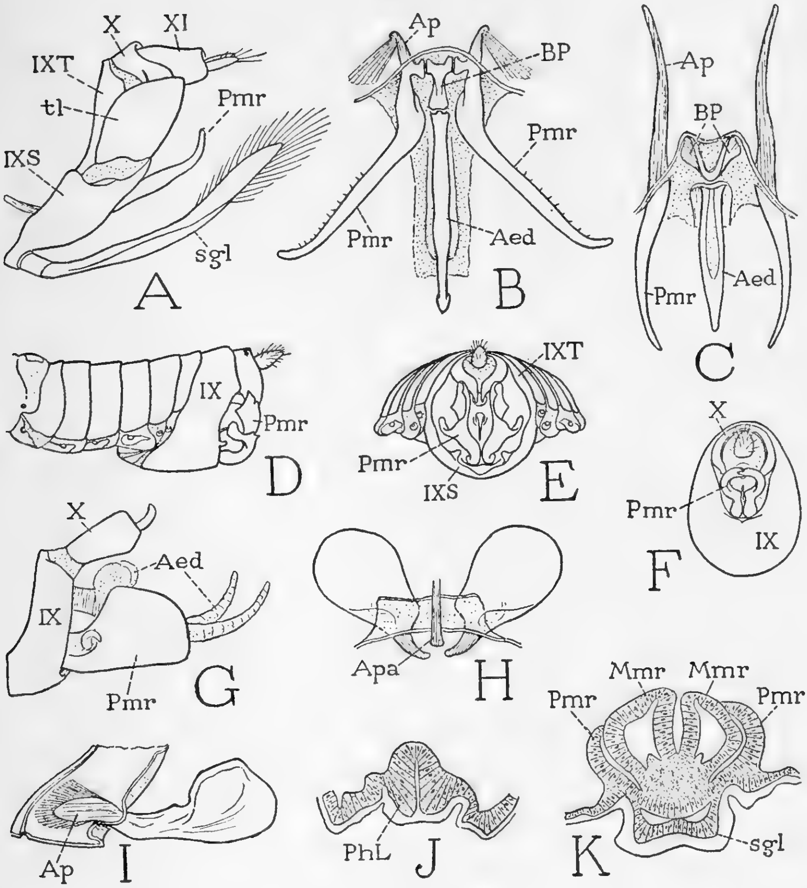

Fig. 6.—Homoptera.

A, *Idiocerus atkinsoni* Leth. (Cicadellidae), ninth and tenth abdominal segments, lateral, with subgenital lobe of left side. B, same, aedeagus and parameres, ventral. C, *Stictocephala bubalus* (Fab.) (Membracidae), aedeagus and parameres, ventral. D, *Megameles* sp. (Delphacidae), abdomen. E, same, end of abdomen, posterior. F, *Perigrinus maidis* (Ashm.) (Delphacidae), end of abdomen, posterior. G, *Poblicia fuliginosa* (Oliv.) (Fulgoridae), end of abdomen, left. H, same, showing parameral apodemes convergent to end of aedeagal apodeme, anterior. I, *Laternaria* sp. (Fulgoridae), right paramere and muscles, mesal. J, *Philaenus spumarius* L, (Cercopidae), section through primary phallic lobes of young nymph (from Metcalfe, 1932b). K, same, later stage, primary lobes divided into mesomeres and parameres (from Metcalfe, 1932b).

6 B), must represent the retention of a relatively primitive condition in the adult. In some other Homoptera, however, the parameres become displaced laterally from the aedeagus (C) and lose their connection with the basal plate of the latter. In still others the parameres become movably seated on the margin of the ninth sternum, as in the Delphacidae (D, E, F), in which they are articulated close together (E, F, *Pmr*) on the ventral rim of the ninth segment. From this position the parameres may be supposed capable of moving outward to the lateral parts of the segment. Thus we find in the Fulgoridae (G) a pair of large clasper lobes (*Pmr*) arising from the sides of the ninth segment. In this position the parameres are readily mistaken for ninth-segment appendages ("coxites"). Qadri (1949) asserts that the fulgorid claspers, in fact, are not derived from the phallic rudiments, but are formed at a later stage of development, and are therefore ninth-segment appendages. However, the fulgorid claspers (I) have the structure and musculature of the parameres in other families, and the evidence of lateral displacement of the parameres is too evident to be discounted. The apodemes of the fulgorid claspers, moreover, converge to the end of the median aedeagal apodeme (H, *Apa*).

The aedeagus of the Homoptera presents numerous modifications and complexities of structure in different families and genera, but with its features we need not be concerned in the present discussion.

In the Heteroptera there is present in most families a pair of small movable appendages borne on the ninth abdominal segment well separated from the aedeagus. Typical examples are shown on figure 7 at G, H, K, L (*Pmr*). According to Qadri (1949) these appendages are developed in the last nymphal stage quite independent of the phallic lobes, and are therefore styli of the ninth segment. Dupuis (1955), however, questions the accuracy of Qadri's observations, and he interprets the heteropterous claspers as displaced phallic parameres. A comparative study of the genital organs in different families will bear out Dupuis's conclusions, and it seems hardly probable that claspers should be developed from two different sources in the same order.

A simple condition of the genital organs among the Heteroptera is seen in the nymph of Cimicidae (fig. 7 D). Here there is a simple median aedeagus (*Aed*) flanked by a pair of small parameres (*Pmr*). The three parts are shown by Christophers and Cragg (1922) to be developed from a pair of primitive phallic lobes (A, *PhL*) that first appear on a young nymph between the ninth and tenth abdominal segments. With further development each lobe divides into a meso-

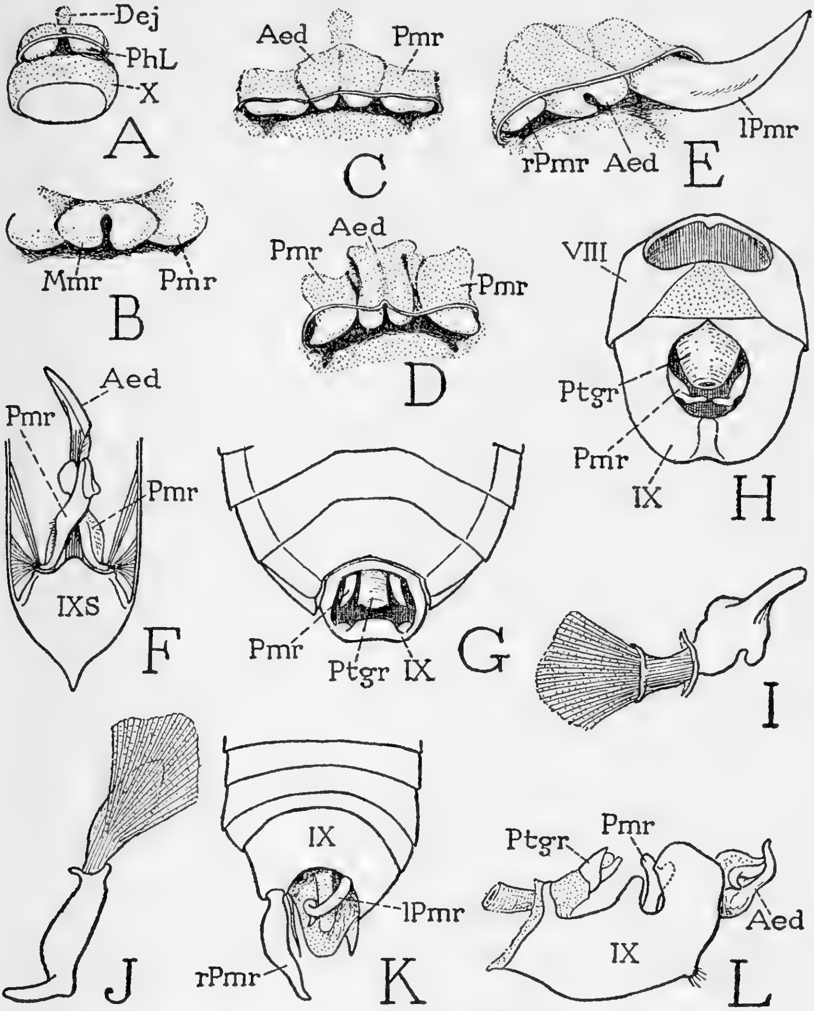

FIG. 7.—Heteroptera.

A-E, *Cimex lectularius L.*, development of the phallic organs (from Christophers and Cragg, 1922). A, nymph at end of penultimate instar, ventral; B, later stage; C, last instar; D, later stage of same; E, near end of last instar, ventral. F, *Naucoris cimicoides* (L.), aedeagus, parameres, and dorsally reflected end of ninth sternum, dorsal. G, *Euschistus servis* (Say), end of abdomen, dorsal. H, *Anasa tristis* (DeG.), end of abdomen, dorsal. I, *Euschistus variolarius* (P. de B.), paramere. J, *Anasa tristis* (DeG.), paramere. K, *Hesperolabops picta* (H., M., and P.), end of abdomen, dorsal. L, *Notonecta variabilis* (Fieb.), ninth abdominal segment and proctiger, left.

mere and a paramere (B); later the mesomeres unite to form the aedeagus (C, D). Finally the left paramere (E, *lPmr*) becomes long and sharp-pointed, serving the adult male as an instrument (formerly called the "penis") for piercing the integument of the female to allow the injection of sperm from the aedeagus. There is no question that the parameres of the bedbug are phallic derivations.

In *Naucoris cimicoides* (fig. 7 F) the slender aedeagus (*Aed*) is closely embraced by a pair of arms (*Pmr*) that unquestionably appear to be parameres. They are so interpreted by Rawat (1939), who says they arise in the same way as the parameres of Homoptera, and that one of the basal muscles of each organ is attached on a ridge connecting the paramere with the base of the aedeagus. There is thus no doubt that the claspers of *Naucoris* are true parameres. In the adult, however, they are displaced from the aedeagus and are articulated on the margin of the dorsally reflected posterior part of the ninth sternum (F, *IXS*).

The secondary articulation of the parameres on the edge of the ninth sternum, which occurs in many insects, gives these appendages a fulcrum for more effective movement, and, once established, there is nothing to prevent their migration to a more lateral position. Thus among the Heteroptera we find the parameres in various degrees separated from the aedeagus (fig. 7 G, H) until they come to have the appearance of being appendages of the ninth sternum (K, L). Regardless of their position, however, the parameres have the same structure (F, I, J), each being produced basally into a muscle-bearing apodeme. We may conclude, therefore, that in all the Hemiptera the claspers, whatever their position may be in the adult, are phallic parameres.

VIII. COLEOPTERA

The male genital organ of the beetles is characteristically a tripartite structure composed of the aedeagus and parameres supported on a proximal plate, or phallobase. The shape and relative size of the parts are highly variable in different species. The terms here used are not those commonly found in the nomenclature of coleopterists, in which the phallobase is the "basal piece," the phallobase and the parameres together the "tegmen," the parameres the "lateral lobes," and the aedeagus the "median lobe" or "penis." According to a current theory of genital homologies, however, as reflected in a paper by Wood (1952) on Coleoptera, the phallobase is the "gonocoxite" and the parameres are "gonostyli." This nomenclature presupposes a relation of the parts so named to the ninth-segment appendages of Thysanura, which is not borne out by the known development of the genital organs in Coleoptera, as in other insects, from a single pair of primary phallic rudiments. It may be noted here again that the term *paramere* was first given by Verhoeff (1893) to the lateral phallic lobes of Coleoptera, and thus has unquestioned priority for these structures, though it has been applied to various other parts of the genitalia.

The phallobase in what is probably its generalized form is an elongate ventral plate (fig. 8 B, *Phb*) with its margins folded dorsally (A), and sometimes fused in a complete arch over the base of the aedeagus (F, I). However, it may be reduced to a small basal collar (C). In other cases the phallobase becomes a narrow U-shaped band (F) curved over the base of the aedeagus (*Aed*) with long arms carrying the parameres (*Pmr*). As a modification of this form it may take that of a V (G) enlarged around the aedeagus (H). In some species the phallobase is provided with a large apodeme (I, J, *Apb*) giving attachment to strong muscles (I, *mcl*) of the parameres.

The parameres are of various sizes and shapes; in some species they are movably articulated on the phallobase (fig. 8 A, B, C, F, *Pmr*), in others they are continuous with it (G, H, I). In a few species parameres are absent. The aedeagus is usually a sclerotic tube lying between the parameres (A, B, C, *Aed*), or between the arms of the phallobase (F, H). It may be provided with a pair of long aedeagal apodemes (A, H, *Apa*). In *Phyllophaga* (I) there is a single aedeagal apodeme covered by the apodeme of the phallobase (*Apb*). The aedeagus contains an eversible endophallus, which when everted appears as a simple sac, or vesica, or as a long tube that becomes the functional intromittent organ, or penis, with the gonopore at its apex.

The development of the male genitalia of Coleoptera from a single pair of primary phallic rudiments has been described by Kerschner (1913) and by Pruthi (1924) in *Tenebrio molitor* L., by Metcalfe (1932a) in *Sitodrepa panicea* L., by Pradhan (1949) in *Anthrenus fasciatus* Herbst, and by Srivastava (1953) in *Tribolium castaneum* Herbst.

In the larva of *Tenebrio molitor,* according to Pruthi, there appears just behind the ninth abdominal sternum a small pocket in the body wall with a minute external opening. The lateral walls of the pocket become thickened, and when the larva is almost fully grown the thickenings project into the lumen of the pocket as a pair of conspicuous budlike lobes. On the approach of pupation each bud

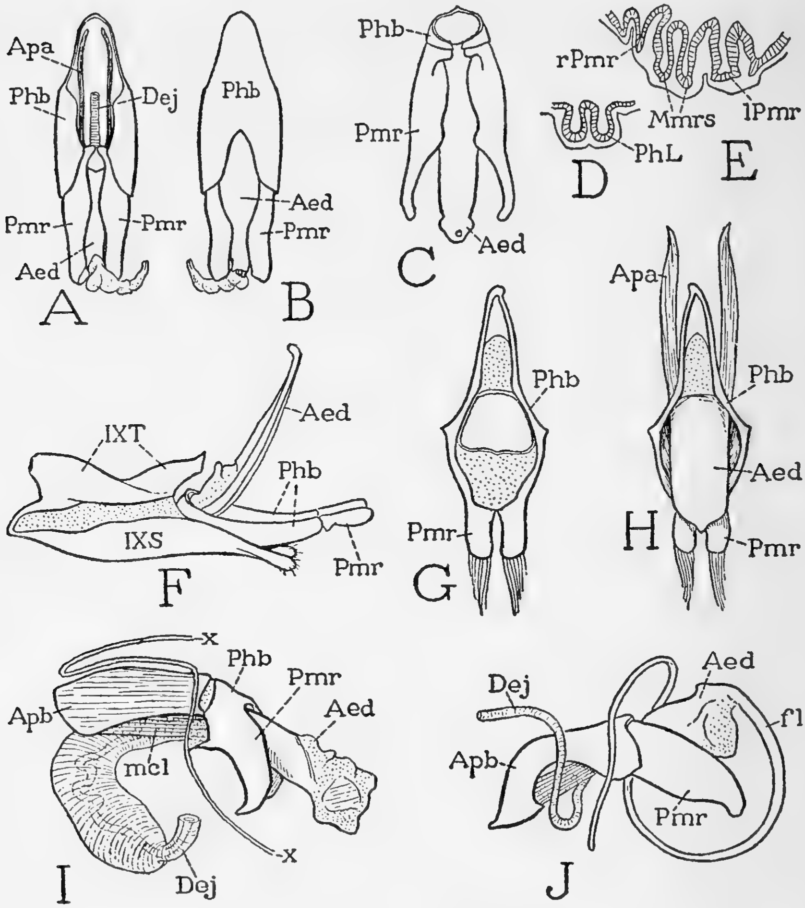

FIG. 8.—Coleoptera.

A, *Ceruchus striatus* Lec. (Lucanidae), phallus, dorsal. B, same, ventral. C, *Ceratognathus niger* Westw. (Lucanidae), phallus, dorsal. D, *Stegobium* (*Sitodrepa*) *paniceum* (L.) (Anobiidae), horizontal section of phallic lobes of prepupa (from Metcalfe, 1932a). E, same at later stage, phallic lobes divided into mesomeres and parameres (from Metcalfe, 1932a). F, *Stenotrachelus aeneus* Payk. (Serropalpidae), ninth abdominal segment and protruding phallic organs, left. G, *Cerambycid* sp.?, phallobase and parameres, dorsal. H, same, with aedeagus, ventral. I, *Phyllophaga chiriquina* (Bates) (Scarabiidae), phallic organs, left. J, *Pseudolecanus capriolus* (L.) (Lucanidae), phallic organs in functional position, left.

splits into two lobes, forming thus two pairs of processes which are the rudiments of the aedeagus and the parameres of the mature organ. During pupation the genital pocket enlarges and its inner end everts, carrying with it the four genital lobes, which thus come to be borne on an undivided basal stalk (the future phallobase). The median lobes, which are grooved on their opposed surfaces, now come together and unite, first along their dorsal margins and then ventrally, producing in this manner a tubular organ, which is the aedeagus. The lateral lobes develop directly into the parameres.

The development of the genital organs of the anobiid *Sitodrepa panicea* as described by Metcalfe is very similar to that of *Tenebrio.* In the larval stage a depression of the body wall is formed behind the ninth abdominal sternum, from which, in the pupal stage, a median ingrowth becomes the ejaculatory duct. Then there arises at the sides of the mouth of the duct a pair of ectodermal outgrowths (fig. 8 D, *PhL*), which are the primary genital rudiments. Each rudiment soon divides by a vertical cleft into a pair of secondary lobes (E). Then the lobes of the inner pair (*Mmrs*) fuse along their dorsal and ventral margins to form the aedeagus, the lateral lobes become the parameres (*Pmr*). In beetles that have no parameres, such as *Gasteriodea polygoni* L. and *Anthonomus pomorum* L., Metcalfe says the primary genital lobes fuse to form the aedeagus without any preliminary division.

Though neither Pruthi nor Metcalfe appear to have any doubt that the genital organs of Coleoptera belong to the ninth abdominal segment, it is to be noted that they both describe the rudiments as arising in a pocket *behind* the ninth sternum. It might be suspected, therefore, that the organs really pertain to the venter of the reduced tenth segment. Ninth-segment styli are not present in any adult Coleoptera, but Pruthi describes a pair of small styluslike papillae on the posterior margin of the ninth sternum in the larva of *Tenebrio,* which are lost at pupation. He regards these structures as "coxites" of the ninth segment, but he states significantly that they have no connection with the genital rudiments.

IX. MEGALOPTERA

In this group we first encounter a two-segmented structure of the genital claspers, which is characteristic also of the Trichoptera, Mecoptera, orthorrhaphous Diptera, and some Hymenoptera. Developmental studies of the genital organs in Trichoptera, Diptera, and Hymenoptera have shown that the claspers in these orders are formed from lateral branches of the primary phallic lobes, and that the segmentation results from a secondary constriction in the primarily undivided clasper. The claspers in these orders are therefore phallic parameres, though they have generally been called "coxites" and "styli" on the theory that they represent the ninth-segment appendages of Thysanura. A theory, however, cannot take precedence over the known facts of development. The two segments of the holometabolous parameres were termed by Crampton (1942) *basimeres* and *distimeres,* but linguistically *telomere* should be preferable to the hybrid "distimere."

Since apparently no studies have been made on the development of the genital organ in the Megaloptera or other Neuroptera, we must depend on comparative anatomy for an interpretation of homologies. The close association of the claspers with the aedeagus in some adult Megaloptera, however, leaves little doubt that the three parts are derived from common rudiments as in other insects.

In the species of *Agulla* illustrated at C of figure 9 the male genital complex consists of a pair of large, two-segmented parameres and a thick, bottle-shaped aedeagus. The long basimeres (*Bmr*) embrace the aedeagus (*Aed*) and are closely connected with its base, but laterally they are attached to the margins of the ninth segment (A). The movable telomeres (C, *Tmr*) are each articulated on the end of an internal ridge of the basimere (B, *ri*) and equipped with abductor and adductor muscles. Ventrally from the bases of the parameres two narrow sclerotic ridges converge into the under wall of the aedeagus (C) and follow the edges of a median groove of the latter to its distal end. The lateral walls of the aedeagus are formed by two long plates. The phallotreme is a transverse aperture at the apex of the aedeagus, and opens from a large, probably eversible, endophallic sac.

The genital organ of *Agulla adnixa* (fig. 9 D) is similar to that of the species just described, but the parameres and the aedeagus are broadly continuous at their bases. Where they separate there is attached ventrally on each side a hooked triangular plate (*a*). In *Agulla arizonica* (E, F) each plate has a thick posterior arm. These plates are termed "fragmenta of the coxopodites" by Ferris and Pennebaker (1939), but in *A. arizonica* (G) they arise distinctly from the base of the aedeagus. Michener (1944) likens the plates to the claspettes of Diptera and the volsellae of Hymenoptera, but they are not comparable to either of these structures, both of which are associated with the parameres.

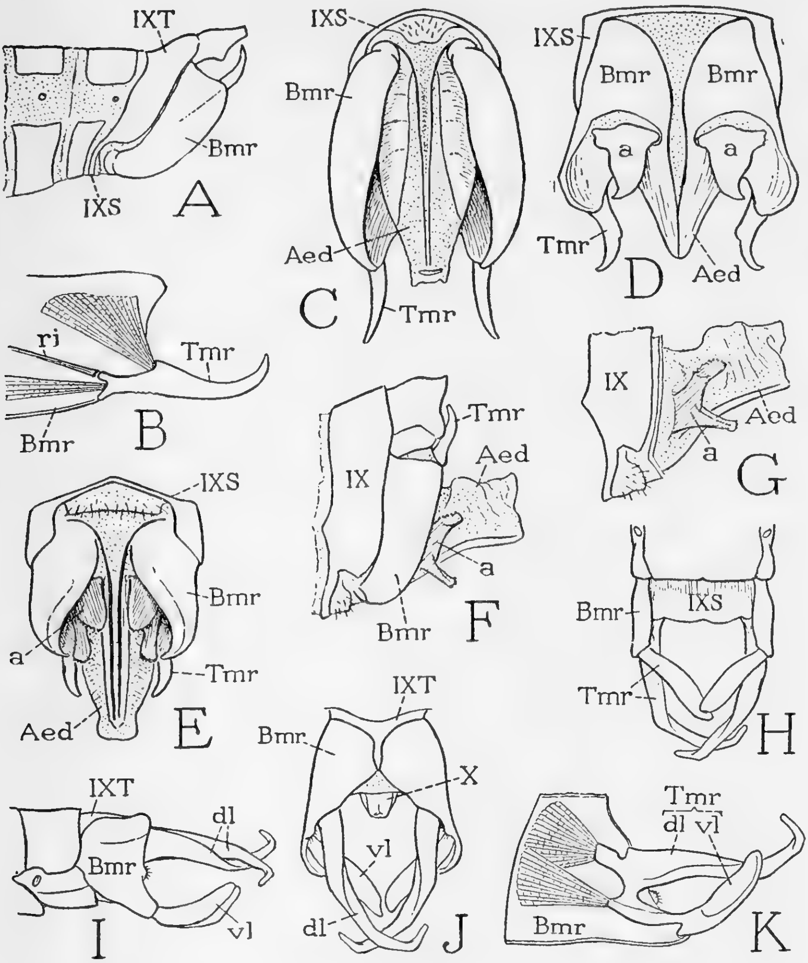

FIG. 9.—Megaloptera.

A, *Agulla* sp., end of abdomen, left. B, right telomere and muscles from basimere, mesal. C, same, phallic organs, ventral. D, *Agulla adnixa* (Hagen), phallic organs, ventral. E. *Agulla arizonica* Banks, phallic organs, ventral. F, same, end of abdomen, left. G, same, ninth abdominal tergum and aedeagus, left, parameres removed. H, *Corydalus cornutus* (L.), end of abdomen, ventral. I, same, end of abdomen, lateral. J, same, ninth abdominal tergum and parameres, dorsal. K, same, right telomere and muscles from basimere, mesal.

a, a, accessory phallic plates.

In *Corydalus cornutus* the parameres are highly developed, but the aedeagus is greatly reduced and is scarcely perceptible as a distinct organ. The basimere of each paramere is a large lateral plate (fig. 9 I, *Bmr*) attached to the narrow ninth segment, which is mostly concealed within the eighth segment. Dorsally (J) the basimeres are separated only by a median tongue of the ninth tergum (*IXT*), but ventrally (H) a wide sternal plate intervenes between their lower margin. The basimeres each bear two pairs of arms (I, J), a long, forcipate dorsal pair (*dl*) and a shorter ventral pair (*vl*). The two arms on each side, however, are branches of a single telomere as shown by the fact that they arise from a common base (K) inflected into the end of the basimere, on which two large muscles are attached.

The genital structure of *Agulla* is cited by Michener (1944) as showing that "the gonocoxites, gonostyli, and the penis are clearly homologous with those of *Machilis*." The likeness between the two, however, must be visible only to one whose vision is clarified in the light of a theory. The "gonocoxites" and the penis of *Machilis* have quite separate origins, and even in the adult there is no actual connection of the coxal plates with the penis. The demonstrated origin of the parameres and the aedeagus in other holometabolous insects from a common pair of rudiments is good reason for believing that the closely associated claspers and aedeagus of the adult *Agulla* had a like origin, and that the megalopterous claspers are phallic parameres.

The genitalia of the Planipennia do not resemble those of the Megaloptera, and are difficult to understand. The principal clasping organs in some families are a pair of large, variously armed lobes articulated on the dorsal part of the ninth abdominal segment. Ferris (1940) refers these lobes to the tenth segment, and Carpenter (1940) calls them "anal plates." The small aedeagus is supported on a transverse plate in the floor of the genital chamber, which Carpenter calls the tenth sternum, and it may be such. A similar plate arched over the base of the aedeagus in the mantispid *Climaceiella* is the "coxopodite" of Ferris (1940). In reference to the same species Michener says "a sclerotic arch extends between the bases of the gonocoxites over the aedeagus," which "appears to be a fusion product of the bases of the gonocoxites." The union of the bases of a pair of legs behind the sternum of their segment would be a rare anatomical event, but, as we shall see, the parameres of the higher insects are frequently connected by an interparameral bridge.

X. TRICHOPTERA

The trichopterous genitalia include a median aedeagus and a pair of lateral parameres. The parameres are articulated on the posterior margin of the ninth abdominal segment (fig. 10 A, E) and are musculated from the sternum (C, E). In some families the parameres are undivided lobes (E, *Pmr*), in others they are distinctly two-segmented (A) and the telomere is provided with antagonistic muscles arising in the basimere (C). Because of the apparent relation of the parameres to the ninth abdominal segment, as seen from the side, the parameres are commonly regarded as gonopods of this segment, and their parts are called "gonocoxites" and "gonostyli." This interpretation, however, ignores the ontogenetic evidence of the origin of the claspers in common with the aedeagus from a pair of primary phallic rudiments, and their subsequent lateral migration to the sides of the ninth segment.

The development of the trichopterous male genitalia has been fully described for species of *Limnophila* by Zander (1901). The first rudiments of the organs appear toward the end of the larval period, when there is to be seen in sections just behind the ventral margin of the ninth abdominal segment a small, flask-shaped pouch. From the inner wall of the pouch there grows out a pair of small lobes. Then, on the median dorsal wall of each lobe a vertical cleft is formed, by which the primary lobe is partly divided into two secondary lobes (fig. 10 F, *Pmr, Mmr*). The cleft deepens until each primary lobe is completely divided (G), while the pouch becomes wider. The two median lobes quickly unite to form the aedeagus (*Aed*) ; the lateral lobes, or parameres (*Pmr*), however, move slowly toward the side walls of the pouch and become broad, flat appendages ("valvae" of Zander) projecting outside the pouch. When the larva begins to change to the pupa, the genital pouch flattens out, bringing the parameres and the aedeagus to the outer surface of the body. The base of the aedeagus, however, becomes surrounded by a circular ingrowth of the body wall, which is the aedeagal pocket of the adult. This account by Zander shows clearly that the trichopterous claspers are parameres derived with the aedeagus from a pair of primary phallic lobes, and that their lateral position in the adult is secondary.

Further evidence of the phallic nature of the trichopterous claspers may be seen in the fact that the two basimeres are often connected in the adult by a broad sclerotic bridge (fig. 10 B, *pmB*) in the ventral wall of the genital chamber below the base of the aedeagus. Close behind the bridge is a dorsally inflected posterior part of the ninth

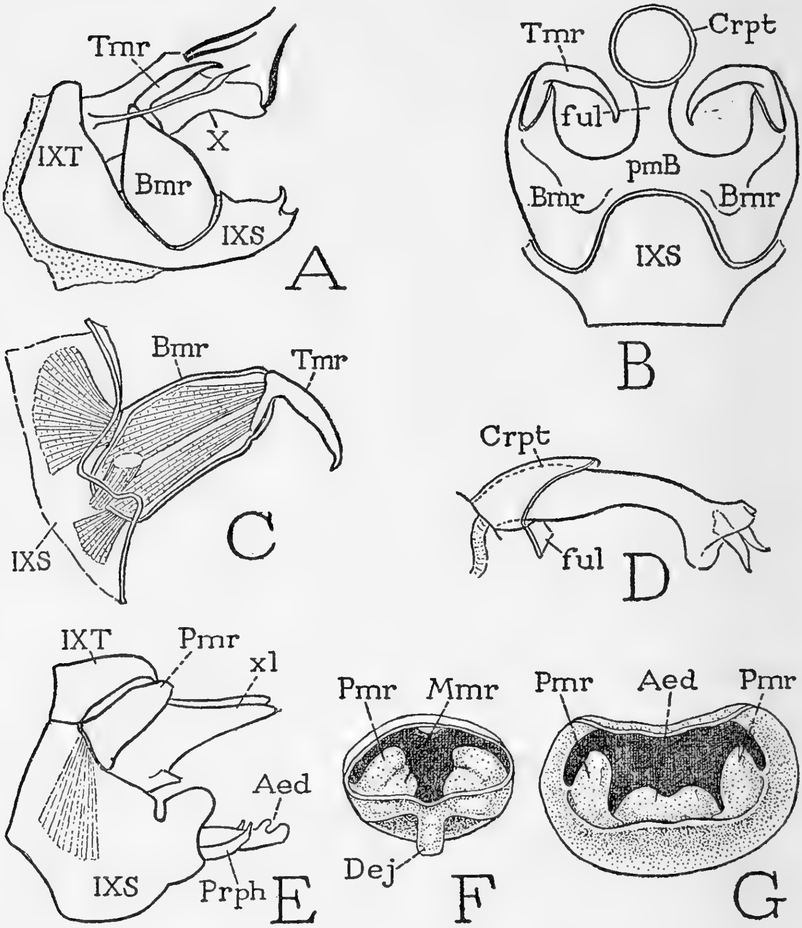

FIG. 10.—Trichoptera.

A, *Neuronia semifasciata* (Say), end of abdomen, left. B, same, end of abdomen, posterior. C, same, right paramere and muscles, mesal. D, aedeagus and crypt, left. E, *Platycentropus maculipennis* Rambur, end of abdomen, left. F, *Limnophilus bipunctatus*, genital pocket with primary phallic lobes dividing into mesomeres and parameres (from Zander, 1901). G, same, later stage, phallic lobes completely divided, mesomeres united to form aedeagus (from Zander, 1901).

sternum (*IXS*). It is evident, therefore, that in such species the parameres have simply expanded their united bases along the margin of the sternum until their free parts have attained a lateral position on the ninth segment. In both their development and in their adult structure the trichopterous claspers attest that they are not primarily ninth-segment appendages. The position of the parameral bridge immediately adjoining the reflected posterior margin of the ninth abdominal sternum (B, *IXS*) is suggestive that the bridge is derived from the tenth sternum. From the middle of the bridge a lobe (*ful*) extends upward and supports the lower rim of the aedeagal pouch (*Crpt*). This lobe is the "juxta" of lepidopterists; it appears to serve as a fulcrum for the movement of the aedeagus.

The aedeagus of the Trichoptera is a large sclerotic organ (fig. 10 D) arising from a pouch, or aedeagal crypt (*Crpt*), of the genital chamber wall above the parameral bridge (B, *pmB*). The aedeagus of *Neuronia* (D) in the nonfunctional position is ensheathed in a groove on the ventral side of the tenth segment (A, *X*). In some species long processes arise from the base of the aedeagus, which may be dorsal, ventral, or lateral (E, *Prph*). These aedeagal processes have been called "titillators" and "parameres," but, as suggested in the Introduction, such structures might be termed paraphyses.

The tenth segment often has a pair of appendicular processes of various forms and sizes arising from its base. In *Neuronia* (fig. 10 A) these processes are long, slender lateral arms, suggesting by their position the so-called "socii" of Lepidoptera, but it seems improbable that they are cerci.

XI. LEPIDOPTERA

The genitalia of Lepidoptera have many features in common with those of Trichoptera, particularly in the presence of large lateral parameres ("harpes," "valvae") articulated on the ninth abdominal segment, and in the partial ensheathment of the aedeagus in a pouch of the genital chamber wall. Furthermore, the bases of the parameres may be confluent in an interparameral bridge behind the margin of the ninth sternum.

In some Lepidoptera, as in *Carpocapsa* (fig. 11 A), though the parameres (*Pmr*) are attached laterally on the ninth abdominal sternum, their bases converge medially behind the sternum (B) and are here articulated on a small median plate (*BP*) in the floor of the genital chamber. From this plate an arm (*ful*) extends upward and forks around the mouth of the aedeagal pouch. The base of the

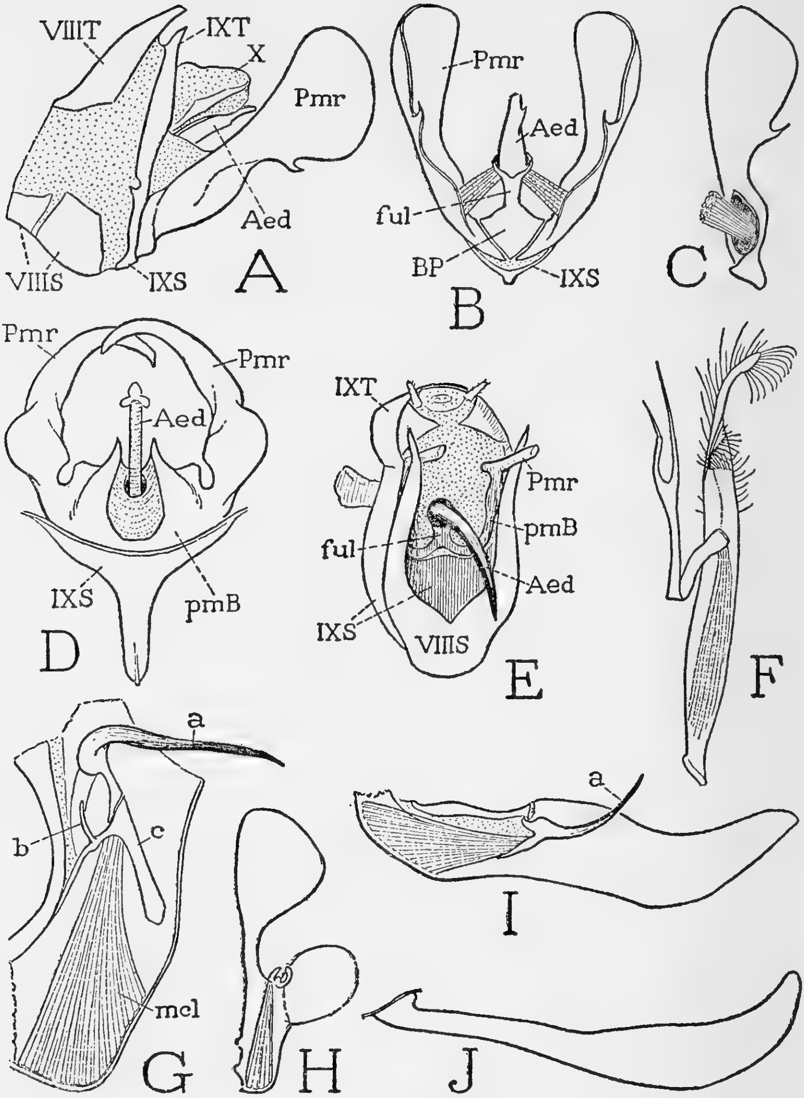

FIG. 11.—Lepidoptera.

A, *Carpocapsa pomonella* (L.), terminal abdominal segments and genital structures, left. B, same, genitalia, ventral. C, same, right paramere, mesal. D, *Bombyx mori* (L.), genitalia and ninth abdominal sternum, ventral. E, *Malacosoma americanum* (F.), end of abdomen, posterior. F, *Promalactis holozona* Meyrick, left paramere, mesal. G, *Sepsis artica* (Freyer), basal part of right paramere, mesal. H, *Pseudoletia unipuncta* (Haw.), left paramere, mesal. I, *Feltia herilis* (Grote), right paramere, mesal. J, *Heliothis phloxiphaga* Grt. and Rob., left paramere, mesal.

a, b, prongs of mesal armature of paramere; *c,* plate in mesal wall of paramere.

aedeagus is thus dissociated from the interparameral plate only by being sunken into a pouch above it. Otherwise the plate supporting the aedeagal pouch is quite comparable to the basal plate of the aedeagus in those Homoptera in which the parameres are articulated on it (fig. 6 B). The articulation of the parameres on the basal plate that supports the aedeagus in *Carpocapsa* suggests that the parameres and the aedeagus have a common origin as in other insects. The flexor muscles of the lepidopterous parameres are shown by Forbes (1939) to arise on the inner face of the supporting plate of the aedeagus; in *Carpocapsa* these muscles (fig. 11 B) arise on the branches of the arm that embrace the aedeagal pouch.

The arm of the basal plate that supports the aedeagal pouch (fig. 11 B, *ful*) is the *juxta* of lepidopterists, but the word "juxta" is an adverb and not a noun in Latin. The arm apparently serves as a prop for the movement of the aedeagus, and is here termed the aedeagal *fulcrum.*

In some other lepidopterous families, as seen in *Bombyx* (fig. 11 D), the bases of the parameres are united in an interparameral bridge (*pmB*) lying close to the margin of the ninth sternum, as in the trichopteron *Neuronia* (fig. 10 B). In *Bombyx,* however, there is no fulcral arm from the bridge to the aedeagal pouch.

An interesting condition is seen in *Malacosoma* (fig. 11 E), showing the extent to which modification may be carried without disrupting the fundamental plan of structure. The parameral bridge (*pmB*) with the aedeagal fulcrum (*ful*) has the shape of a W, the lateral arms of which extend far above the level of the aedeagal pouch, where they support a pair of short, rodlike parameres (*Pmr*). The ventral part of the ninth sternum (*IXS*) is a large plate beneath the bridge with its posterior end reflected forming a pocket like the toe of a slipper. The eighth sternum (*VIIIS*) projects ventrally beyond the ninth and is produced upward in a pair of long, tapering lateral arms behind the ninth segment.

Studies on the developmental origin of the lepidopterous claspers are not all in harmony. Mehta (1932, 1933) claimed that the phallic rudiments in *Pieris* and other species, which appear in the fourth larval instar, unite to form only the aedeagus. The rudiments of the claspers (valvae) he says are formed later than the aedeagal lobes toward the end of the larval period as thickenings of the lateral walls of the genital chamber. Mehta contends, therefore, that the claspers are appendages of the ninth abdominal segment.

On the other hand, Zander (1903), and Rakshpal (1944) say that both the claspers and the aedeagus of species they studied are developed from a single pair of phallic rudiments as in other insects. According to Zander, in *Paraponyx stratiolarius* a pair of genital rudiments first appears in a small flask-shaped pouch on the ventral region of the ninth abdominal segment toward the end of the larval period. The lobes divide in the usual manner into four secondary lobes; those of the median pair unite to form the aedeagus. The lateral lobes move posteriorly on the walls of the pouch, and when the latter opens out, as the larva enters the pupal stage, these lobes are carried to the exterior, where they grow quickly into strong appendages, which are the parameres (valvae) of the adult. Likewise Rakshpal finds that in *Galleria* and *Acroia* both the aedeagus and the parameres are formed by the splitting of a pair of primary phallic rudiments. The parameral lobes (valvae) he says become separated from the aedeagus shortly before pupation. It seems fair to conclude that Mehta failed to observe the lateral displacement of the clasper rudiments, and that the lepidopterous valvae are truly phallic derivatives, and are therefore parameres as in Trichoptera. The close association of the parameral bases with the aedeagus in the adult supports this conclusion.

The parameres of Lepidoptera are highly variable in shape and relative size, but there is no division into a basimere and a muscularly movable telomere as in many of the Trichoptera (fig. 10 C). On the mesal surface of each paramere in many lepidopterous families, however, is an armature consisting of one or two variously developed processes, with which is associated a long muscle arising in the base of the paramere (fig. 11 F, G, H, I, *a, b*).

A typical example of the parameral armature is seen in *Sepsis arctica* (fig. 11 G). Here there is a long, strong, tapering distal process (*a*) turned ventrally from a thickened base with a proximal extension apparently articulated on the end of an elongate plate (*c*) in the mesal wall of the paramere. A slender dorsal recurved arm of the plate bears a small second free process (*b*). In the notch between the plate and its arm is attached a large muscle (*mcl*) from the extreme base of the paramere. In the genus *Pseudoletia* (H) there are two very small processes arising side by side, with the muscle attached on one of them. In *Feltia herilis* (I) the single, hooked process has a basal arm on which the muscle is attached, but it is little movable on the paramere. An unusual structure is seen in *Promalactis holozona* (F) in which the parameral armature consists of a single, long, sharply elbowed arm ending in two tapering prongs. This appendage is articulated on the paramere, and evidently is movable by the muscle attached on its base.

The parameral armature was termed the "stylus" by Warren (1926), who illustrated it in numerous species of Hesperiidae. Most lepidopterists call the major process the "clasper," and the smaller one the "ampulla" because it is sometimes enlarged at the end. The presence of a muscle associated with these structures, sometimes attached directly on the base of the major process, might suggest that the latter is the telomere of a two-segmented paramere displaced proximally on the mesal surface. However, in most cases the prongs seem to be firmly fixed on the parameral surface, and to have only an indirect connection with the muscle. Yet it is difficult to account for the presence of a muscle within the paramere if it has no homologue in other orders. Forbes (1939) says the muscle of the clasper is "found in every member examined of the Lepidoptera which has a functional valve." The writer, however, has failed to see the muscle in such forms as *Carpocapsa* (fig. 11 C) and *Heliothis* (J), which have no parameral armature.

XII. MECOPTERA

The mecopterous genitalia resemble those of Trichoptera that have large, two-segmented claspers borne on the ninth abdominal segment. In *Panorpa* (fig. 12 A) the oval basal segments (*Bmr*) of the claspers are set into deep emarginations of the ninth-segment annulus; the hooklike distal segments (*Tmr*) are articulated on the basal segments and are provided with abductor and adductor muscles (C). The tergum of the ninth segment is produced into a pair of short arms; the sternal region bears two long subgenital lobes (*sgl*) projecting posteriorly. The aedeagus is a complex structure (G) between the bases of the claspers.

Most students of the mecopterous genitalia, including Ferris and Rees (1939), Grell (1942), and Tjeder (1956), have regarded the panorpid claspers as gonopods of the ninth abdominal segment composed of "gonocoxites" and "gonostyli." In this they conform with the terminology formerly used by the writer (1935), which is here discarded as no longer tenable. Apparently no studies have been made on the development of the mecopterous genitalia, but when we turn from *Panorpa* to *Merope* a condition is found strongly suggestive that the claspers are phallic parameres. In *Merope tuber* the claspers are long, slender, two-segmented arms (fig. 12 D); their bases converge above the ninth sternum and are united above and below the aedeagus (E, *Aed*), which is mostly invaginated between them. Crampton (1931) noted that the claspers of *Nannochorista* appear to be solidly united, and Michener (1944) says the claspers of *Apterobittacus, Bittacus,* and *Panorpa* "are fused both above and below the base of the aedeagus, encircling a genital foramen," but he appears to attach no significance to this fact. Yet it is evident that there is here an inti-

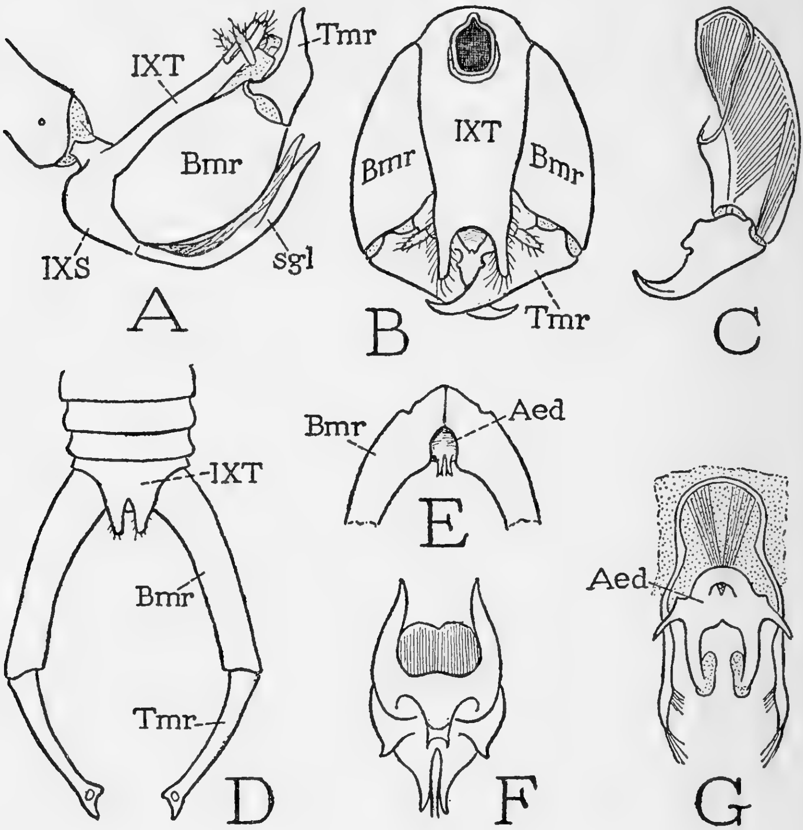

Fig. 12.—Mecoptera.

A, *Panorpa* sp., end of male abdomen, left. B, same, ninth abdominal segment and parameres, dorsal. C, same, paramere with muscles of telomere. D, *Merope tuber* Newm., end of abdomen, and parameres, dorsal. E, same, united bases of parameres and end of aedeagus. F, same, aedeagus, dorsal. G, *Panorpa* sp., aedeagus.

mate association of the claspers with the aedeagus characteristic of insects in which the claspers are known to be developed from lateral lobes of the phallic rudiments. From anatomical evidence, therefore, we can hardly avoid the conclusion that the claspers of Mecoptera are phallic parameres, which, as in Trichoptera, may be more or less displaced laterally on the margin of the ninth segment. Though Crampton (1931) regarded the mecopterous claspers as "gonocoxites," he later (1942) asserted that they must be parameres as in related holometabolous insects.

The aedeagus of *Merope tuber* (fig. 12 F) is an oval, capsulelike structure with a pair of long, dorsal basal arms, pointed lateral lobes, and two tapering, spine-bearing distal processes. It is mostly enclosed by the united bases of the parameral basimeres (E, *Aed*). In *Panorpa* the aedeagus is highly variable in different species. In the species shown at G of the figure it is a flattened structure with tapering lateral processes and a pair of posterior arms. Surrounding the base is a narrow U-shaped sclerotization in the supporting membrane, the arms of which are produced into a pair of free processes at the sides of the aedeagus. These processes have been called "parameres," but since no strictly comparable structures have been observed in other insects, they would appear to be special developments in the Mecoptera.

XIII. DIPTERA

In this order the male genitalia attain a varied and complex structure. While many of their unusual features are simply modifications of the basic structure of the genital organs, others are secondary additions to it. The problem of determining whether secondary parts in different families are homologous or not and of devising names for them is the business of the taxonomists. The major problem for the morphologist concerns the nature of the clasping organs of the Orthorrhapha, and the question of their possible homologues in the Cyclorrhapha, but some attention must be given also to the nature of the secondary organs.

In the Nematocera the claspers are two-segmented appendages closely resembling the parameres of Trichoptera and Mecoptera. They are usually articulated on the ninth segment, but are often interpolated between the tergum and the sternum of this segment, and may even be partly or entirely fused with the sternum. Consequently the claspers of the Diptera have commonly been regarded as "gonopods" of the ninth segment. Arising from the mesal surfaces of the basal segments of the claspers there may be variously developed structures that form a pair of "inner claspers"; and long or short processes are sometimes closely associated with the base of the aedeagus. All these structures have been differently interpreted and named by different students of the dipterous genitalia, leading to a great confusion of terminology and ideas of homology, which has been amply reviewed by Crampton (1942), who fortunately has left us a sound morphological basis for a uniform nomenclature.

A relatively simple structure of the genital organs is seen in the Culicidae. It must first be observed that the eighth abdominal segment and the ninth segment with its appurtenances in the mosquitoes have been inverted (fig. 13 A), so that the claspers (*Pmr*) are dorsal in position and the proctiger (*Ptgr*) ventral. According to Christophers (1922) the inversion is completed in *Culex fatigans* 24 to 48 hours after emergence of the adult. The ninth segment is greatly reduced (A) and is normally concealed within the eighth. The irregular tergum is produced into a pair of processes beneath the bases of the claspers (B); the small sternum (C) somewhat overlaps the upper surfaces of the claspers. In the following descriptions "dorsal" and "ventral" will be used in a morphological sense.

The typical structure of the culicid genitalia is well shown in *Anopheles* (fig. 13 D). The large, two-segmented claspers are membranously attached to the annulus of the ninth segment. Between their bases is a short, slender aedeagus (*Aed*) connected with the proximal angles of the claspers by a pair of small *basal plates* (*bp*). Arising proximally from the mesal surface of each clasper is a broad, mostly membranous, spine-bearing lobe (*clsp*), known as a *claspette* or *claspette lobe*. In *Anopheles* the two lobes are confluent ventral to the aedeagus, but in other species the claspettes may be entirely separate and take on various forms. In *Aedes pullatus* (E), for example, they are sclerotic hook-shaped processes (*clsp*). Claspettes of this type have usually been termed "parameres" by dipterists without checking on their credentials. The anatomical unity of the genital parts in the mosquito, together with their development from a single pair of rudiments, leaves no doubt that the true parameres are the large outer claspers.

Christophers (1922) has shown that the whole genital complex of *Anopheles* is developed from a single pair of primary phallic lobes, which he called the "proandropodites." The primary rudiments (fig. 14 A, *PhL*) are formed behind the ninth abdominal sternum as the larva enters its last instar. The lobes at first sink into pockets of the epidermis, but in the pupa they are everted and become relatively large (B). With further development a secondary lobe (C, *Mmr*) is budded off mesally from the dorsal side of the base of each primary lobe. A fissure now surrounds these mesal lobes and cuts them off from the principal lobes (D). The mesal lobes elongate (E) and then unite (F, G) to form the aedeagus (*Aed*), or "phallosome" of Christophers. The main lobes become the parameres (C, *Pmr*), or "an-

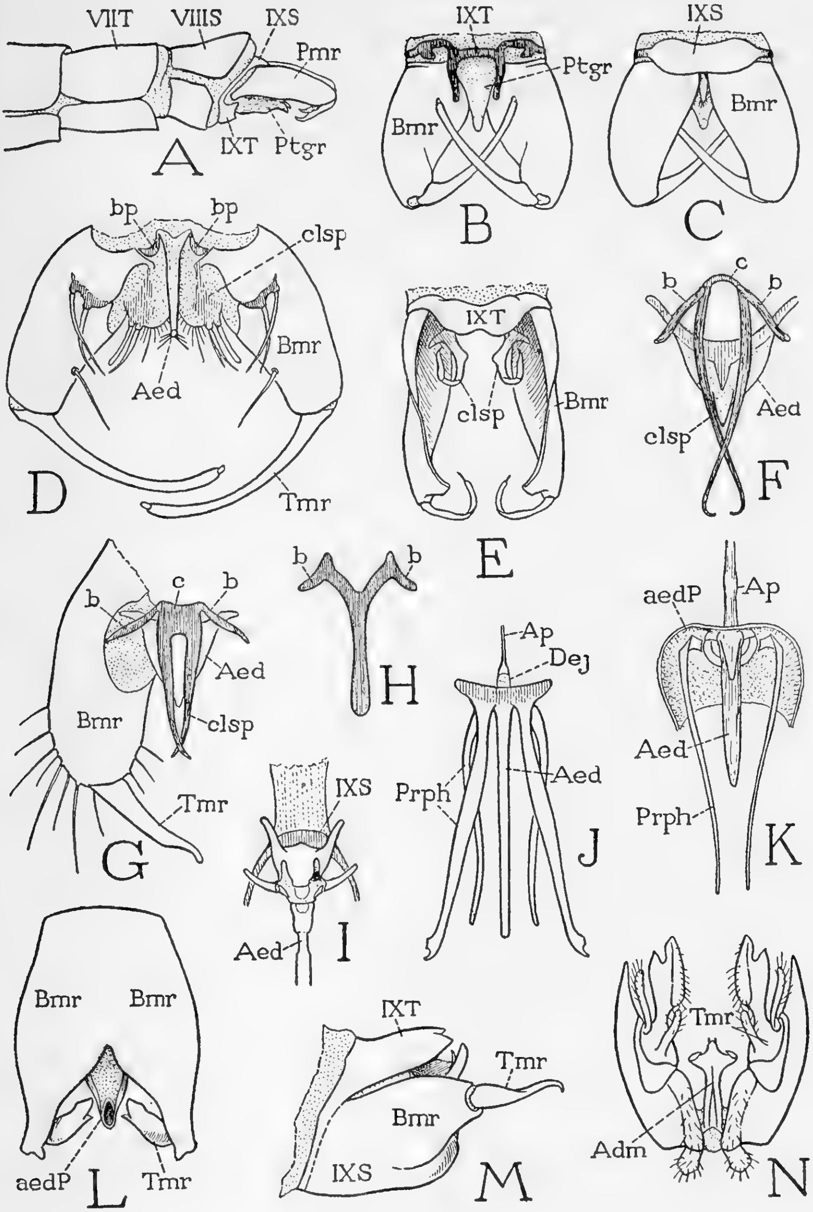

FIG. 13.—Diptera.

A, *Aedes aegypti* (L.) (Culicidae), end of abdomen with segments pulled apart, showing inversion of segments VIII and IX. B, *Anopheles quadrimaculatus* Say (Culicidae), ninth tergum and parameres. C, same, ninth sternum and parameres. D, same, aedeagus and parameres, dorsal. E, *Aedes pullatus* (Coq.) (Culicidae), ninth tergum, parameres, and claspettes. F, *Forcipomyia cilipes* (Coq.) (Heleidae), claspettes and aedeagus, ventral. G, *Forcipomyia specularis* (Coq.) (Heleidae), right paramere, claspettes, and aedeagus, ventral. H, *Palpomyia* sp. (Heleidae), claspettes united in a median lobe. I, *Lucilia sericata* Meigen (Calliphoridae), base of aedeagus and associated processes. J, *Blepharocera tenuipes* Walker (Blepharoceridae), aedeagus and paraphyses. K, *Tabanus sulcifrons* (Macq.) (Tabanidae), aedeagus and paraphyses in base of aedeagal pouch. L, same, parameres and outer end of aedeagal pouch. M, *Bibio longipes* Lw. (Bibionidae), ninth abdominal segment and left paramere. N, *Tipula triplax* Walker (Tipulidae), parameres and adminiculum, posterior.

b, b, basal arms of claspettes; *c,* basal union of claspettes.

dropodites," each of which is finally divided into a large basal segment and a slender distal segment. At the base of each paramere appears a fold (G, *bf*), apparently the rudiment of the claspette lobe.

Likewise, though under different names, the parts of the genital apparatus of *Phlebotomus* are shown by Christophers and Barraud (1926) to be derived from a single pair of primary genital lobes (here termed "precoxites") that appear in the last larval instar at the bases

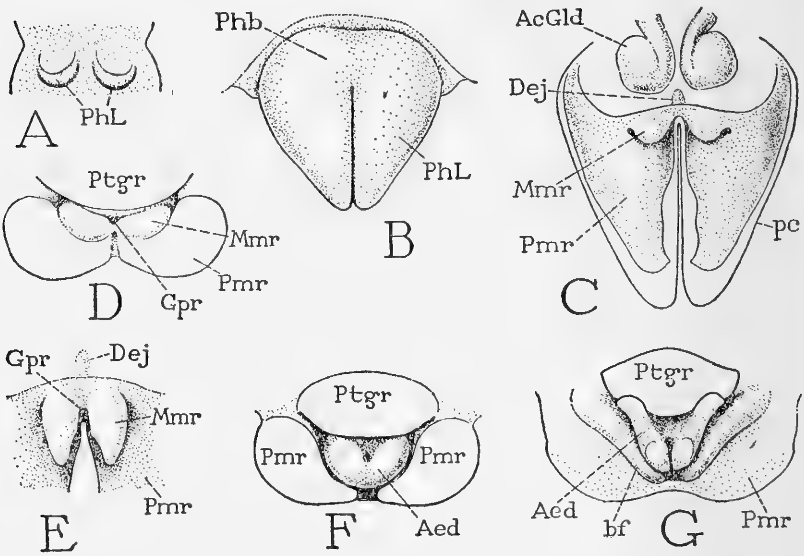

FIG. 14.—Diptera, development of the phallic organs of Culicidae. (From Christophers, 1922, with names used in this paper.)

A, primary phallic lobes behind ninth abdominal sternum of last larval instar. B, same, later stage. C, differentiation of primary lobes into mesomeres and parameres within pupal cuticle. D, mesomeres uniting around the gonopore. E, later stage, mesomeres enlarged. F, mesomeres united to form the aedeagus. G, folds (*bf*) developed on bases of parameres, probably rudiments of claspette lobes.

of the anal lobes. In the pupa a pair of median lobes is cut off from the bases of the primary lobes and form the intermediate parts of the genital complex. The aedeagus of *Phlebotomus* is quite different from that of the mosquito; it is sunken into an ensheathing pouch and has two long apical processes that project from the mouth of the pouch. The lateral lobes become secondarily constricted into basal parts ("coxites") and distal parts ("styles"). There are no claspettes or other secondary structures developed from the parameres of *Phlebotomus*.

These accounts of the development of the phallic organs in two species of Diptera show that the claspers are lateral branches of the primary phallic rudiments, and are therefore parameres as in other insects. Crampton (1942, p. 85) has strongly contended that "if comparative morphology has any meaning at all, the segmented genital forceps flanking the aedeagus in male Mecoptera, Trichoptera, Diptera, etc., must be homologous with the genital forceps, or parameres, flanking the aedeagus in male Hymenoptera, Coleoptera, etc., instead of representing the coxites and styli of lower insects, as maintained by other investigators."

Van Emden and Hennig (1956) object to Crampton's use of the term paramere for the lateral claspers. They say that the developmental studies of Abul-Nasr (1950) on dipterous genitalia "seem to have proved that the structures under discussion are genuine gonopods." Actually, what Abul-Nasr has shown is that the entire genital complex of Ditpera is derived from a pair of primary lobes as in other insects. The primary lobes divide each into two secondary lobes, one lateral, the other mesal. The lateral lobes become the claspers; the mesal lobes form the aedeagus and whatever structures may be intermediate between the aedeagus and the claspers. In the case of *"Chironomus"* (*Tendipes*), however, in which there is no aedeagus, mesal lobes developed on the basal segments of the claspers evidently become the endoparameral processes of the adult called "parameres." These processes are solid outgrowths from the distal parts of the basimeres, and clearly are secondary structures not equivalent to the claspettes of other species. An identity of the lateral claspers with gonopods of the ninth segment is apparently taken for granted in Abul-Nasr's discussion; by his own evidence the claspers are phallic parameres.

The adult structure of the genitalia in many nematocerous families is similar to that of the Culicidae, but the parts themselves are highly variable in form. Parameral claspers are present in most of the Orthorrhapha; they may become displaced laterally from the adeagus and attached laterally on the annulus of the ninth segment. In *Tabanus* (fig. 13 L) the basimeres are united ventrally with each other; in various nematocerous and brachycerous species the basimeres may be partly or entirely fused with the ninth sternum (M). Among the Tipulidae the basimeres are often so deeply interpolated between the tergum and the sternum of the ninth segment that the writer formerly (1904) interpreted them as the "pleura" of this segment. The telomeres likewise are variable and may be complicated by the development of accessory lobes (N).

The claspettes of the Nematocera are of interest because of the various forms they assume. They are always connected with the inner faces of the parameres, and thus appear to be secondary outgrowths of the latter. As already noted, in the Culicidae they may be membranous lobes confluent beneath the aedeagus (fig. 13 D) or entirely independent sclerotic arms (E). In the Heleidae the claspettes may be broad platelike appendages of the parameres, but in species of *Forcipomyia* (F, G) they are long, slender processes connected with the parameres by only a pair of basal arms (*b, b*). In *F. cilipes* (F) the two claspettes are joined by a narrow median basal bridge (c), which in *F. specularis* (G) becomes a wide plate solidly supporting the claspette processes. Finally the claspettes in some species are themselves united in a single median process (H), which may take the form of a broad spatulate lobe. In the last case "claspette" becomes a doubtfully appropriate term; but nomenclature often is not sufficiently elastic to keep pace with the anatomical versatility of insect structures.

Another set of structures occurring in various unrelated species are outgrowths arising at the base of the aedeagus, which are quite distinct from the parameral claspettes. In *Blepharocera tenuipes* (fig. 13 J) four long arms (*Prph*) arise from a small basal plate that supports also the rodlike median aedeagus (*Aed*). In *Tabanus sulcifrons* (K) the aedeagus and a pair of long slender accessory processes connected with its base arise from the inner end of a deep pouch that opens by a narrow aperture between the parameres (L, *aedP*). These basal processes of the aedeagus, which occur also in some other insects, seem to have been given no special names; they are here termed in general *paraphyses* (lateral outgrowths). Structures perhaps of a similar nature are the short processes arising from a basal plate of the aedeagus in the muscoid flies (I). These processes are commonly called "gonapophyses," but Crampton (1942) suggests the name *gonites* for them, since the term gonapophyses commonly refers to the valves of the female ovipositor. Some recent writers, however, call the processes "parameres" in the belief that they represent the phallic parameres of other Diptera. That they cannot be parameres is pointed out by Crampton, since they are present in some brachycerous families that have true lateral parameres.

In the Cyclorrhapha parameral claspers appear to be suppressed. Some writers suggest that a pair of lobes or arms on the lower posterior angles of the ninth tergum are "gonopods" representing the parameres, but we have no account of the development of the genitalia in the cyclorrhaphous flies. The lobes in question may be solid outgrowths of the tergum, flexible at their bases, or freely movable by muscles, and they probably serve as claspers, but it is incongruous that either gonopods or parameres should be borne on the tergal plate of a segment. Crampton called these lobes "surstyli." Paired lobes or processes of various shapes and sizes are of common occurrence on the ninth abdominal tergum throughout the insects, and, as already noted, are conspicuous in some Culicidae (fig. 13 B).

XIV. HYMENOPTERA

The genital organ typical of male Hymenoptera (fig. 15 A) differs in several respects from that of other insects. The parameres are never entirely separated from the aedeagus, the three parts being united proximally in a common base. Between the parameres and the aedeagus on each side is a pincerlike organ known as the *volsella* (*Vol.*). These several elements are differentiated at an early stage of development (D) from the primary phallic rudiments (C). Finally, the whole phallic structure of the adult is supported on a sclerotic *basal ring* (A, *BR*)

The basal ring is typically an annular sclerite; it may be much reduced or incomplete, but rarely is it absent. According to Zander (1900) the ring is formed relatively late in development from the epidermis at the base of the primary phallus. Yet it bcomes an essential part of the adult organ, since the extrinsic phallic muscles from the ninth abdominal segment are inserted on it.

The hymenopterous parameres are usually elongate, undivided lobes of various shapes united proximally with the aedeagus (fig. 15 G, *Pmr*). In most of the Chalastogastra, however, the parameres are distinctly segmented into basimeres and telomeres (L), and the telomeres are movable by muscles from the basimeres. In some of the Clistogastra the distal part of the paramere may be flexible or even articulated on the basal part (N), but in only a few such cases is the telomere provided with muscles. The writer (1941) limited the term "paramere" to the free terminal part of the clasper, or to the movable telomere, and called the basal part the "parameral plate" because it is so intimately united with the base of the aedeagus; but clearly the whole structure is the paramere.

The free part of the aedeagus projects from between the bases of the parameres (fig. 15 A, G, L, *Aed*) and assumes various forms. Characteristically it contains a pair of rods (A, *r*) in its lateral walls, the apices of which usually project as free points. These aedeagal rods are called "parameres" by Beck (1933), who says they "are the gonapophyses of the ninth sternite." Other writers more commonly

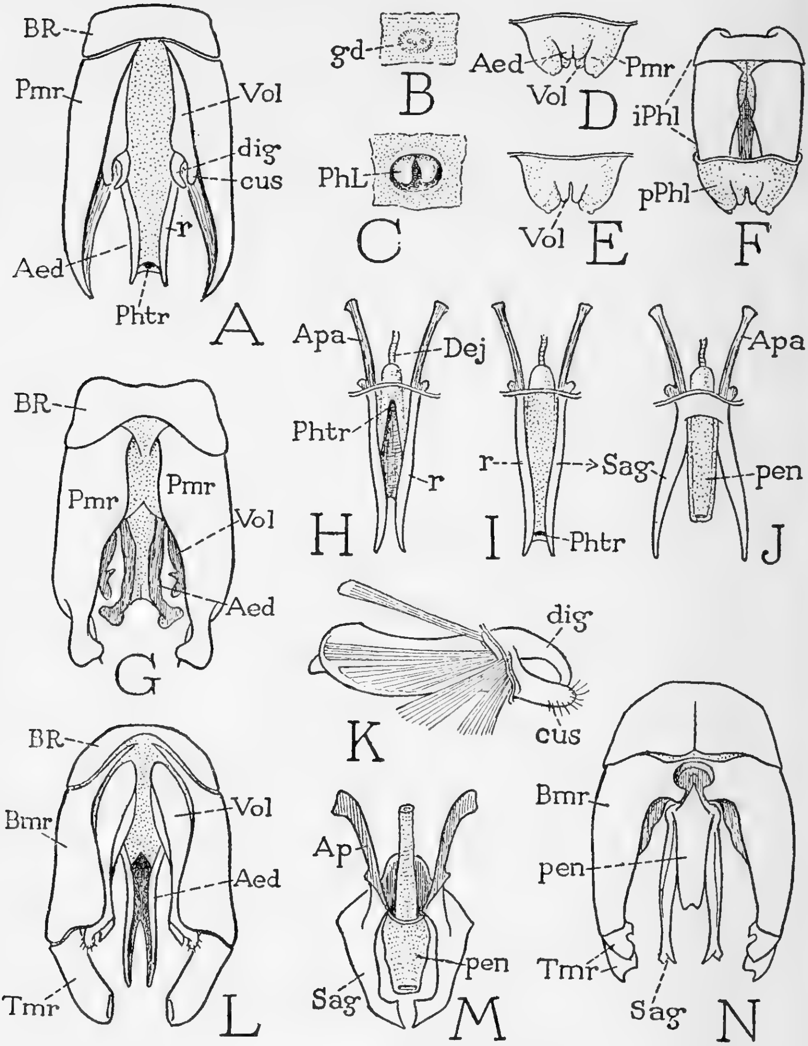

FIG. 15.—Hymenoptera.

A, diagram of general structure of hymenopterous phallic organ, ventral. B, *Vespula maculata* (L.), genital disc on venter of ninth abdominal segment of penultimate larval instar. C, same, phallic lobes in pocket of integument of next larval instar. D, same, phallic organ of pupa, dorsal. E, same, ventral. F, same, phallic organ of adult growing from within pupal organ. G, same, adult phallus. H, diagram of primitive hymenopterous aedeagus, ventral. I, aedeagal groove closed, bringing phallotreme to apex. J, typical phallic structure of Apoidea. K, *Megaryssa lunator* (F.), volsella and muscles. L, *Xiphydria maculata* (Say), phallus, ventral. M, *Anthophora abrupta* Say, penis and sagittae, ventral. M, *Bombus lapidarius* (L.), phallus, dorsal.

term them the "penis valves," which Michener (1944) defines as "mesal basal processes of the gonocoxopodites," and homologizes them with the ninth-segment coxal endites of *Machilis* (fig. 2 G, *Endt*). However, the aedeagal rods of the Hymenoptera have no connection with the parameres, which are supposed to be the "gonocoxites" of the ninth segment. Their bases are prolonged into free apodemes (fig. 15, H, I, J, *Apa*), on which the aedeagal muscles are attached. Deprived of any theoretical status, the rods are simply lateral sclerotizations of the aedeagus supporting the aedeagal apodemes.

In most of the bees the aedeagal rods have become almost entirely separated from the median membranous part of the aedeagus (fig. 15 J, M, N), giving the apoid aedeagus a tripartite structure. The free lateral rods are then known as the *sagittae* (J, *Sag*), but their identity with the rods in other forms is shown by the fact that they still carry the aedeagal apodemes (J, M). The median remnant of the aedeagus may be termed the *penis* (*pen*). The sagittae of *Bombus* are said by Zander (1900) to be developed directly from the aedeagal lobes of the primary phallic rudiments, the penis being a secondary outgrowth between them. This observation shows at least that the aedeagal rods belong to the aedeagus and not to the parameres or "coxites." In some of the Hymenoptera, particularly among the Chalastogastra and Ichneumonidae, the aedeagus appears to retain a primitive structure in that it is widely open below (H, L) with the phallotreme (H, *Phtr*) at the base of the ventral channel. In most cases, however, the aedeagus is closed below, bringing the phallotreme to the apex (I, J, M, N).

An endophallic sac traverses the aedeagus from the phallotreme and may project beyond the aedeagal base, where it receives the ductus ejaculatorius (fig. 15 H, *Dej*). The honey bee has no aedeagus, since the primary median lobes of the phallic rudiments do not unite. Both the mesomeres and the parameres remain undeveloped and in the adult form only a pair of small lobes guarding the phallotreme. The endophallus, on the other hand, is enormously developed, and when partly or fully everted becomes the functional intromittent organ.

The volsellae appear to be phallic elements peculiar to the Hymenoptera. In most families they are well developed, but in the bees they are much reduced or absent. Typically each volsella consists of an elongate plate on the ventral surface of the phallus lying close to the inner margin of the corresponding paramere (fig. 15 A, L, *Vol*). At its free distal end the volsellar plate bears two small processes that form a pincer, one being an immovable projection or *cuspis* (A, K, *cus*) of the plate, the other a curved or hooked *digitus* (*dig*) movably opposed to the cuspis. Both cuspis and digitus are strongly musculated (K), and a large protractor muscle of the entire volsella arising in the neighboring paramere is attached on the inner end of the plate. Retractor muscles arise proximally in the paramere and on the aedeagal apodeme. A full description of the phallic musculature and mechanism of a braconid is given by Alam (1952). The elaborate musculature of the volsellae seems to show that in the insects special muscles can be developed wherever they are needed. The volsellae evidently are important elements of the genital mechanism in Hymenoptera. According to observations of Peck (1937) on ichneumonids taken during mating, the volsellar pincers grasp the membrane near the female gonopore, keeping the membrane taut while the aedeagus is inserted. In the braconid *Stenobracon* Alam says the two digiti enter the gonopore. The volsellae are developed from a pair of small ventral lobes of the pupal phallus (D, E, *Vol*) and are thus independent primary elements of the hymenopterous genital complex.

The development of the hymenopterous phallus has been described by Seurat (1899) in the braconid *Dorcytes;* by Michaëlis (1900) in *Apis;* by Zander (1900) in *Vespa, Bombus,* and *Apis;* by Boulangé (1924) in *Sirex;* and by Snodgrass (1941) in *Vespula* and *Apis.* In *Vespula* the genital rudiments are first visible as a pair of minute thickenings in a small disc (fig. 15 B, *gd*) on the posterior part of the venter of the ninth abdominal segment of a late-instar larva. Beneath the disc in a pocket of the integument of the enclosed instar are two small primary phallic lobes (C, *PhL*). In the pupa (D) the primary lobes have divided into six secondary lobes united on a common base. The median dorsal lobes (*Aed*) will form the aedeagus, the lateral lobes (*Pmr*) the parameres, and the ventral lobes (D, E, *Vol*) the volsellae. The greatly larger phallus of the adult (F, *iPhl*) will then develop from within the pupal organ (*pPhl*), and finally take on the mature structure (G). The whole genital complex of the adult thus takes its origin from a single pair of minute phallic rudiments.

SUMMARY

1. The organs associated with the genital outlet in the male insect, in all orders in which their ontogenetic origin has been observed, are developed from a pair of primary phallic lobes that appear on the nymph or larva.

2. In the lower insects there is evidence that the phallic rudiments pertain to the tenth abdominal segment. In the higher insects they usually rise on the apparent posterior part of the ninth segment of the

larva, but in the adult they are situated *behind* the sternal plate of this segment.

3. The terminal ampullae of the vasa deferentia usually lie at least partly within the phallic lobes, suggestive that originally they may have opened through the lobes, and that the latter, therefore, were a pair of penes. This suspicion appears to be confirmed in the Ephemeroptera, if the rudiments of the two penes in this order are homologues of the phallic lobes in other insects, as they appear to be. The ephemeropterid penes are penetrated by ectodermal exit ducts that unite with the vasa deferentia.

4. In insects other than the Ephemeroptera a secondary median ectodermal ejaculatory duct grows inward between the bases of the phallic lobes. The ampullae of the vasa deferentia then withdraw from the lobes to unite with the inner end of this duct, which becomes the definitive genital outlet.

5. In the Thysanura the primary phallic lobes unite to form a simple median penis giving exit through a very short ejaculatory duct to both vasa deferentia.

6. The primary phallic lobes of insects that have lateral copulatory claspers associated with a median intromittent aedeagus divide each into two secondary lobes. The secondary lobes of the median pair, or *mesomeres,* unite with each other to form the aedeagus, the lateral lobes, or *parameres,* become the claspers. Secondarily in their development the parameres may become two-segmented.

7. Stylus-bearing plates of the ninth abdominal segment, which are commonly regarded as the coxae of former limbs of this segment, are present in Thysanura, Ephemeroptera, and Grylloblattidae. The current idea that the parameral claspers are "coxites" equivalent to these stylus-bearing plates ignores the fact that the parameres are derived along with the aedeagus from the phallic lobes, and that the single penis of the Thysanura is also formed from two primary phallic lobes that have no actual connection with the coxal plates. The idea expressed by some writers that the phallic lobes are the telopodites of ninth-segment appendages would imply that the telopodites of a primitive pair of legs have united to form an intromittent organ, the aedeagus, an interpretation hardly to be taken seriously. Likewise, the theory that endites of the ninth-segment coxae, such as are present in some species of Machilidae, have united with a primitive median penis to form the aedeagus is untenable since it is not supported by observed facts. The coxal endites of Machilidae are not united with the penis, which, moreover, is itself formed from two primary lobes. The so-called "penis valves" of the aedeagus of some insects, inter-

preted as "coxal endites," are merely lateral sclerotizations of the aedeagal wall.

8. In some Orthoptera styli are borne on the ninth sternal plate of the male abdomen, in which case it is evident that the corresponding coxae have been incorporated into the definitive sternum. Yet the phallic lobes in this order divide as usual each into two secondary lobes. Therefore, if these secondary phallic lobes in Orthoptera are equivalent to the mesomeres and parameres of other insects, the parameres are not coxal plates, or "coxites." However, in the Orthoptera the phallic lobes do not form typical parameres and an aedeagus.

9. The commonly held idea that the phallic lobes represent a pair of appendages of the ninth or tenth abdominal segment must assume that the male genital organs were once a pair of legs. It is not explained, however, in what manner these legs became modified into an intromittent organ containing the genital outlet and into a pair of lateral claspers. If the phallic lobes of modern insects ever had any relation to appendages, it seems more probable, by comparison with other arthropods, that they were originally penes on the coxae of a pair of legs. If so, the supposed appendages themselves have been suppressed, and the isolated penes then developed into the aedeagus and parameres of modern insects. If the parameres represent the coxae of the vanished legs, they must be theoretically regenerated from the penes they once bore. Considering the known facts concerning the ontogenetic development of the phallic organs, it needs a strong imagination to visualize their evolution from a pair of legs. Though Else (1934) claimed to have traced the phallic rudiments of *Melanoplus* from tenth-segment limb buds on the embryo, it is perhaps possible he confused the limb buds with the genital rudiments. Other writers describe the phallic lobes as making their first appearance on the nymph or larva, after the abdominal limb buds of the embryo have disappeared.

10. Since biological theories of origins and evolution cannot be subjected to experimental tests, as can theories in physics, and since we cannot go backward in time to observe the facts, no biological theory is really capable of demonstration. For practical purposes, therefore, in the study of the insect male genitalia, if we care to disregard questions of the nature of the primitive phallic organs, and *theories* on the homologies of the adult organs, we still have the known facts of their ontogenetic development. It has been demonstrated that the aedeagus and claspers are derived from a pair of primary rudiments, and this fact gives us a basis for homologizing these major parts of

the genitalic complex throughout the insect orders. On this assured information a simple, uniform terminology can be based.

11. Most taxonomists seem to regard the preservation of a traditional anatomical nomenclature as something to be desired above all else; but the result is confusion, since each taxonomist has his own traditional nomenclature. The plan here offered, therefore, would relieve this confusion, and is one that *can* be consistently followed if nomenclatural uniformity is desired. In addition to the major phallic organs, however, numerous secondary structures have been developed independently in nearly all the insect orders. Such structures necessarily must be given special names for taxonomic purposes.

ABBREVIATIONS ON THE FIGURES

AcGld, accessory gland.
Adm, adminiculum.
Aed, aedeagus.
aedP, aedeagal pouch.
Amp, ampulla.
Ap, apodeme.
Apa, aedeagal apodeme.
Apb, apodeme of phallobase.

bf, basal fold.
Bmr, basimere.
bp, basal plate.
BP, basal plate.
BR, basal ring.

Cer, cercus.
cf, caudal filament.
clsp, claspette.
Crpt, aedeagal crypt.
cus, cuspis.
Cx, coxa.
cxmcl, coxal muscle.

dej, nonfunctional duct.
Dej, ductus ejaculatorius.
Dejcn, ductus ejaculatorius conjunctus.
dig, digitus.
dl, dorsal lobe of telomere.

Endt, coxal endite.
Enph, endophallus.
Eppt, epiproct.

fl, flagellum.
ful, fulcrum (juxta).

gd, genital disc.
Gpr, gonopore.

iPhl, imaginal phallus.

lPmr, left paramere.

mcl, mcls, muscle, muscles.
mL, median lobe.
Mmr, Mmrs, mesomere, mesomeres.

Papt, paraproct.
pc, pupal cuticle.
pen, median lobe of aedeagus.
Pen, penis.
Phb, phallobase.
PhL, primary phallic lobe.
Phm, phallomere.
Phtr, phallotreme.
pmB, interparameral bridge.
Pmr, paramere.
pPhl, pupal phallus.
Prph, paraphysis.
Ptgr, proctiger.

ri, ridge.
rMmr, right mesomere.
rPhm, right phallomere.
rPmr, right paramere.

S, sternum.
Sag, sagitta.
sgl, subgenital lobe.
smcl, stylus muscle.
Sty, stylus.

T, tergum.
tl, tergal lobe.
Tmr, telomere.
tp, tergal process.

Vd, vas deferens.
Ves, vesicle.
Vir, virga.
vl, ventral lobe of telomere.
Vol, volsella.

xl, lobe of tenth segment.
x-x, cut edge of genital chamber.

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THE ANATOMY OF THE LABRADOR DUCK, CAMPTORHYNCHUS LABRADORIUS (GMELIN)

(WITH FIVE PLATES)

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THE ANATOMY OF THE LABRADOR DUCK, CAMPTORHYNCHUS LABRADORIUS (GMELIN)

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Very little is known about the anatomy of the Labrador duck. Wilson (1829, p. 370) briefly described the trachea of the male and remarked, in addition, that "the intestines measured six feet . . ." Leib (1840, pp. 170-171), describing a supposedly new species of *Fuligula* (*grisea*), which later turned out to be "the young of *labradora* in a plumage heretofore undescribed or figured . . . ," said of the trachea that "the labyrinth of the male is large." The sternum, coracoid, and furcula (articulated) are illustrated in Rowley (1877), but there are no published measurements or descriptions of these bones, the only known skeletal remains of the Labrador duck.

The paucity of anatomical, behavioral, and distributional information about the Labrador duck accounts for considerable uncertainty as to the relationships of the genus. Rowley (1877, pp. 215-216), with some misgivings, followed Newton (1875, p. 735) and put the Labrador duck in the eider genus *Somateria,* saying (op. cit., p. 217) that it "had better remain among the Eiders, in which group it appears to be the least beautiful member." Rowley's evidence for this arrangement was the eiderlike modified feathers of the cheek of the adult male Labrador duck. Delacour and Mayr (1945, p. 33) said that "the extinct Labrador duck (*Camptorhynchus*) seems to be about halfway between the eiders and the Old-squaw. The male is colored more like an eider, the female more like a scoter or Old-squaw." The possibility that the eiders (*Somateria* and *Polysticta*) do not belong in Delacour and Mayr's tribe Mergini (Humphrey, in press) leads us to wonder whether the eiders or the scoters are the closest relatives of the Labrador duck.

Realizing that a great deal could be learned about the osteology and other aspects of the anatomy of the Labrador duck by dismantling a study skin of the species, we discussed the problem with Dr. Herbert Friedmann, curator of birds, United States National Museum, who agreed to lend us a specimen of a male with the understanding that we reassemble the specimen after having removed its skeletal elements. Our original purpose was to describe as much as possible of the pterylosis and osteology of the specimen. However, we found on removing the limb bones that their distal musculature is well enough preserved to warrant description. We plan to describe the myology and detailed osteology of the appendages in a separate publication.

ACKNOWLEDGMENTS

It would have been impossible for us to undertake our study of the Labrador duck without the specimen lent to us by the U. S. National Museum through the courtesy of Dr. Herbert Friedmann. We are very grateful to him for allowing us to study this specimen and for giving us helpful advice at the inception of our project. We are also grateful to Dr. Hugh B. Cott, Museum of the University of Cambridge, England, for lending us the only known sternum, coracoids, and furcula. These elements will be described in a future publication on the osteology and myology of the Labrador duck. Dr. Robert R. Miller gave generously of his time, taking several X-rays, without which our study would have been very much more difficult. William L. Brudon exposed and processed all photographs of the specimen. The late Dr. Josselyn Van Tyne gave us much helpful advice and allowed us full use of the facilities of the bird division, University of Michigan Museum of Zoology. We are grateful to Peter Stettenheim, Richard L. Zusi, and Dr. Robert W. Storer for advice and assistance.

Humphrey's part of this study was supported by the National Science Foundation as part of a project on the anatomy of the trachea of ducks and the classification of that group.

SPECIMENS

Study skin.—The specimen lent us by Dr. Friedmann is a male in adult plumage and bears U. S. National Museum catalog number 1972. This specimen is one of a pair presented by S. F. Baird to the Museum. According to Baird (1860, p. 804), the data for this specimen are as follows: "Locality:—North Atlantic . . . Whence obtained:—S. F. Baird . . . Collected by:—J. J. Audubon." In 1846 Audubon gave Baird a pair of Labrador ducks, one of which is

U.S.N.M. No. 1972 (Phillips, 1926, p. 61). There is some question as to the origin of the pair of birds Audubon gave Baird. Audubon (1843, p. 329) says: "The Honorable Daniel Webster of Boston sent me a fine pair killed by himself, on the Vineyard Islands, on the coast of Massachusetts, from which I made the drawing for the plate before you." That these birds may have been the ones given by Audubon to Baird is suggested by Ridgway's statement (*in* Dutcher, 1891, p. 210) that "there were two specimens (male and female) . . . in Professor Baird's private collection. . . . They are the pair figured and described by Audubon, and given by him to Professor Baird." How did Ridgway know that these two birds were in fact the ones figured by Audubon? Phillips (1926, p. 61) has the following to say in his list of specimens in the U. S. National Museum: "1 male adult, No. 1972, skin from Baird's collection, given to him by Audubon, figured by Audubon in his plate of the species. Is this one of a pair presented to Audubon by Daniel Webster who shot them 'on the Vineyard Islands'?" There seems to be no proof that the two Baird specimens are the ones described and illustrated by Audubon, although it seems likely that this was the case. If so, we have Audubon's word that the two birds were collected by Daniel Webster.

Sternum, coracoids, and furcula.—Through the courtesy of Dr. Hugh B. Cott, the only known sternum, coracoids, and furcula of a Labrador duck were lent to us by the Museum of the University of Cambridge, England. These elements are wired together in their proper articulated relationship and mounted on a stand. According to Rowley (1877, p. 214), they were "part of the large collection made by Messrs. Alfred and Edward Newton, now in the Museum of the University of Cambridge." Alfred Newton (1896, p. 222) states that the specimen from which these bones were taken "was killed by Col. Wedderburn in Halifax harbour in the autumn of 1852. . . . The skin of this example is in Canon Tristram's collection, its sternum, which was figured by Rowley . . . , is in the Cambridge Museum." Phillips (1926, p. 62), listing the material in Colonel Wedderburn's collection, mentions "1 male shot by him in Halifax Harbor; sternum in Cambridge Museum."

METHODS

Before beginning to dismantle the study skin of the Labrador duck, we made a series of X-rays, photographs, and measurements of it. All such records of the specimen are on file at the U. S. National Museum. The X-rays were particularly useful, for with their help we were able to learn what bones were present in the study skin before attempting to remove them. The photographs, each showing a millimeter rule in the picture, serve as a permanent record of the original condition of the specimen.

The following X-rays were made of the study skin:

1. View of body of specimen, showing wings, feet, and tail. (Hard ray.)
2. Lateral view of head. (Hard ray.)
3. Ventral view of head. (Hard ray.)
4. Right wing (prior to removal of bones); under surface of wing closest to film. (Soft ray; exposure 12 minutes.)
5. Left wing (prior to removal of bones); upper surface of wing closest to film. (Soft ray; exposure 12 minutes.)
6. Right wing (prior to removal of bones); upper surface of wing closest to film. (Hard ray.)
7. Left wing (prior to removal of bones); upper surface of wing closest to film. (Hard ray.)
8. Right wing (prior to removal of bones); under surface of wing closest to film. (Hard ray.)
9. Left wing (prior to removal of bones); under surface of wing closest to film. (Hard ray.)
10. Right wing (after removal of bones); under surface of wing closest to film. (Soft ray; exposure 12 minutes.)
11. View of spinal tract of opened skin; feathered surface of skin closest to film. (Soft ray; exposure $3\frac{1}{2}$ minutes at a distance of 20 inches.)

Measurements of the specimen prior to removal of any bones are as follows: Right wing, chord, 220 mm.; left wing, chord, 220 mm.; tail, 78 mm.

Butsch took care of all the dismantling and relaxing operations on the specimen. He began by removing the wings and legs. Each appendage was dealt with individually, and work on each was largely completed before beginning on the next. Relaxing a leg or a wing in a box of damp sand took a day or so; removing the bones from an appendage and taking care that they remained articulated and that none of the musculature was damaged generally took the better part of a day. Before beginning work on the wings, Butsch drew a detailed plan of the spread wing, using the unrelaxed folded wing as a model. This basic drawing of the spread wing was later modified when we completed our study of the pterylosis of the wing from the relaxed specimen. When study of the wings and legs was completed, Butsch relaxed the body of the specimen and opened the midventral incision. This incision was extended a slight distance anteriorly to facilitate taking an X-ray ("soft ray"; see Robert R. Miller, 1957) of the spinal tract of the opened skin. We did not, however, extend the incision far enough anteriorly to allow us to include all the spinal apterium in the X-ray. The skin of the neck was not opened, nor was what remained of the skull disturbed. The only skeletal elements remaining in the specimen are the incomplete skull, the pygostyle, and the ungual phalanges of the feet.

When examination of the dismantled specimen was completed, Butsch replaced the bones with wire, tow, etc., and put the specimen back together again. This took several days.

Before we began our study, this specimen was in rather poor condition. The neck was weak and had a large tear in it from which cotton protruded; there was a transverse break in the skin of the belly near the tail. Most of the exposed plumage that should have been white was gray with dirt.

The completed specimen is considerably improved in appearance, parts of it having been washed and degreased; it is also substantially more durable. Plate 1, figures 1 and 2, are photographs of the specimen before work was begun on it; plate 2, figures 1 and 2, are photographs of the same specimen after dismantling, removal of the limb bones, and reassembling of the parts.

PTERYLOSIS

In studying the pterylosis of the Labrador duck we depended not only on several careful examinations of the specimen but also on X-rays (both "soft" and "hard") of the wings (with and without bones) and of the spinal and other tracts. All drawings have been critically compared to the specimen many times.

We have followed Compton (1938) in naming the various feather tracts and their regions. We have followed Howard (1929) in naming bones and parts of bones. To avoid confusion we have retained the older nomenclature of the digits of the wing (digits I, II, and III, digit I being the pollex and bearing the alula) instead of following Montagna (1945).

ALAR TRACT

Primaries.—There are 11 primaries, of which the eleventh (the distalmost) is very much reduced. Primaries 1 through 5 cross the intermetacarpal space and are attached to metacarpal II; primary 6 is also attached to metacarpal II but passes distal to the intermetacarpal space. Primary 7 is attached to digit III. Primaries 8 and 9 are attached to phalanx 1 (proximal) of digit II; primary 10 is attached to phalanx 2 of digit II; primary 11 (reduced) is attached to the minute phalanx 3 of digit II.

Primary 11 of each wing became detached during the skinning process. The measurements of the right eleventh primary are as follows: Total length (i.e., shaft length), 29.8 mm.; calamus length, 5.8 mm.; rhachis length, 24.0 mm.; greatest width, 3.9 mm. The eleventh primary is slightly shorter than its greater upper primary covert.

The distal end of the inner vane of primary 10 is incised for approximately 45 mm.; the outer vane is not incised. The distal end

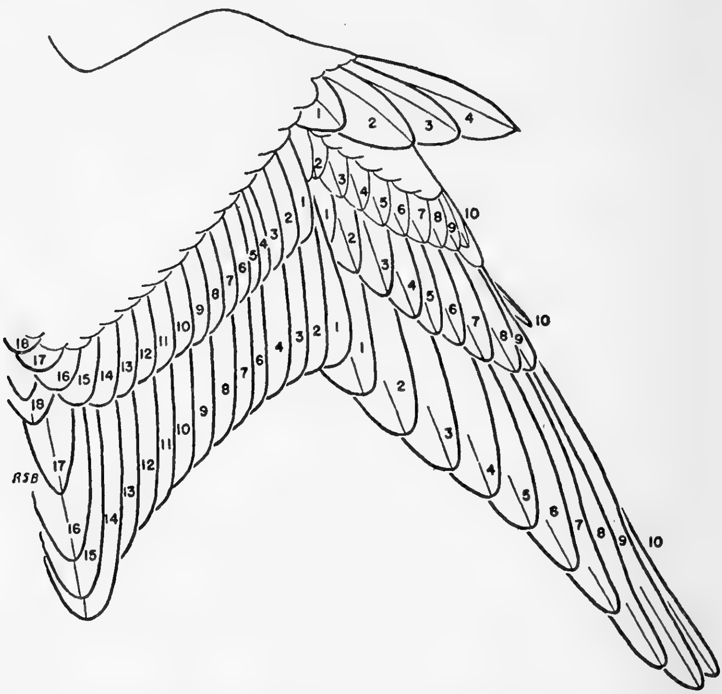
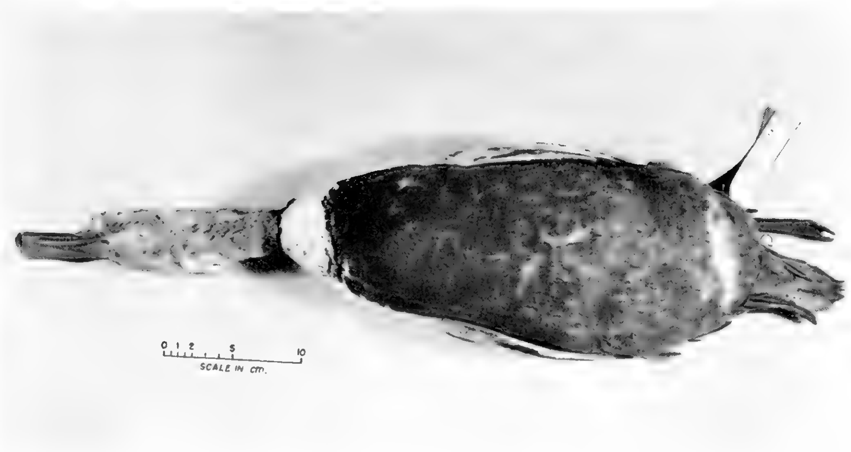


FIG. 1.—Diagram showing arrangement of feathers on dorsal surface of wing of male. (Compare with wing on plate 3. The same base drawing was used for both figures.)

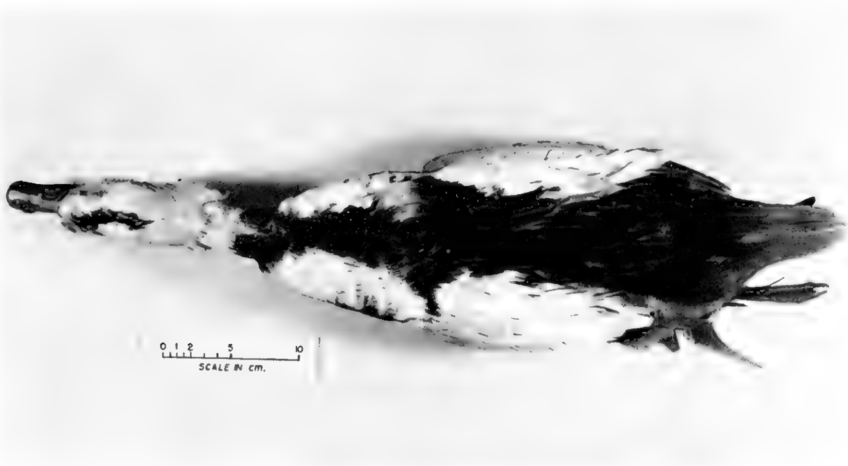
of the inner vane of primary 9 is also incised for approximately 45 mm. but less deeply than in primary 10. The outer vane of primary 9 is incised for approximately 45 mm. The outer vane of primary 8 is incised but less deeply than in the ninth primary.

The primaries, arranged in order of decreasing length are: 9-10-8-7 (right wing); 9-10(equal)-8-7(left wing).

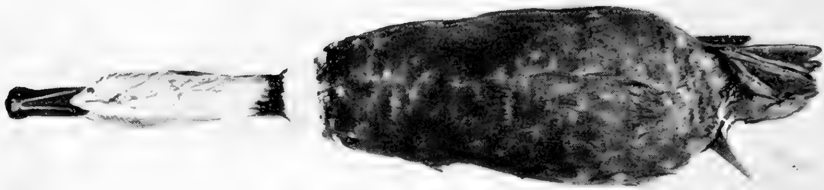
Primary coverts.—There are 10 greater upper primary coverts of which the tenth (distalmost) is quite reduced (see pl. 3, and fig. 1) and the ninth is slightly reduced. Greater upper primary coverts 1 and 2 have pale markings on outer webs.



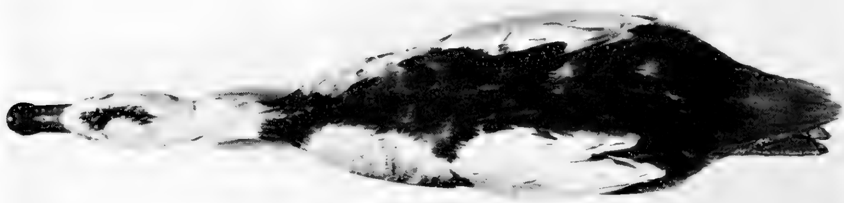
1. Ventral view of study skin of male Labrador duck, *Camptorhynchus labradorius*, in its original condition. (U.S.N.M. No. 1972.)



2. Dorsal view of study skin of male in its original condition.



1. Ventral view of study skin of male after removal of limb bones.



2. Dorsal view of study skin of male after removal of limb bones.

There are 10 middle upper primary coverts of which the tenth (distalmost) is slightly reduced and the first is greatly reduced. Middle upper primary coverts 9 and 10 are dark colored and lack the white edging present on the others.

There are 11 greater under primary coverts of which the eleventh (distalmost) is quite reduced and the tenth is slightly reduced (see pl. 4 and fig. 2).

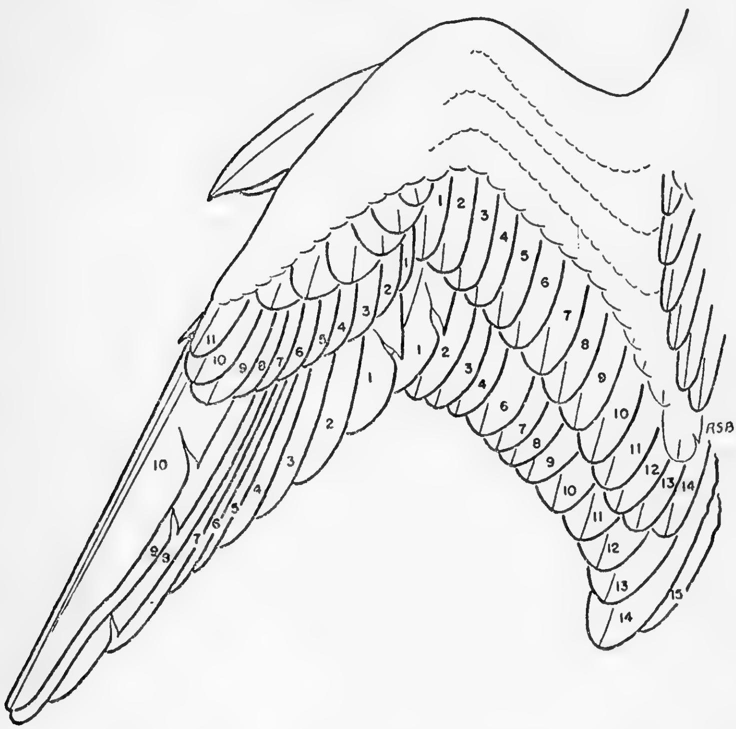


FIG. 2.—Diagram showing arrangement of feathers on ventral surface of wing of male. (Compare with wing on plate 4. The same base drawing was used for both figures.)

Secondaries.—We have been unable to discover any satisfactory definition for the proximal limit of the secondaries in Anseres. All feathers forming a continuation of the secondary series in the region of the elbow were counted as secondaries even though they have no direct connection with the ulna. We do not recognize the terms "tertial" or "tertiary."

There are 17 secondaries. The Labrador duck is diastataxic—that is, lacks the fifth secondary. In numbering the secondaries, *we have* *assigned a number* (5) *to the missing fifth secondary.* Secondaries 12 through 16 are elongate and secondaries 17 and 18 are shorter than secondaries 1 through 11. The secondaries, arranged in order of decreasing length are: 14-15-13-16-12-11-1(11 through 1 equal in length)-17-18.

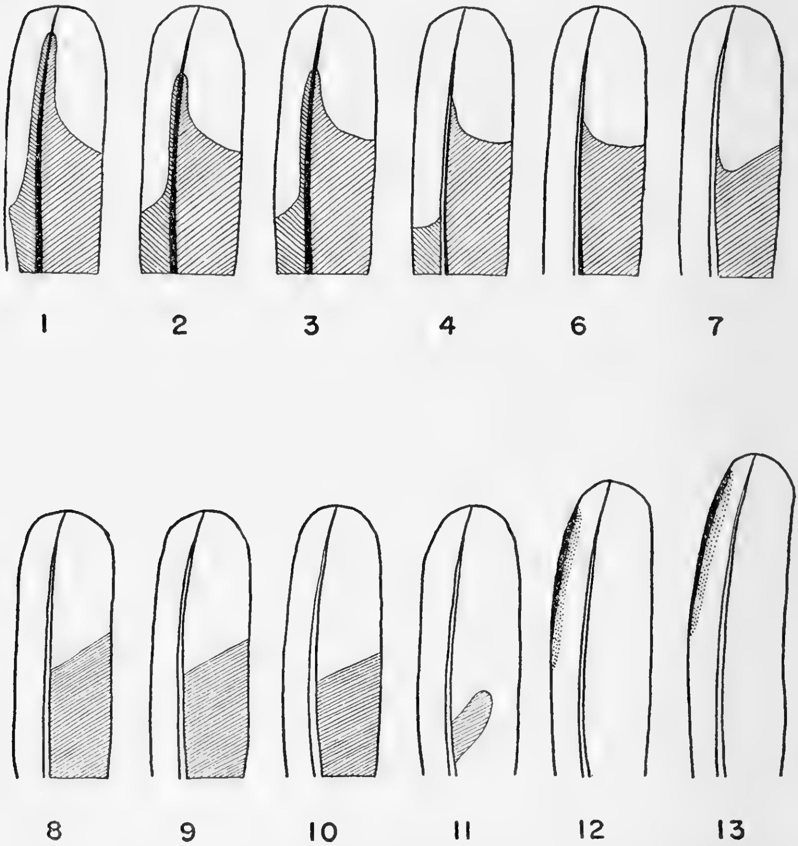


FIG. 3.—Dorsal view of secondaries 1 through 13 from the right wing of male. The missing fifth secondary (the Labrador duck is diastataxic) was assigned the number 5.

In order adequately to describe the distribution of pattern and texture on the dorsal surface of each of the secondaries, these feathers are described individually in the following. Secondaries 1 (distal) through 11 (proximal) lack markings on the distal margins of the inner and outer webs. The outer web of secondary 11 has a slightly velvety texture.

The pattern in the medial and proximal parts of each of secondaries 1 through 11 is best shown in a diagram (see fig. 3).

Secondaries 12 through 14 have pearly-gray and black edgings on the distal margin of the outer web (see pl. 3). Secondary 12: distal half of outer web velvety; distal third of inner web near shaft velvety. Secondary 13: distal two-thirds of outer web velvety; distal third of inner web velvety although velvety structure does not run to margin of the web. Secondary 14: distal two-thirds of outer web velvety; distal half of inner web velvety although the velvety texture does not extend to the margin of the web except at the distal quarter of the feather; there is a narrow black margin on the distal sixth of the inner web. Secondary 15: distal two-thirds of outer web velvety; distal half of inner web velvety. The whole margin of the inner web is soft gray; this gray margin decreases in width toward the distal end of the feather and is darkest (almost black) at the distal end of the feather. Secondary 16: distal half of outer web velvety; distal quarter of inner web velvety. Secondary 17: distal third of outer web velvety; distal eighth of inner web velvety. Secondary 18: not at all velvety.

Secondary coverts.—There are 18 greater upper secondary coverts of which numbers 17 and 18 are very much shorter than the others.

There are 17 greater under secondary coverts. Numbers 1 through 13 have brownish-gray tips; numbers 1 through 7 have only a narrow margin of brownish gray at the tip; from 8 through 13 this apical mark increases in size. The proximal four greater under secondary coverts (numbers 14 through 17) are entirely dark in color and show no pattern; all four of these feathers are reduced in size—17 the most, 14 the least.

Alula and claw.—The alula has four quills; the distalmost one became detached during skinning. There is a very small element at the distal end of digit I; this may be a much-reduced claw.

Carpal remex.—The carpal remex, carpal covert, and middle carpal covert present.

SPINAL TRACT

Our study of the pterylosis of the trunk of the Labrador duck was necessarily limited because of the inadvisability of using the more usual method of clipping the feathers. Nor was it possible to make a careful examination of the interior of the skin. The fragility of the skin and the accumulation of fat obscuring many of the feather bases made it inadvisable to conduct a prolonged examination which might damage the specimen.

The following description of the pterylosis of the trunk is based entirely on an X-ray ("soft ray") of the opened skin. A contact print of the X-ray was made and the feather tracts were traced from the print. Insofar as possible, the feather tracts were drawn feather by feather. Because certain feather areas were difficult to interpret from the X-ray, and because we could not compare our drawing with the specimen itself, we cannot be sure that the drawing is entirely

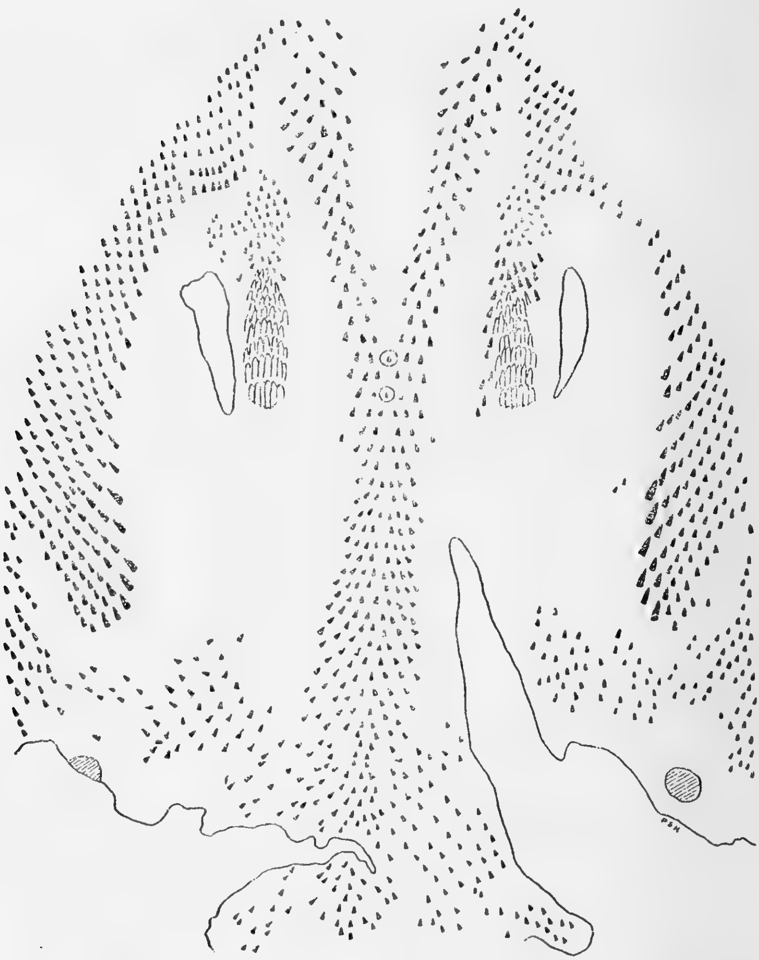


FIG. 4.—Pterylosis of trunk of male. This diagram was traced from the positive print shown on plate 5. For the nomenclature of the feather tracts and their regions, see text figure 5 (opposite) and the text.

accurate. This is the case for the humeral tract and for the enlarged feathers (flank feathers) at the dorsocaudal margins of the sternal regions of the ventral tract. The loss of feathers from certain areas of the skin is another possible source of error. There seem to be feathers missing from the area of the junction of the humeral tract (right side) and the ventral cervical and sternal regions of the ventral tract. There are probably some feathers missing from the posterior part of the pelvic region of the spinal tract, and from the femoral tracts.

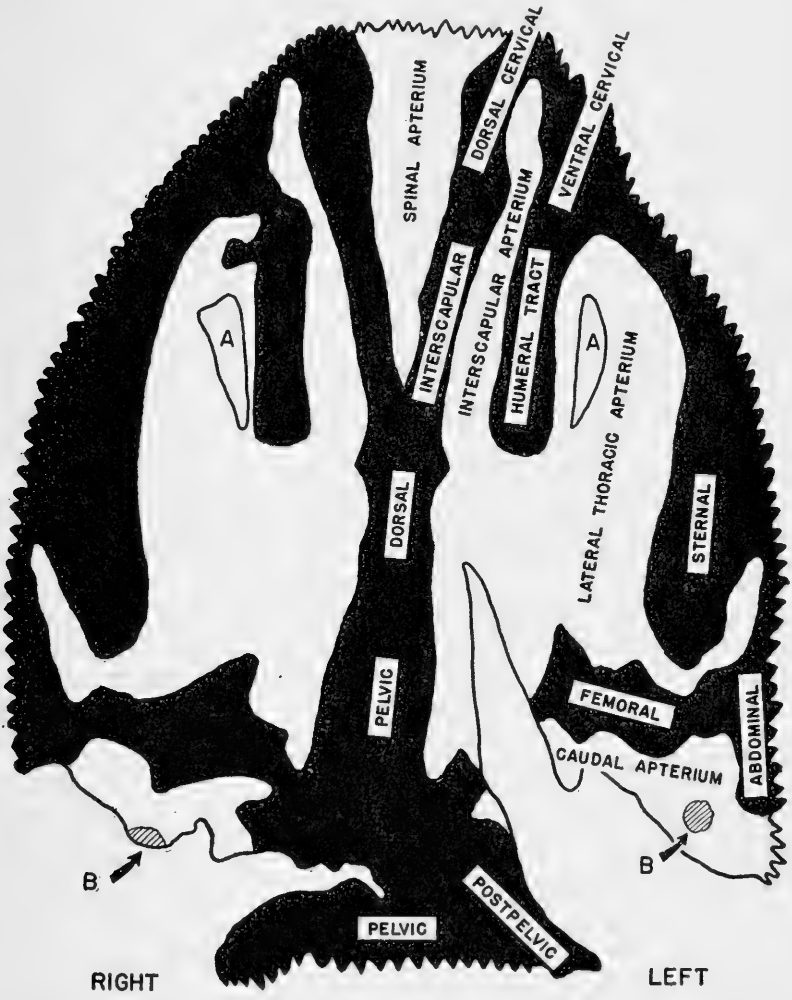


Fig. 5.—Nomenclature of the feather tracts (and their regions) of the trunk of the male. Feathered areas are shown in black. The feathered areas outlined with a scalloped margin extend beyond the limits of the diagram. The letter "A" marks the holes cut in the skin when the wings were removed. The letter "B" marks the locations of the legs. (Compare with plate 5 and text figure 4.)

Plate 5 and figures 4 and 5 illustrate as much of the skin as could be studied. The feather tracts outlined with a scalloped margin (see fig. 5) extend beyond the limits of the diagram. The wings and legs of the specimen were removed before the X-ray was taken. The letter "A" on figure 5 marks the holes cut in the skin when the wings were removed. The letter "B" marks the locations of the legs.

Because there seem to be no natural boundaries between most of the feather tracts (or their regions) on the trunk of the Labrador duck, we have avoided drawing any arbitrary divisions between them. We were unable to delimit the following regions illustrated by Compton (1938, pp. 182, 190): Lateral scapular and lateral pelvic regions of the spinal tract; axillar and subaxillar regions of the ventral tract. We are not sure that what we have designated the "postpelvic region" of the Labrador duck corresponds to Compton's term.

The posterior margin of the pelvic region shown in plate 5 and figures 4 and 5 is slightly anterior to the uropygial gland.

Compton (1938, pp. 182-183) divides the spinal tract into six regions: (1) Dorsal cervical, (2) interscapular, (3) lateral scapular, (4) dorsal, (5) pelvic, and (6) lateral pelvic. Compton includes the postpelvic region in the caudal tract.

We judge that our figures (pl. 5 and figures 4 and 5) show the posterior ends of the paired dorsal cervical regions. There is no perceptible division between the posterior end of the dorsal cervical region of each side and the anterior margin of the corresponding interscapular region. The dorsal cervical regions are each bounded laterally by an interscapular apterium and medially by the unpaired spinal apterium. We do not know how far anteriorly the spinal apterium extends. This should be determined on another specimen as the extent of the spinal apterium is a matter of considerable interest. The spinal apterium terminates posteriorly at the posterior junction of the interscapular regions. The interscapular regions join at a median, unpaired feather (anteriormost encircled feather on fig. 4). From the median unpaired feather caudad, the interscapular region is a single median region. Two rows posterior to the median unpaired feather which forms the caudal limit of the spinal apterium there is a second median unpaired feather. The dorsal region continues caudally from the interscapular region without any break. Nor is there any perceptible break between the dorsal region and the pelvic region. The spinal tract anterior to its junction with the paired femoral tracts forms a continuous Y-shaped area of feathers. Posterior to its junction with the femoral tracts, the pelvic region becomes considerably broader and terminates caudolaterally on each side in the so-called postpelvic regions which may or may not be distinct from the median posterior part of the pelvic region. We have no way of knowing how many feathers are missing from this part of the specimen.

HUMERAL TRACT

The paired humeral tracts (comprising the scapulars) are each bounded laterally and caudally by a lateral thoracic apterium. Medially each is bounded by an interscapular apterium. Anteriorly each humeral tract merges with a dorsal spur of the ventral cervical region of the ventral tract and with the anterodorsal extremity of the sternal region. Drawing boundary lines in this area of junction seems to us an arbitrary matter; we therefore refrained from doing so.

We are vague about the arrangement and number of feathers in the humeral tract. There was so much overlap of the calami of the large feathers that the X-ray did not give a clear picture. We did not feel justified in risking damage to the specimen to obtain a more accurate idea of the disposition of the scapular feathers.

FEMORAL TRACT

The paired femoral tracts join the pelvic region medially and extend laterally and ventrally to merge with the corresponding abdominal region of the ventral tract. The femoral tract is bounded anteriorly by a lateral thoracic apterium and posteriorly by a caudal apterium. Near the junction with the abdominal region, the femoral tract becomes very narrow. This narrow area in each femoral tract lies anterior to the place on the skin where the leg was located.

VENTRAL TRACT

Compton (1938, pp. 189-191) divides the ventral tract into five regions: (1) Ventral cervical, (2) sternal, (3) axillar, (4) subaxillar, and (5) abdominal. Our figures (pl. 5 and figs. 4 and 5) illustrate parts of the ventral cervical, sternal, and abdominal regions. All these regions are paired, the two sides being separated by a narrow, midventral apterium. Because the specimen was prepared by the original collector by making an initial midventral incision, the midventral apterium was obscured. The edges of the incision were puckered and drawn together so much anteriorly that a midventral apterium could not be distinguished in that area. The midventral apterium was present between the abdominal regions but its width and posterior extent could not be determined.

The paired ventral cervical regions each merged posteriorly with the corresponding sternal region. At this area of junction a spur arises and extends dorsally and posteriorly to join with the dorsally located humeral tracts. The ventral cervical and dorsal cervical regions merge on the lateral surfaces of the base of the neck and presumably extend anteriorly uninterrupted.

The paired sternal regions extend from the ventral cervical region caudad over the breast to merge posteriorly with the corresponding abdominal regions. The lateral and posterior end of each sternal region is a lobe-shaped area of feathers bounded by the lateral thoracic apterium dorsally, and by a narrow extension of the lateral thoracic apterium caudally and ventrally. The posterior, dorsolateral rows of feathers of the sternal region are the large flank feathers.

CAUDAL TRACT

Compton (1938, p. 197) includes the following in the caudal tract: (1) Rectrices, (2) upper tail coverts, (3) under tail coverts, (4) postpelvic region, (5) tuft and covering of the uropygial gland, (6) postventral region, and (7) anal circlet.

This specimen of the Labrador duck has 14 rectrices. The tail is graduated, the paired "deck" feathers being the longest (79 mm.) and the lateralmost rectrices the shortest (59 mm.). DeKay (1844, p. 326) lists 16 rectrices for the Labrador duck.

We counted 14 greater under tail coverts; however, we are not certain of this count. We could not distinguish satisfactorily between lateral greater under tail coverts and feathers which were not greater under tail coverts.

There are seven upper tail coverts on the left side and six upper tail coverts on the right side of this specimen. Counting the medial pair of upper tail coverts as 1, right upper tail covert number 3 is missing. Anterior to the V-shaped row of upper tail coverts there is a V-shaped row of short, stiff feathers. This area consists of three or four rows of feathers. At the apex of the V these feathers are short (12 mm.) and somewhat downlike (although the rhachis is very stiff); they increase in length (the longest was 25 mm.) and become less downlike toward the anterolateral extremities of the V. The barbs of these feathers do not adhere to one another. The uropygial gland is bounded caudally and caudolaterally by the arms of this V-shaped area of feathers.

When this specimen was originally prepared, most of the uropygial gland was removed from the inner surface of the skin and the base of the tail. The posterior end of the gland (papilla) and the superficial covering of the gland were left untouched by the original preparator. We removed what remained of the uropygial gland and its dermal covering. This part of the specimen has been preserved

Right dorsolateral view of male; dorsal view of head. (Compare wing with text figure 1.)

Right ventrolateral view of male; ventral view of head. (Compare wing with text figure 2.)

in alcohol. The uropygial gland is tufted (as in other Anseres) and anterior to the papilla is covered with feathers. The tuft on the papilla of the uropygial gland is tawny in color and consists of 36 smaller tufts which are oriented in a definite pattern on the posterior surface of the papilla (see figs. 6 and 7). The papilla anterior to the

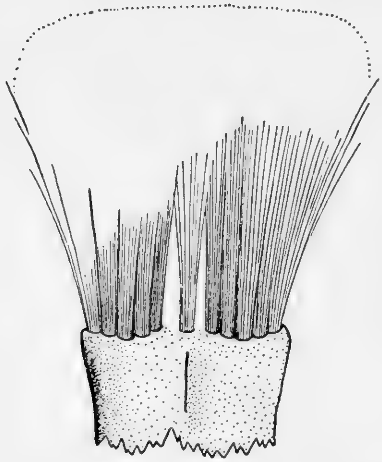


FIG. 6.—Dorsal view of papilla of uropygial gland of male.

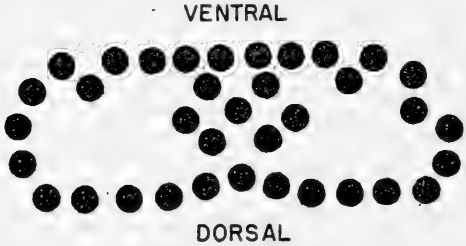


FIG. 7.—Diagram showing distribution of feather tufts on posterior surface of papilla of uropygial gland of male.

tuft is naked. We could not determine how many orifices there are in the papilla of the uropygial gland. There is a median sagittal groove on the dorsal surface of the papilla (see fig. 6).

The postpelvic region of the caudal tract has been discussed elsewhere (see section on spinal tract). Because of the condition of the skin we were unable to distinguish the postventral region of the caudal tract or an anal circlet.

CAPITAL TRACT

Compton (1938, p. 177) has divided the capital tract into 11 areas. Because the head of the Labrador duck (and other Anatidae) appears to be covered uniformly with feathers it seems to us pointless in this case to attempt to subdivide arbitrarily the capital tract into the areas described by Compton.

The patch of modified feathers on the cheek of the male (see pls. 3 and 4) is the only noteworthy feature of the capital tract of the Labrador duck. Rowley (1877, pp. 216-217) felt that this patch of modified feathers was decisive evidence that the Labrador duck is related to the eiders. Rowley states that "there is one point of resemblance, however, which (though a superficial one), in the absence of the bird in the flesh, decided me. It is the presence in the male Pied Duck of those stiff and glistening feathers in the head, which (so far as I have been able to discover), among Ducks, belong to the Eiders alone . . ."

Wilson and Bonaparte (1878, p. 126), describing an adult male Labrador duck, say: "The plumage of the cheeks is of a peculiar bristly nature at the points . . . In young birds, the whole of the white plumage is generally strongly tinged with a yellowish cream color; in old males these parts are pure white, with the exception of the bristly pointed plumage of the cheeks, which retains its cream tint the longest . . ." Audubon (1843, p. 330) described the feathers "on the lower part of the cheeks" as being "very stiff, having the terminal filaments more or less united into a horney plate."

BILL

Audubon (1843, p. 330) described the bill of an adult male Labrador duck as follows:

> Bill nearly as long as the head, rather broader at the base, the sides nearly parallel, but at the end enlarged by soft membranous expansions to the upper mandible. The latter has the dorsal outline at first straight and declinate, then direct and slightly convex, at the extremity decurved; the ridge broad at the base, convex toward the end; the side sloping at the base, then convex, the extremity broad and rounded, the unguis broadly obovate; the margins soft, expanded toward the end, and with about 50 lamellae, of which the anterior are inconspicuous. Nasal groove oblong, nostrils linear-oblong, sub-basal near the ridge. Lower mandible flattened, curved upwards, with the angle very long and narrow, the dorsal line very short, and nearly straight, the nearly erect edges with about 30 large and prominent lamellae; the unguis very broad.

Wilson (Wilson and Bonaparte, 1878, p. 126), discussing the bill of a male, says that "towards the extremity it widens a little in the manner of the Shovellers, the sides there having the singularity of being only a soft, loose, pendulous skin . . . the edges of both mandibles are largely pectinated."

The lamellae on the lower mandible are large as Audubon has pointed out; most of them are much larger than those of the upper mandible. The anterior 12 lamellae project about 2 mm. laterally from the rami; they become progressively smaller posteriorly. The posteriormost five or six lamellae project less than 1 mm. from the rami. The largest lamella in the upper mandible projects 1.3 mm. anteromesially; counting from anterior to posterior, lamellae 8 through 12 project 1.2 to 1.3 mm. from the mesial surface of the upper bill. The anteriormost four lamellae are little more than wrinkles in the ramphotheca; lamellae 13 through 23 become progressively smaller posteriorly. The upper mandible bears 30 lamellae on the left side and 31 on the right; the lower mandible has 23 lamellae on each side. Audubon must have included both sides in his count of "about 50 lamellae" for the upper mandible.

There is very little information on the food and feeding habits of the Labrador duck. According to Audubon (1843, pp. 329-330) and Wilson (Wilson and Bonaparte, 1878, pp. 126-127), it subsisted on the common mussel, small clams, small shellfish, fry, and various kinds of seaweeds. Audubon (1843, p. 330) said that "it procures its food by diving amidst the rolling surf over sand or mud bars; although at times it comes along the shore, and searches in the manner of the Spoonbill Duck."

We cannot even speculate on the function of the loose flaps of skin on the end of the upper mandible of the Labrador duck. The information on the food habits of the species is so scanty that there is no way of knowing whether it had a highly specialized diet to which its peculiar bill was adapted. Phillips (1926, p. 60), commenting on the extinction of this duck, said: "A far more reasonable view, suggested to me by Mr. Outram Bangs, is to suppose that the Labrador Duck had very specialized food habits and that changes in the molluscan fauna, brought about by increased population along our coast, may have proved disastrous. Such changes in minute shell-fish are known to have taken place."

FEET

Audubon (1843, p. 330), describing the feet of the adult male Labrador duck, said that they were "very short, strong, placed rather far behind; tarsus very short, compressed, with two anterior series of rather small scutella, the sides and back part reticulated with angular scales. Hind toe very small, with a free membrane beneath; outer anterior toes double the length of the tarsus, and nearly equal, the inner much shorter, and with a broad marginal membrane. Claws small, slightly arched, compressed, rather acute."

As Audubon pointed out, the Labrador duck has two rows of rather small scutes on the anterior surface of the tarsometatarsus;

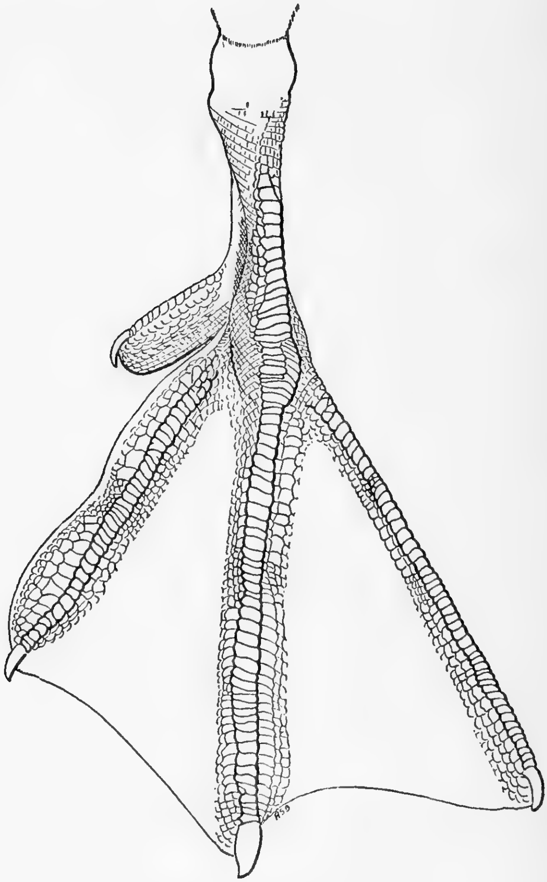


FIG. 8.—Left foot of male.

there are about 14 scutes in the row, of which the row of scutes on digit III forms a continuation. There are about 12 scutes on the lateral row. There is a third row of about 11 small scutes on the medial surface of the tarsometatarsus bordering the medial margin of the row leading to digit III. (See fig. 8.)

Positive print of X-ray ("soft ray") of inner surface of opened skin of male showing feather tracts. (Compare with text figures 4 and 5.)

COLORATION OF SOFT PARTS

There is considerable disagreement in the literature concerning the colors of the soft parts of the adult male Labrador duck. Opinions on this subject are summarized in table 1. Numbers corresponding to parts of the bill are illustrated in figure 9; see also the dorsal view of the head illustrated in plate 3.

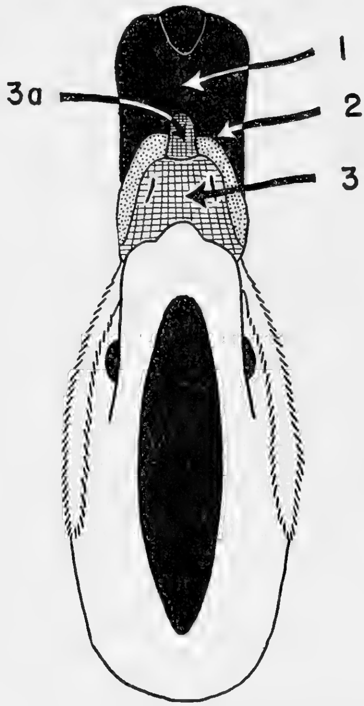


FIG. 9.—Dorsal view of head of male. For explanation see text and table 1.

Study of the upper bill of Labrador duck specimen U.S.N.M. 1972 convinced us that the area marked "3a" in figure 9 could well have been orange in color. We have no evidence on this point except for a slight difference in the appearance of area "3a" suggesting that it might have been differently pigmented than area "3."

TRACHEA

There is no known specimen of the trachea of the Labrador duck. Wilson (1829, p. 370) describes the trachea of the male Labrador duck as follows:

The windpipe of the male measures ten inches in length, and has four enlargements, viz., one immediately below the mouth, and another at the interval

TABLE-I.—*Colors of the soft parts of the adult male Labrador duck* (Camptorhynchus labradorius) *according to various authors*

Numbers corresponding to the parts of the bill are illustrated in figure 9.

	Irides	Tarsus and toes	Web	Bill 1	Bill 2	Bill 3 and 3a
Audubon (1843, p. 331)	Reddish hazel	Light grayish blue	Dusky	Black	Dull pale orange	Pale grayish blue
Fuertes (*in* Phillips, 1926, p. 58)	Reddish hazel	Light grayish blue	Dusky	Black	Dull pale orange	Pale grayish blue
Phillips (1926, p. 57)	Reddish hazel to yellow	?	?	Black to blackish brown	Pale yellow or orange	Pale yellow or orange
Hall (1862, p. 427)	Yellow	Yellow	?	Blackish horn color	Flesh color	Flesh color
Baird (1860, p. 803)	?	?	?	Black	Yellowish	Yellowish
DeKay (1844, p. 326)	Hazel	Light bluish	Darker	Black	Pale orange	Pale orange
Pennant (1792, p. 282)	?	Black	?	?	?	?
Rowley (1877, pl. facing p. 205)	Bright yellowish	Light-yellowish tan	Medium brown	Black	Yellow	Yellow
Wilson (1829, p. 370)	Dark hazel	Pale whitish ash	Black	Black	Pale orange color	Pale orange color

of an inch; it then bends largely down to the breast bone, to which it adheres by two strong muscles, and this has at that place a third expansion. It then becomes flattened, and before it separates into the lungs, has a fourth enlargement much greater than any of the former, which is bony, and round, puffing out from the left side.

Leib (1840, p. 171) says only that "the labyrynth of the male is large."

The tracheas of male white-winged and surf scoters are the only ones having any resemblance to that described by Wilson for the male Labrador duck. Male white-winged and surf scoters are the only species of waterfowl known to have an expansion of the trachea immediately posterior to the larynx. The Labrador duck differs from the scoters in having two midtracheal expansions (the white-winged and surf scoters have but one) in addition to an expansion at either end of the trachea. For figures of the tracheas of scoters see W. deW. Miller (1926, p. 2).

RELATIONSHIPS

We judge that the Labrador duck should be placed in the tribe Mergini along with the scoters, oldsquaw, bufflehead, goldeneyes, and mergansers. The eiders, as Humphrey (in press) has pointed out, are best taken out of the Mergini as originally defined by Delacour and Mayr (1945) and placed either in, or close to, the tribe Anatini. The Labrador duck seems to us most closely allied with the scoters and the oldsquaw. In a linear classification the genera are probably best arranged as follows:

Melanitta
Camptorhynchus
Clangula
Bucephala
Mergus

We have little evidence on which to base our tentative remarks on the relationships of the Labrador duck. Wilson's (1829, p. 370) description of the trachea of a male strongly suggests affinities with the scoters. The plumage patterns of the male and female suggest affinities not only with the scoters but also with the goldeneyes and mergansers. Humphrey (Ph.D. thesis), discussing plumage characters of the scoter–goldeneye–merganser group (Mergini), says that "except for three species (*Oidemia nigra, Melanitta perspicillata,* and *Clangula hyemalis*) both sexes have extensive white on the proximal part of the wing (dorsal surface). This white area always includes most of the secondaries; it may also include most of the greater upper secondary coverts and, in some species, a varying number of the lesser upper secondary coverts." This is not true of the eiders. The Labrador duck shares with most species of the scoter–goldeneye–merganser group the character of a dorsal white patch on the secondaries. This seems to us additional evidence for placing it in the tribe Mergini.

In the hope that we will be able to find more evidence clarifying the relationships of the Labrador duck, we are now engaged in a comparative study of the pterylosis, appendicular myology, and osteology of the Labrador duck, scoters, oldsquaw, and eiders.

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MISCELLANEOUS NOTES ON FOSSIL BIRDS

(With Five Plates)

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MISCELLANEOUS NOTES ON FOSSIL BIRDS

By Alexander Wetmore

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(With Five Plates)

The following observations cover some recent studies. While the separate accounts have no relationship to one another other than that concerned in the general field of paleo-ornithology, it has seemed desirable to present them as sections under one general title, rather than as separate notes published individually.

I. OBSERVATIONS ON THE GENERA OF FOSSIL KITES, WITH DESCRIPTIONS OF TWO ADDITIONAL SPECIES

The first fossil species described as a kitelike hawk from North America was *Proictinia gilmorei* Shufeldt (1913, p. 301) based on a right coracoid from the lower Pliocene of Phillips County, Kans. While the author called it a kite, he was not definite regarding its affinities, as he remarked that "it is not far removed from such genera as *Ibycter* or *Milvus* or *Ictinia*." His uncertainty is evident when it is remembered that his "Ibycter," now a synonym of *Daptrius*, is a species allied to the caracaras in the family Falconidae, while *Milvus* and *Ictinia* are found in the subfamily Milvinae of the family Accipitridae.

The second bird assigned to this general category of fossil hawks was *Proictinia effera* Wetmore (1923, p. 504), named from a tarsometatarsus with associated phalanges from the lower Miocene of the Agate fossil quarry in Sioux County, Nebr. Though my study of Shufeldt's type of *P. gilmorei* in 1923 was sufficient to indicate that it was a species of the Accipitridae, skeletons of enough of the modern species of kites were not available then to give clear understanding of relationships. In view of this I placed *effera* tentatively in Shufeldt's genus *Proictinia*. Recently, when Brodkorb (1956, p. 368) named *Proictinia floridana* on the distal end of a tarsometatarsus from the lower Miocene of Gilchrist County, Fla., he described it also tentatively in *Proictinia* as it is generally similar to *effera*. In the 35 years since 1923 there have been important additions to the collection of skeletons of kites and allied species in the United States National Museum so that now better understanding of their characters is possible. With further fossils in this general area of related species now at hand for description it is desirable to make a detailed examination to determine more definitely the generic relationships of those already named.

The type coracoid of *Proictinia gilmorei* appears most like that of the Everglade Kite *Rostrhamus sociabilis* (Vieillot) among living kinds, differing from that species in the more central position of the tubercle on the dorsal face of the shaft, in a slight thickening of the inner edge of the bone opposite this tubercle, and in being slightly shorter and more robust. Though the distinction between the two is not of great amount, it appears sufficient to maintain *Proictinia* as a valid genus, since the coracoid is an element that shows slight variation in species that are closely related. Through its resemblance to *Rostrhamus* it is therefore to be placed near that genus in the subfamily Milvinae.

Since *Proictinia gilmorei* and *P. effera* are represented by different parts of the skeleton, their relationship may be determined only by analogy. It has been stated above that on the basis of the coracoid *gilmorei* is most like *Rostrhamus sociabilis* among living kites. Comparison of the tarsometatarsus of the fossil *Proictinia effera* with that of living *Rostrhamus* shows that this second fossil differs in form, having the upper end of the outer face of the shaft distinctly narrowed below the head, the lower end of this same surface immediately above the trochlea for digit 4 broader, and the tubercle for insertion of the tibialis anticus slightly more elevated and located relatively nearer the head. In each of these particulars the fossil is nearer the living species of *Milvus*, as represented by *Milvus milvus*, *M. migrans*, and *M. lineatus*. *P. effera* differs from *Milvus* in having the tarsometatarsus relatively slighter throughout, this being especially apparent in the proportions of the head and of the second and third trochleae in comparison to the total length of the bone. The tibialis anticus tubercle also is weaker and is located higher on the shaft, and the attachment for the external ligament is less evident. The fourth trochlea is heavier as it is in *Rostrhamus*.

In view of these comparisons it seems warranted to describe in the subfamily Milvinae as an additional genus—

PROMILIO, new genus

Characters.—Similar to *Milvus* Lacépède, but tarsometatarsus relatively longer and more slender; tubercle for insertion of the tibialis anticus tendon weaker, and located higher on the shaft, toward the head; attachment for the external ligament less evident; fourth trochlea relatively heavier; second and third trochleae weaker; inner ridge on head of hypotarsus relatively longer.

Type.—*Proictinia effera* Wetmore, which becomes *Promilio efferus* (Wetmore).

Proictinia floridana Brodkorb, which differs mainly from the type species in slightly smaller size, and larger distal foramen which opens lower down on the shaft, is also to be referred to this genus, where it will be listed as *Promilio floridanus* (Brodkorb).

Milvus deperditus named by Milne-Edwards (1871, p. 461) from lower Miocene (Aquitanean) deposits at Langy in the Department of Allier, France, according to the original description and figures appears to be a small species of kite. It seems to resemble *Milvus,* the genus in which it was described, in form of shaft, and in form and relatively short length of the inner head of the hypotarsus (or talon). The attachment for the external ligament is less evident, and the articular facet for the first metatarsal apparently is relatively shorter and smaller. It seems to be distinct from *Promilio,* but the type should be examined in detail to determine that it is truly a form of the genus *Milvus.*

The only other fossil genus requiring consideration that has come to my attention is *Thegornis,* in which Ameghino (1895, pp. 598-600) described two species from the Miocene of Patagonia. These are named from the distal ends of two right tarsometatarsi, which in the illustration accompanying the description appear rather similar to one another in outline but differ decidedly in size. Lambrecht (1933, p. 421) listed these two, without special comment, adjacent to *Proictinia,* apparently indicating possible relationship to the Milvinae. Superficially, the larger one, *Thegornis musculosus,* does suggest a kite, but on close comparison with *Milvus* and *Rostrhamus* which are the genera apparently most similar, it is seen that the second trochlea of *musculosus* appears heavier, the base of the shaft relatively more slender, and the trochleae smaller. This indicates placement in another subfamily of the Accipitridae, perhaps in the Circinae. While relationship may be decided finally only by direct examination of the types, it appears definite that the two species of *Thegornis* are not to be included in the Milvinae.

Apparently the Milvinae were as varied in kinds in the latter part of the Tertiary as were the Buteoninae, since following this preliminary discussion I have for description two additional species that are to be named in the genus *Promilio,* as follows:

PROMILIO EPILEUS, new species

Characters.—Femur (pl. 5, fig. 2) similar in size to that of *Milvus lineatus* (J. E. Gray), but head, including the neck, relatively smaller; shaft somewhat more slender; rotular groove narrowed, with the ridges bounding it on either side longer; internal condyle with articular surfaces slightly less swollen, the planes being flattened rather than rounded.

Type.—Museum of Comparative Zoölogy No. 2716, right femur (a section missing from center of shaft), from Lower Miocene, Thomas Farm, 8 miles north of Bell, Gilchrist County, Fla., collected February 1955, by S. J. Olsen.

Measurements.—Transverse diameter of bone through head 15.0, transverse diameter of shaft near center 6.7; transverse breadth of distal end 14.9 mm.

Remarks.—The present species is readily separated from the other kites allocated to this genus by greater size, as it is approximately 50 percent larger than any of them. The missing part of the shaft is that adjacent to the nutrient foramen, the break being slightly more than is indicated by the gap shown in the drawing. The general resemblance to *Milvus,* except in the points noted in the diagnosis, indicates its systematic position in the subfamily Milvinae, where it appears related to others now allocated to *Promilio.*

The name epileus was applied by Pliny to a kind of hawk.

PROMILIO BRODKORBI, new species

Characters.—Tarsometatarsus (pl. 5, fig. 1) similar to that of *Promilio efferus* (Wetmore), but definitely larger, the bone being heavier throughout; intercotylar area of head relatively broader and more prominent; the attachment for the external ligament more prominent, with the upper end of the shaft supporting it more compressed; anterior face of shaft below head decidedly concave.

Type.—Collection of Pierce Brodkorb No. 1775, proximal two-thirds of left tarsometatarsus, from Lower Miocene, Thomas Farm, 8 miles north of Bell, Gilchrist County, Fla.

Measurements.—Transverse breadth of head 11.0; width of outer face of shaft, near center, 6.0; anterior-posterior diameter of head through hypotarsus 9.3 mm.

Remarks.—The present species in size apparently stood more or less midway between *Promilio efferus* and *P. epileus* named above. It is named for Dr. Pierce Brodkorb, in recognition of his contributions to our knowledge of fossil birds, particularly those of Florida.

II. A SPECIMEN OF *BATHORNIS CELERIPES*

Dr. James Bump, Director of the Museum of Geology, South Dakota School of Mines and Technology, has sent me for examination a fossil collected from the base of the Scenic member of the Middle Oligocene, 2 miles east of Scenic, S. Dak., which I have identified as *Bathornis celeripes* Wetmore. The specimen (catalog No. 422) includes a leg nearly complete, except for the femur, and the distal ends of right and left humeri. The tibiotarsus, tarsometatarsus, and phalanges, which were found associated in such a manner that there is no doubt as to their belonging to the same individual, agree definitely with the abundant material of *Bathornis celeripes* from the type locality in the Brule formation of the Upper Oligocene, near Torrington, Wyo. The new material is of especial interest for the presence of tendons from the back of the tarsus, an element infrequently preserved in fossil bird remains. The tendons in this area in the living *Cariama cristata* regularly are calcified so that they appear as firm as the tarsometatarsus with which they are associated. Their preservation in this specimen of *Bathornis* is indication of a similar condition in this genus, confirming still further the supposed relationship of the Bathornithidae with the Cariamidae.

The two fragments of humeri are of equal interest, since they constitute the first representation of this part of the skeleton in any of the four species that have been described in the Bathornithidae. The bones (pl. 4, fig. 2) have the shafts distorted by having been somewhat flattened by pressure, and the right fragment has part of the posterior surface at the articular end missing. The two, however, in combination serve to illustrate this part of the skeleton sufficiently to bear out also the assumptions of relationship of the family with the living Cariamidae of South America.

Allowing for the distortion mentioned, the size of the humeri is approximately that of larger specimens of *Cariama cristata* of the Cariamidae, and the general appearance, particularly the outline, is similar to that species. The ulnar trochlea is about as long as that of *Cariama,* but the bulk is less. The radial trochlea does not appear to differ. These details are shown in the drawings (pl. 4, fig. 2). Aside from this there is little that may be said as to characters because of uncertainties due to distortion. Also because of this distortion it has not seemed desirable to give detailed measurements, as these might be misleading.

The two humeral fragments were found with the leg bones in such a way that they are supposed to have come from the same individual bird. This is indicated also by the size, since they have the dimensions, with due allowance for crushing, to be expected in *Bathornis celeripes*. The species *Bathornis cursor* Wetmore, found associated with *B. celeripes* in the Oligocene deposits at Torrington, has the lower limb bones decidedly larger, so that it would be expected that the wing also would be larger.

The general impression to be derived from these wing bones verifies the earlier idea that *Bathornis* was a cursorial species that retained the power of flight but that it did not regularly utilize this. In this apparently it was like the two living species in the family Cariamidae, *Cariama cristata* and *Chunga burmeisteri*.

The drawings illustrating this note are the last made for me by my friend, the late Sidney Prentice.

III. THE CANADA GOOSE IN THE PLEISTOCENE OF MINNESOTA

The Canada Goose, *Branta canadensis* (Linnaeus), distributed across the continent in the present day, seems to have had equally wide range for a long period of time, since its bones have been reported from Pleistocene deposits in Oregon, California (including offshore Santa Rosa Island), and Florida, and from beds of supposed Pleistocene age in Nevada. As an additional, interior, link between the western and the southeastern localities it is of interest to report the occurrence of the species at St. Paul, Minn. The record is based on the distal end of a right ulna, sent to me for identification by Scott K. Wright of that city. Mr. Wright reports that the bone was found at the bottom of a large trench dug by the City Water Department in an ancient peat bog. Bones of the Pleistocene *Bison occidentalis* came from the same trench, though it is noted that there were also other remains identified as the modern *Bison bison*. While the goose bone was not encountered in place, having been found, as stated, in the bottom of the trench, Mr. Wright believes it to be of Pleistocene age. This conclusion is substantiated by the condition of the bone, which has lost all free animal matter, in addition to having the dark brown discoloration usual to specimens found in peat deposits. The occurrence of *Bison bison* should not preclude a late Pleistocene age so that it appears proper to record the occurrence as Pleistocene.

IV. THE IDENTITY OF THE PLEISTOCENE CRANE *GRUS PROAVUS* MARSH

Grus proavus was named by Marsh (1872, p. 261) from "Post-pliocene deposits of Monmouth County, New Jersey," on the basis of "a nearly perfect sternum, a femur, and a few other less important remains, which are probably all parts of the same skeleton." The brief original description has been the only source of information on this fossil bird to date, since while the type material was listed as "in the collections of the Yale Museum," subsequently it could not be found in the Peabody Museum of that institution. In fact, it was recorded by Shufeldt (1915, pp. 65, 77) as apparently lost.

It appears that Marsh was in error in ascribing the specimens to "the Yale Museum," since William F. Rapp, Jr. (1944, p. 218) found in the paleontological collections at Princeton University an avian sternum marked *"Grus proavus,"* which was appropriate in size to match Marsh's description. Subsequently, a femur came to light that also matched Marsh's description, so that Dr. Glenn L. Jepsen reached the definite conclusion that these two bones were the important parts of the original type material. More recently Dr. Donald Baird has confirmed this belief, a decision in which I am fully in accord. When Dr. Baird mentioned the matter to me recently I asked to see the bones, a privilege that Dr. Jepsen has kindly accorded me. The two specimens are illustrated, natural size, in the accompanying plates.

The sternum, now Princeton University Department of Geology No. 16258, bears the ancient marking printed in ink *"Grus proavus* N.J." While Marsh noted it as "a nearly perfect sternum" the bone has suffered somewhat with the passage of years as the posterior end and much of the keel are missing, and part of what remains has been broken and repaired. It is fortunate that the main portion, including the anterior end, is intact as this part furnished the dimensions published in the original description. Marsh gives these as follows:

Width of sternum between outer ends of coracoid grooves....	45 mm.
Width of sternum at middle..................................	39
Distance between coracoid grooves...........................	5

These sizes check exactly in the specimen at hand. The color of the bone is dull earthy brown. While it is not mineralized there is no indication of organic material other than the bony structure itself. Though much of the keel is missing, the basal part of the anterior cavity that originally held the tracheal loop is intact, except for a small irregular hole in the bottom, as are the costal margins, and the anterior end, barring a few minor breaks. Apparently the specimen was never washed, as a few flakes of somewhat sandy soil, blackish in color, still cling closely to irregularities on the under surface at the anterior end.

Marsh's statement as to the characters by which the sternum may be separated from that of the living sandhill crane does not hold. He wrote that his specimen differs "in not having the grooves for the coracoids meet on the median line. They are in fact separated from each other by a space nearly equal to the width of the adjacent groove. The sternum is, moreover, less constricted near the middle than in *G. canadensis*." Actually, the variation in four sterna of living *Grus canadensis* of the larger subspecies (two of which are certainly subspecies *tabida* while the third, without locality, is assumed to be the same) covers completely the form found in the fossil.

The femur, catalog No. 16528-A, is lettered "N.J." in the same hand as the sternum. This bone lacks the anterior articular head and neck with adjacent parts, but is otherwise complete. The texture of the bone is like that of the sternum, while the color is lighter brown. Marsh, in the original description wrote, "The femur differs from the corresponding bone in that species [i.e., *Grus canadensis*] mainly in having the shaft less curved: in other respects the resemblance is close." He gave the following measurements:

Length (approximate) of femur	126 mm.
Transverse diameter of shaft at middle	12.5
Transverse diameter of distal end	26

Here, also, the measurements are so exactly identical as to leave no question but that this bone is the actual one that Marsh had in hand. On careful comparison with the corresponding femora of three of the modern skeletons listed above, it is found again that the rather slight amount of individual variation, including the curvature of the shaft, covers the characters found in the fossil.

There is no hesitation, therefore, in assigning *Grus proavus* Marsh as a synonym of the sandhill crane *Grus canadensis* (Linnaeus), with the observation that the fossil belongs in the category of the larger subspecies, e.g., *Grus canadensis tabida* Peters, whose modern range has reached, casually at least, to New England, eastern New York, and the District of Columbia. Monmouth County, in east-central New Jersey, is to be added to the Pleistocene range of *Grus canadensis.*

V. PLEISTOCENE BIRD RECORDS FROM ONTARIO

Bones of birds from deposits of Pleistocene age have been found in abundance at several localities in the United States, but until now none has been reported from Canada. Recently Dr. Hugh R. Thompson of the Department of Geography at Hamilton College, McMaster University, has placed in my hands a small collection secured near Hamilton, Ontario, from a find made early in 1955 by J. N. Weber (1955, p. 2) during an investigation of rock shelters in the Hamilton area.

The bones were obtained in two small caves, located 6 feet apart, and were collected through the efforts of Dr. Thompson and his colleagues, Dr. D. M. Davies and Dr. D. E. Dalzell of the Department of Zoology, and Dr. G. V. Middleton and R. V. Best of the Department of Geology. The bone-bearing deposit consisted of sediments ranging from medium sand to raisin gravel, underlying much coarser deposits from 3 to 4 feet in depth that constituted a part of the former shoreline of Pleistocene Lake Iroquois during the period of shrinkage of that body of water. The site is at an altitude of about 275 feet above sea level, and is dated as Late Pleistocene (late Lake Iroquois). According to Dr. Thompson, the bone bed is interpreted as an inshore lake-bottom deposit that became covered with true beach material as the lake level lowered.

Four species of birds are represented, as follows:

Wood Duck, *Aix sponsa* (Linnaeus). A complete cranium, and the distal end of a right humerus. This is the first Pleistocene record of this species.

Barred Owl, *Strix varia* Barton. The shaft of a left humerus. This owl has been found previously in Pleistocene deposits at several localities in Florida.

Red-winged Blackbird, *Agelaius phoeniceus* (Linnaeus). A complete left ulna. The species has been identified from the Pleistocene of Florida.

Common Grackle, *Quiscalus quiscula* (Linnaeus). A sternum nearly complete. The grackle also has been found in Pleistocene beds in Florida.

Mammal remains associated with the birds are more abundant, the following 10 species having been identified by Dr. Charles O. Handley, Jr.:

Short-tailed shrew, *Blarina brevicauda* Say.
Chipmunk, *Tamias striatus* (Linnaeus).
Gray squirrel, *Sciurus carolinensis* Gmelin.
Red squirrel, *Tamiasciurus hudsonicus* (Erxleben).
Flying squirrel, *Glaucomys sabrinus* (Shaw).
White-footed mouse, *Peromyscus* sp.
Meadow mouse, *Microtus pennsylvanicus* (Ord).
Pine mouse, *Pitymys pinetorum* (LeConte).
Muskrat, *Ondatra zibethicus* (Linnaeus).
Red fox, *Vulpes fulva* (Desmarest).

There are also part of the jaw of a frog (*Rana* sp.) and vertebrae of a colubrid snake, identified by Dr. Doris M. Cochran, a few bones of a pickerel (*Esox* sp.), determined by Dr. Leonard P. Schultz, and two snails, *Mesomphix* (*Omphalina*) *cupreus* (Rafinesque), identified by Dr. Harald Rehder.

The material is preserved in the collections of the U.S. National Museum, through the kindness of Dr. Thompson.

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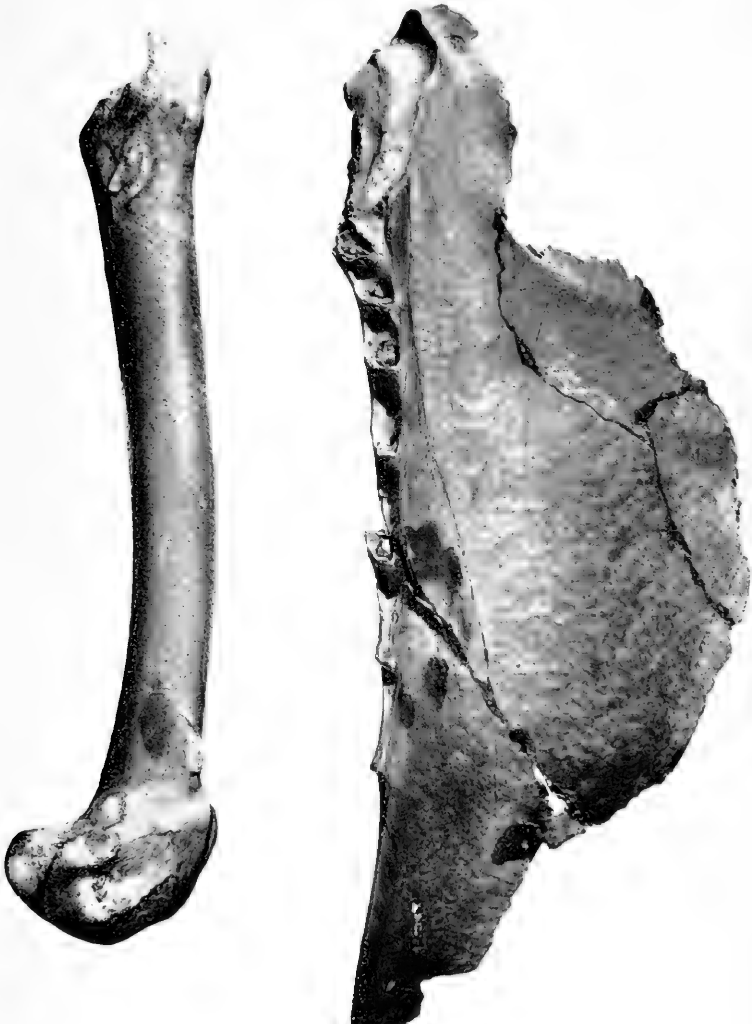
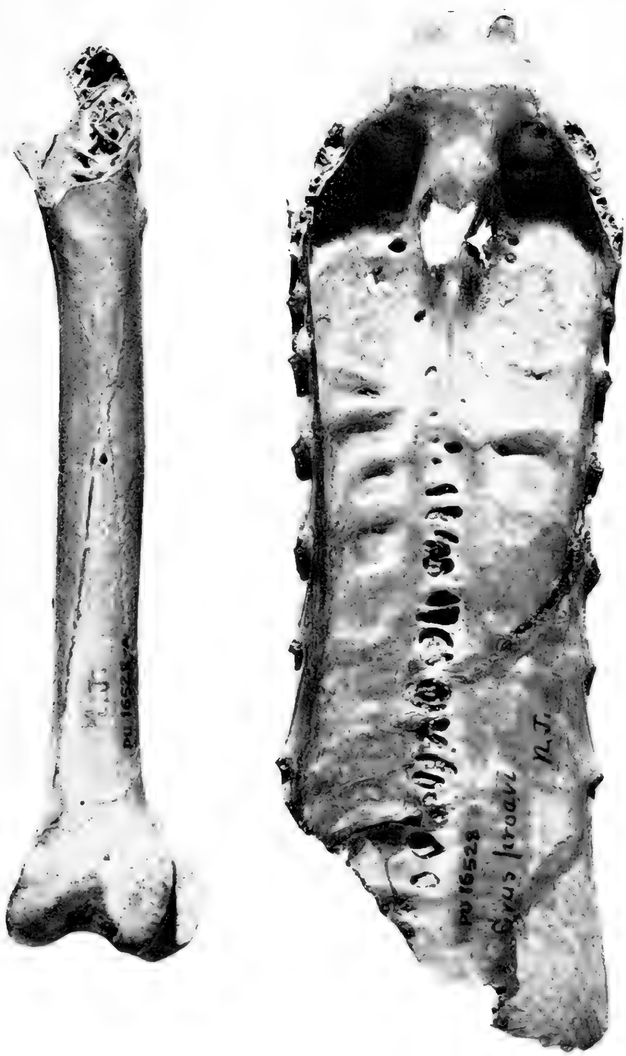
PLATES

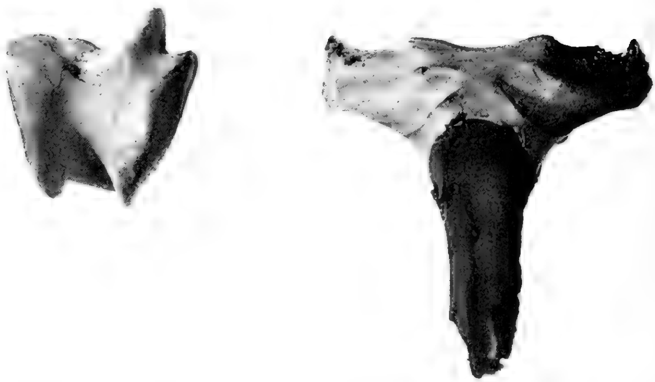


Cotypes of *Grus proavus* Marsh, lateral view, about natural size.

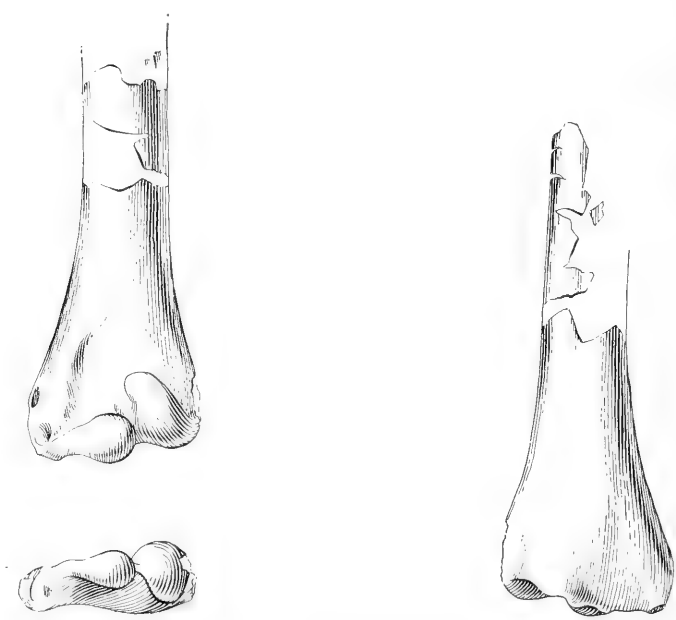
Cotypes of *Grus proavus* Marsh, ventral view, about natural size.



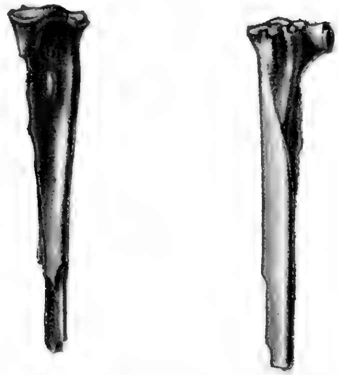
Cotypes of *Grus proavus* Marsh, dorsal view, about natural size.



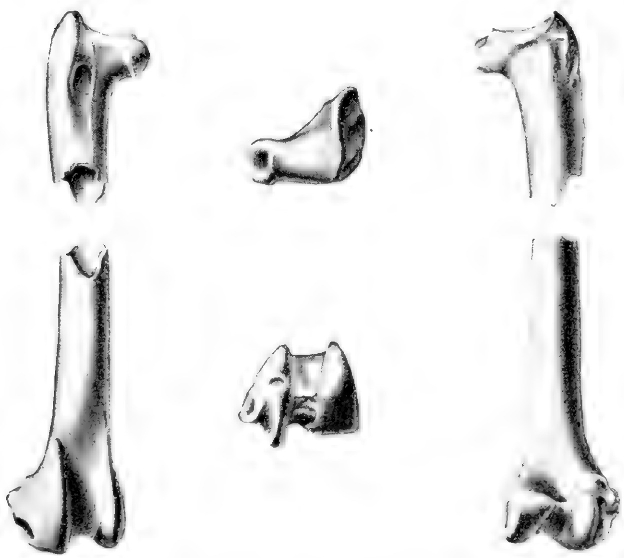
1. Cotypes of *Grus proavus* Marsh, anterior view, about natural size.



2. Humerus of *Bathornis celeripes* Wetmore, about natural size.



1. Type of *Promilio brodkorbi,* about natural size.



2. Type of *Promilio epileus,* about natural size.

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NEW AMERICAN PALEOZOIC ECHINOIDS

(With Eight Plates)

By

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and Paleobotany
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NEW AMERICAN PALEOZOIC ECHINOIDS

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(WITH EIGHT PLATES)

INTRODUCTION

Seven new species and one new genus of Paleozoic echinoids are described in this paper. One of the two new species of *Archaeocidaris, A. immanis,* is represented by a magnificent specimen, remarkable not only for its size, being the largest cidarid ever recorded, fossil or Recent, but is the first specimen of the genus showing the original shape of the echinoid. Furthermore, it is the first certain *Archaeocidaris* from the Pennsylvanian. A study of the ambulacral plates of this species, and of other species of the genus, shows that the plates are highly imbricate, a feature not previously known.

Archaeocidaris aliquantula and *Lepidechinus cooperi* are new species from the Gilmore City formation. The numerous specimens of these species in the United States National Museum were collected by Dr. Lowell R. Laudon at the same locality where he collected his beautifully preserved crinoids.

In the Jackson collection at the Museum of Comparative Zoology at Harvard, the author found several specimens of a new species from Crawfordsville, Ind., which clearly represent a new cidarid genus. This genus, herein named *Polytaxicidaris,* is the first cidarid known with more than four columns in each interambulacrum. Also, as its interambulacral plates are similar to those of *Archaeocidaris,* its discovery makes unwise the referring of isolated interambulacral plates or spines to *Archaeocidaris,* as has been done frequently in the past.

A new species of *Palaechinus, P. tetrastichus,* is described from the Mississippian of Montana. This is the first species of this genus found in the United States, and is based on several specimens collected by R. M. Stainforth of the Carter Oil Co.

One of the two new species of *Lepidesthes, L. grandis,* is of considerable interest not only because of its great size, but also as it has more columns (20) in each ambulacrum than any other member of the genus. The plates of the holotype are very well preserved, and from a study of them it is evident that although the plates do imbricate, the test was not flexible, as has been presumed in all echinoids with imbricating plates. The other new *Lepidesthes, L. alta,* is represented by one specimen, and is the first one of the genus preserving its original shape. The test is extremely high, being one of the highest in proportion to its width of all known echinoids.

A specimen of *Archaeocidaris blairi* (Miller) is described in which the apical system has been revealed by removal of the interambulacral plates which had shifted over the apical area. The apical system was hitherto unknown in this genus. This species was placed by Jackson in synonymy with *Archaeocidaris legrandensis* Miller and Gurley, but is here separated and redescribed. Finally, a specimen of *Lepidesthes colletti* White from a new locality is figured.

ACKNOWLEDGMENTS

I am greatly indebted to Dr. G. Arthur Cooper who had, several years ago, cleaned, photographed, and tentatively described the Gilmore City echinoids. The photographs used in this paper of these two species were taken by him. I also acknowledge his helpful suggestions made during the writing of this paper, and express my great appreciation for his part in making it possible for me to study echinoderms at the United States National Museum.

Dr. M. H. Nitecki, curator of the Walker Museum at the University of Chicago, very kindly lent me the type specimen of *Archaeocidaris legrandensis,* and Dr. N. D. Newell sent to me from the American Museum of Natural History a cotype of *Archaeocidaris wortheni.* I am indebted to Dr. L. R. Laudon for the echinoids from Gilmore City, and to B. H. Beane for specimens from Gilmore City and LeGrand, Iowa. Mrs. J. H. Renfro collected the specimens of *Lepidesthes grandis,* and J. L. Borden and Dr. N. D. Newell collected the specimen of *Archaeocidaris immanis.* Dr. J. Thomas Dutro, Jr., brought to my attention the specimens of *Palaechinus tetrastichus,* and Dr. Donald W. Fisher and Clinton F. Kilfoyle very kindly searched through their Crawfordsville material at the New York State Museum and located two specimens of *Polytaxicidaris dyeri.*

Finally, through the courtesy of Dr. C. O. Dunbar, I was able to study the Paleozoic echinoids at the Peabody Museum at Yale, and through the kindness of Dr. H. B. Whittington, the echinoids of the Jackson collection at the Museum of Comparative Zoology at Harvard.

Family ARCHAEOCIDARIDAE McCoy

Genus ARCHAEOCIDARIS McCoy, 1844

Type species.—*Cidaris urii* Fleming, by subsequent designation, Bather, 1907, p. 453. Generic name *Archaeocidaris* validated in Opinion 370 under plenary powers by suppression under same powers of generic name *Echinocrinus* Agassiz, 1841. Opin. Internat. Comm. Zool. Nomencl., vol. 11, pp. 301-320, 1955.

ARCHAEOCIDARIS IMMANIS Kier, new species

Plates 1, 2, 3A; text figures 1, 2

Diagnosis.—Species characterized by large size, slightly developed basal terrace, and frequent occurrence in ambulacra of plates separated from perradial suture.

Material.—The specimen occurred in a dense oolitic limestone, and was cleaned by grinding away this matrix with a dental machine. As the secondary spines were in place on the test before cleaning, the echinoid was obviously little disturbed during its burial by oolitic sands. The test is complete except for the peristomal plates, the lantern, and most of the apical system. The original calcite of the plates is present, with the only change being the filling of the interstices of the plates with clear calcite making their microstructure remarkably clear.

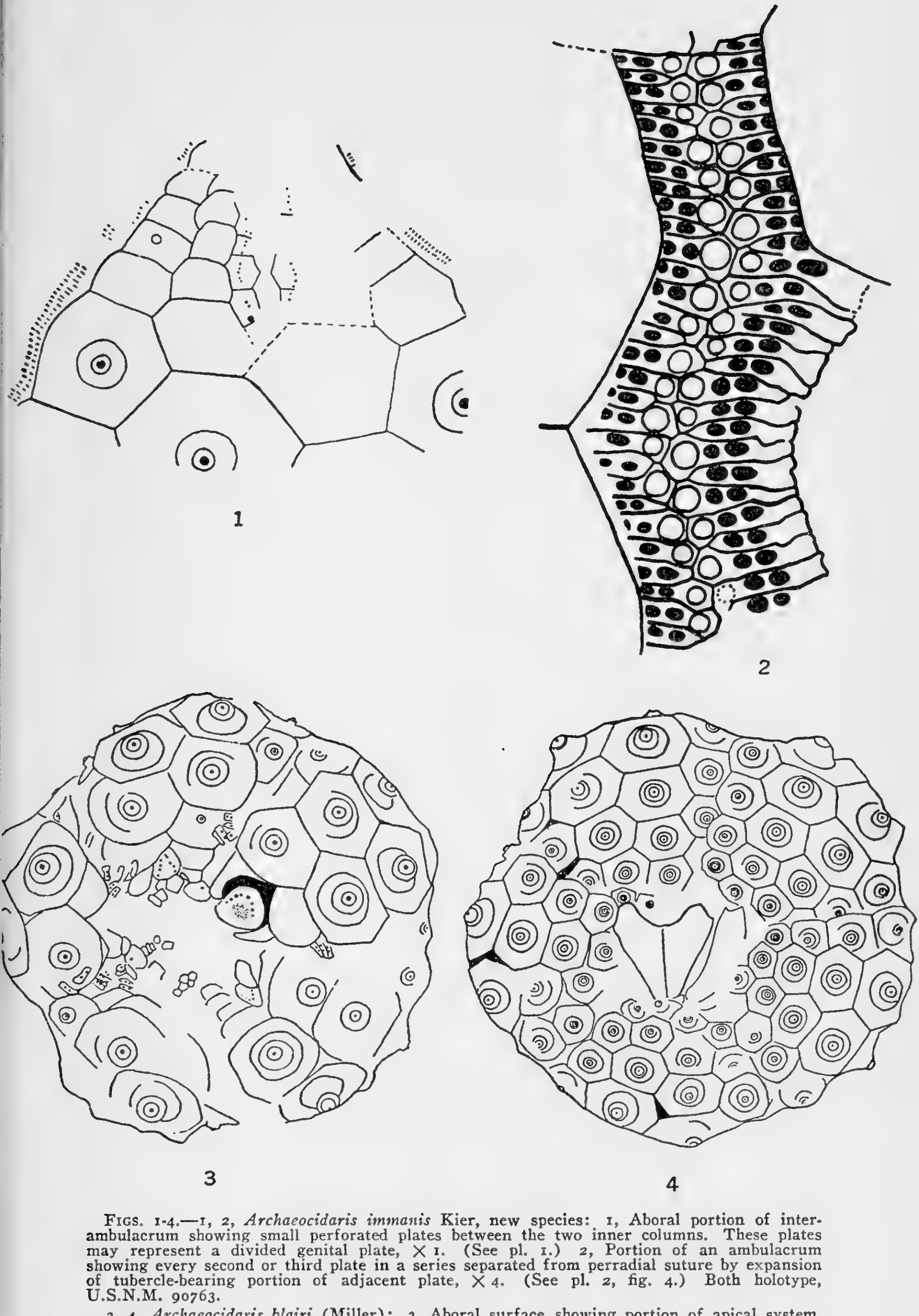
Shape.—Specimen showing no sign of crushing, presumably retaining original shape. Test low, 145 mm. in horizontal diameter, 55 mm. high, with concave apical and peristomal regions. Largest cidarid described with largest previously known (Mortensen, 1928, p. 10) only 110 mm. in horizontal diameter.

Apical system.—Most plates of apical system missing except in oral portion of one interambulacrum having along its midline three columns of small plates with outer columns perforated by longitudinal series of pores, three to five in each plate (text fig. 1). Plate arrangement not clear as this part of test dissolved during fossilization with many plates now absent or only partially preserved. Pores, because of regular pattern, symmetrical occurrence, probably original with echinoid, being unlikely that boring animal would drill such orderly series of holes. Plates perhaps representing single genital plate split into smaller plates, pores being genital pores, as frequently occurring in the Echinothuridae (Agassiz and Clark, 1909, p. 147).

Ambulacra.—Extremely narrow, each approximately 6.5 mm. wide at midzone, one-thirteenth width of interambulacrum, sinuous, reflecting curved surface of adambulacral plates, with 20-25 plates to each adambulacral plate at midzone. Pore pairs uniserial, outer pore larger, more elongated transversely than inner pore. Plates imbricating strongly orally, and under adambulacral plates, extension or flange of each ambulacral plate (pl. 3A, fig. 2) extending aborally from near junction of aboral ambulacral suture and perradial suture. Flange thin, sloping slightly inward, not visible where plates in proper position but seen only where plates displaced away from perradial suture. Ambulacral plate figured in plate 3A, figure 2, revealed by removal of two plates immediately aboral to it. Every second or third plate in a series separated (text fig. 2) from perradial suture by expansion of tubercle-bearing portion of adjacent ambulacral plate. This arrangement of ambulacral plates never described before in any other archaeocidarid, and not found during author's examination of many species of genus. In portion of ambulacra aboral to last tubercle-bearing interambulacral plate, ambulacra nearly straight, with lower plates, outer pore of pore pair more elongated, being slitlike in appearance.

Interambulacra.—Broad, each averaging 85 mm. in width at midzone, with four columns in each area. Plates of two inner columns hexagonal, at midzone each being approximately 25 mm. wide, 17 mm. high. Adambulacral plates narrower, pentagonal with adradial side of plate curved, plate at midzone 22 mm. wide, 17 mm. high. Most interambulacral plates bearing one large perforated tubercle with diameter approximately one-half height of plate. Each tubercle with steep-sided boss, well-developed parapet, straight neck, deeply perforated mamelon, with perforation extending to base of boss. Tubercle illustrated in plate 3A, figure 1, not showing deep perforation because plates not broken in vertical section through perforation but at angle to it. Most of plates with no basal terrace or scrobicule although slightly developed in several. Secondary tubercles in row around margin of each plate with approximately 30 on plate at midzone. Aboral interambulacral plates much smaller, lacking tubercles, one of most oral bearing incipient tubercle with slightly developed boss, no perforation. In nearly complete column, five small aboral plates without tubercles, seven large plates with tubercles. Plates imbricating strongly over ambulacra, very slight imbrication of plates of median columns over adambulacral plates. No evidence of aboral imbrication except in small, thin, tubercleless plates in aboral region.

Spines.—Portions of several primary spines visible in matrix; circular in section, hollow, longitudinally finely striate, long, tapering, with well-developed ring. Longest portion of spine 35 mm. long, but less



1 2 3 4

FIGS. 1-4.—1, 2, *Archaeocidaris immanis* Kier, new species: 1, Aboral portion of interambulacrum showing small perforated plates between the two inner columns. These plates may represent a divided genital plate, × 1. (See pl. 1.) 2, Portion of an ambulacrum showing every second or third plate in a series separated from perradial suture by expansion of tubercle-bearing portion of adjacent plate, × 4. (See pl. 2, fig. 4.) Both holotype, U.S.N.M. 90763.

3, 4, *Archaeocidaris blairi* (Miller): 3, Aboral surface showing portion of apical system, with genital plates revealed by removal of aboral interambulacral plates which had shifted over apical area during flattening of test, × 2.6. (See pl. 4A, fig. 1.) Figured specimen U.S.N.M. S3828. 4, Same specimen, but showing oral surface, × 2.6.

than one-third diameter of thickest spine which must have been considerably longer. Small spines attached to secondary tubercles on edge of interambulacral plates approximately 7 mm. long, longitudinally striated, hollow, nontapering.

Type.—Holotype, U.S.N.M. 90763.

Horizon and locality.—Pennsylvanian (Dewey limestone), NE¼ sec. 33, T. 23 N., R. 12 E., Washington County, Okla.

Discussion.—This specimen is remarkable not only because of its great size, but also as it is the first specimen of *Archaeocidaris* showing its original shape and the first well-preserved member of the genus from the Pennsylvanian. It is easily distinguished from all the other species of *Archaeocidaris,* based on reasonably well-preserved specimens, by its large size, slightly developed basal terrace and scrobicule, and by the frequent occurrence in the ambulacra of plates separated from the perradial suture.

The presence of imbrication in the ambulacral plates of *Archaeocidaris* casts further doubt on any lineage of the Cidaroida from the Archaeocidaridae as proposed by Mortensen (1928, p. 58), and Durham and Melville (1957, p. 245). It seems more reasonable to consider, as Jackson did (1896, p. 237; 1912, p. 249), that the archaeocidarids are not ancestors of the post-Paleozoic cidarids, and that the cidarids never passed through a four-columned interambulacrum stage. Hawkin's series (1943, p. lxv), with the cidarids passing through *Miocidaris,* is much preferred to any lineage through *Archaeocidaris.*

Morphological note.—In no other species of *Archaeocidaris* have ambulacral plates been described with a flange for perradial overlap. This flange, however, is probably present in all species of this genus, as the author has seen it in every specimen having ambulacral plates of every species studied including the following: *A. wortheni* Hall (American Museum Natural History, cotype, 7747/1), *A. agassizi* Hall (U.S.N.M. S3825), *A. legrandensis* Miller and Gurley (University of Chicago Museum, holotype, 6198), *A. aliquantula,* new species (U.S.N.M. 136453), *A. blairi* (Miller) (U.S.N.M. S3828), *A. newberryi* Hambach (U.S.N.M. S3899), *A. rossica* (Buch) (Mus. Comp. Zoology, Harvard, 3087). Jackson (1912, pl. 12, fig. 10) shows a vertical perradial suture in his figure of an ambulacral plate of *A. rossica.* However, I have examined this specimen and found the perradial suture to be oblique, not vertical, with each plate having a flange as described above.

The ambulacral plates were removed and separated in a specimen of *A. agassizi* (see Jackson, op. cit. pl. 13, fig. 4). In Jackson's figure and in plate 3B, figure 3, the overlapping of the plates is not apparent where the plates are in normal position, but their separation (pl. 3B, fig. 4) reveals the flange and perradial overlap.

This overlap in the ambulacral plates of *Archaeocidaris* results in a stronger suture between the plates than that found in plates with a vertical suture (see p. 23).

ARCHAEOCIDARIS ALIQUANTULA Kier, new species

Plate 3C

Diagnosis.—Species characterized by small size, with coarse radial plications on interambulacral plates extending from basal terrace to margin of plates.

Material.—There are many loose specimens and many crowded on slabs. All are flattened and covered with spines, and on many specimens the secondary spines are still attached. The presence of attached spines, and the occurrence of a thin layer of marl over the echinoids indicates that they were smothered and buried by a deposit of calcareous mud which prevented disturbance of the tests by scavengers and currents (Laudon, 1957, p. 963).

Shape.—Probably originally low, with shape similar to *Archaeocidaris immanis.*

Apical system.—On paratype U.S.N:M. 136467 two plates present: genital 2 with madreporic pores, ocular II with one pore.

Ambulacra.—Only short portions and isolated plates present with two columns of low uniserial primaries each bearing one secondary spine. Ambulacra narrow, apparently straight, beveling under adambulacral plates, with approximately four to five ambulacral plates for each adjacent adambulacral plate at midzone. Each plate bearing flange for perradial overlap.

Interambulacra.—Broad, composed of four columns of thin imbricating plates. Adambulacral plates pentagonal, higher than wide; plates of inner columns hexagonal, wider than high. Plates imbricating aborally and over ambulacra, each bearing one large centrally located tubercle deeply perforated with bottom of pit extending to near base of boss. Basal terrace slightly developed, not visible on many specimens. Secondary tubercles around margin of each plate with 25 to 30 on plate at midzone; coarse radial plications extending from tubercles, across slightly developed scrobicule to basal terrace.

Peristome.—Large, 5 mm. in diameter on specimen 13 mm. in horizontal diameter, covered with numerous small, low plates imbricating orally.

Lantern.—Inclined with deep foramen magnum.

Spines.—Primary spines extremely long, over 30 mm., length greater than horizontal diameter of echinoid. Spines slightly striated, no spinules, well-developed milled ring, hollow from near tip to near milled ring with cavity approximately one-half width of spine. Secondary spines short, striated, present on ambulacral plates, peristomal plates, and around margin of each interambulacral plate.

Types.—Holotype, U.S.N.M. 136451; paratypes, U.S.N.M. 136452-3.

Horizon and locality.—Mississippian (Kinderhookian—Gilmore City formation) quarries of Northwestern States Portland Cement Co. and Pennsylvania Dixie Cement Co., about one mile northwest of Gilmore City, Pocahontas County, Iowa. Collector: Lowell R. Laudon.

Discussion.—Of all the species of *Archaeocidaris,* this species resembles most *A. blairi* (Miller) from the Meramecian of Missouri. It is distinguished from this species by its less developed basal terrace and scrobicule, and in having coarse radial plications extending from the secondary tubercle on the margin of each interambulacral plate to the basal terrace, as contrasted to *A. blairi* in which extremely fine radial plications occur along the basal terrace but do not reach these secondary tubercles.

ARCHAEOCIDARIS BLAIRI (Miller)

Plate 4A; text figures 3, 4

Eocidaris blairi Miller, 1891. Advance Sheets, 17th Rep. Geol. Surv. Indiana, p. 73, pl. 12, figs. 1, 2.

Archaeocidaris legrandensis (part) Jackson, 1912. Mem. Boston Soc. Nat. Hist., vol. 7, pp. 260-261, pl. 8, figs. 7, 8, pl. 9, figs. 12, 13.

In order to explain the function of the pore-bearing plates in the aboral interambulacrum of *Archaeocidaris immanis* described above, it was essential to learn the nature of the apical system in *Archaeocidaris.* Except for several possible genital plates described by Jackson (1912, pp. 265-266) the apical system is unknown in the genus. A search was made of all the specimens in the U. S. National Museum and any specimen that might have the plates was cleaned. On a specimen of *A. blairi* occurred a plate larger than the others, pierced with one pore, and located on the edge of the periproctal area. As this plate beveled under adjacent interambulacral plates, these plates were removed, revealing seven more pores of what was obviously a genital plate. The removal of similar plates at the aboral extremities of the ambulacra and interambulacra revealed two more genitals, including the madreporite and two oculars. It is apparent that the flattening of the test of an *Archaeocidaris* forces the thin, nontuberculate aboral interambulacral plates up and over the genitals and oculars, thus hiding the apical system from view.

As the above-mentioned specimen of *A. blairi* is from the same locality, Boonville, Mo., as Miller's type specimen, and as it shows features not visible on his types, it warrants description.

Material.—There is one well-preserved specimen, which, although flattened, shows most of its interambulacral plates. It is 24 mm. in horizontal diameter, 7 mm. at its greatest height.

Apical system.—Genitals 1, 2, 3; oculars I, III visible. Genital 2 broad, rounded (text fig. 3), width nearly equal to height, larger than other genitals, pierced with eight genital pores and numerous madreporic pores. Genital 3 narrow, with eight or nine pores; genital 1 partly uncovered, six pores visible. Genital pores extremely small being of approximately same size as ambulacral pores. Ocular plates small relative to genitals, each pierced in oral region by one small pore. Both ocular and genital plates thin, beveling under interambulacra. Imbrication relationship of oculars to ambulacra not clear. Many small, irregularly shaped periproctal plates within ocular-genital ring.

Ambulacra.—On most of test not visible due to slippage of interambulacral plates over ambulacra at time of flattening of specimen. Plates thin, beveled for perradial imbrication.

Interambulacra.—Four columns in each area with from 9 to 11 plates in a column; plates of median columns hexagonal, wider than high, largest plate approximately 5 mm. wide, 4 mm. high. Adambulacral plates pentagonal, narrow, width less than height, imbricating over ambulacra. Large perforated tubercle with well-developed basal terrace and wide scrobicule on each plate except near apical area. Extremely fine radial plications on edge of basal terrace. Aborally, first three or four plates in a column bearing no tubercles; here plates thin, strongly imbricating aborally. In area 3, most oral plate bearing one incipient perforate tubercle, no basal terrace.

Lantern.—Portions of two pyramids visible; foramen moderately deep.

Figured specimen.—U.S.N.M. S3828.

Horizon and locality.—Mississippian (Meramecian—Warsaw formation), from Boonville, Mo.

Discussion.—Jackson (1912, p. 260) placed *A. blairi* in synonymy with *A. legrandensis,* as he was unable to see any difference between

Miller and Gurley's type specimens of *A. legrandensis* and Miller's of *A. blairi.* However, I have studied the type specimens of *A. legrandensis,* and they are so poorly preserved that it is not possible to determine whether or not the specimens represent the same species as *A. blairi.* Considering the difference in the age of the specimens, *A. legrandensis* being Kinderhookian and *A. blairi* Meramecian, it seems best to maintain the two species.

POLYTAXICIDARIS Kier, new genus

Two columns in each ambulacrum; numerous columns in each interambulacrum. Interambulacral plates thin, imbricating slightly aborally, beveling over ambulacra; adambulacral plates same size as plates of inner columns. Perforated tubercles on most ambulacral and interambulacral plates.

Type species.—*Polytaxicidaris dyeri* Kier, new species.

Discussion.—This genus belongs to the family Archaeocidaridae. Jackson (1912, p. 206) placed three genera in the family: *Eocidaris, Archaeocidaris,* and *Lepidocidaris. Eocidaris* was based on isolated interambulacral plates and cannot be maintained as a usable genus (Mortensen, 1928, p. 58). *Polytaxicidaris* differs from *Archaeocidaris* in having more than four columns in each interambulacrum, and in having perforate tubercles on most of the ambulacral plates. It differs from *Lepidocidaris* in not having every third ambulacral plate higher and wider at the midzone than the others, in having perforate tubercles on most of the ambulacral plates, and in not having a high rounded area beyond the scrobicular ring on each interambulacral plate. Mortensen (1928, p. 58) did not consider *Lepidocidaris* as an archaeocidarid but placed it among the lepidocentrids because of the absence of a cortex layer on the spines in *Lepidocidaris.* However, the presence of a cortex layer cannot be considered a diagnostic feature of the archaeocidarids because most of the species of *Archaeocidaris,* based on well-preserved tests, do not have this layer as shown by the fine longitudinal striations, and lack of spinules on the spines. Both of these characters are considered by Mortensen (1935, p. 48) as evidence of a lack of cortex. He further distinguishes *Lepidocidaris* from this family by the enlargement of every third ambulacral plate at the midzone. However, the ambulacral plates are not always similar in other genera of the family as shown above in *Archaeocidaris immanis* (see text fig. 2) and in *Polytaxicidaris.* It therefore seems more reasonable to consider *Lepidocidaris* as an archaeocidarid.

Mortensen included *Nortonechinus* among the archaeocidarids, but until the number of ambulacral columns is known in this genus, its reference to this family can only be tentative. *Polytaxicidaris* is easily distinguished by its interambulacral plates which are more regular in outline and bear a more pronounced primary tubercle, with the scrobicular tubercles occurring around the margin of the plate instead of being in a ring as in *Nortonechinus.*

The discovery of a species of Paleozoic echinoid having interambulacral plates similar to those found in *Archaeocidaris,* but belonging to a separate genus, makes unwise the erection of species of *Archaeocidaris* based on isolated interambulacral plates.

POLYTAXICIDARIS DYERI Kier, new species

Plates 4B, 5A; text figure 5

Diagnosis.—Having only one reasonably well-preserved specimen, diagnosis of species not possible.

Material.—There are six specimens, all preserved as impressions in a siltstone. The holotype is represented by two impressions, one of the oral surface, the best preserved of all the impressions; the other of the aboral surface showing part of both the inner and outer surface of the plates. Both the apical system and peristome are absent owing to the breaking through of the test of the lantern. The other specimens are not as well preserved and show only portions of the test. All the specific description is based on the holotype except for details of the spines from the paratypes.

Shape.—Not known, specimen flattened during or after burial.

Ambulacra.—Detailed structure not visible, narrow, approximately one-fifth width of interambulacra, straight with curved adradial margins reflecting curved margin of adambulacral plates, with approximately four pore pairs to each adjacent adambulacral plate. On oral surface, single regular series of small perforated tubercles running length of each half-ambulacrum between pore pairs and perradial suture, one-half as many tubercles as pore pairs. Because of poor preservation, not certain whether tubercle on every other ambulacral plate as in *Archaeocidaris* (text fig. 2) or on a compound plate with two pore pairs, as in Jurassic genus *Paracidaris* (illustrated in Mortensen, 1928, p. 478). On aboral surface, at midzone, tubercles as described above for oral surface, but nearer apical system apparently more tubercles, with one tubercle for each pore pair, poor preservation preventing certainty on this point.

Interambulacra.—Seven columns visible in all areas of holotype except in one. In this area, although probably seven originally present, only six visible, as portion of test not preserved where seventh column would occur. Column 5 in middle of each interambulacrum with columns 6 and 7 on either side. Plates thin, imbricating slightly aborally, beveling over ambulacra, with well-developed, perforated primary tubercle near center of plate, slightly developed basal terrace, row of secondary tubercles around margin of each plate with approximately 25 on plate at midzone. Plates of inner columns hexagonal, wider than high except for initial plate of columns 5, 6, 7 where higher than wide, pentagonal, and usually without primary tubercle. Adambulacral plates pentagonal with curved adradial margin, approximately same size as plates of inner columns.

Spines.—Primary spines of interambulacral plates longitudinally finely striate, tapering, with well-developed milled ring. No complete spine, longest fragment 12 mm. long. Ambulacral spines smaller, longest 6 mm. long, with well-developed milled ring, slight taper. Secondary spines, formerly attached to scrobicular tubercles, small, less than 2 mm. long, details not discernible.

Types.—Museum of Comparative Zoology, Harvard: Holotype, 3354; figured paratype, 3353; unfigured paratype, 3352. New York State Museum, Albany: Paratypes, 11060-1.

Horizon and locality.—Mississippian (Osagean, Borden Group), Crawfordsville, Ind. Collector: C. B. Dyer.

Family PALAEOCHINIDAE McCoy

Genus PALAECHINUS McCoy

PALAECHINUS TETRASTICHUS Kier, new species

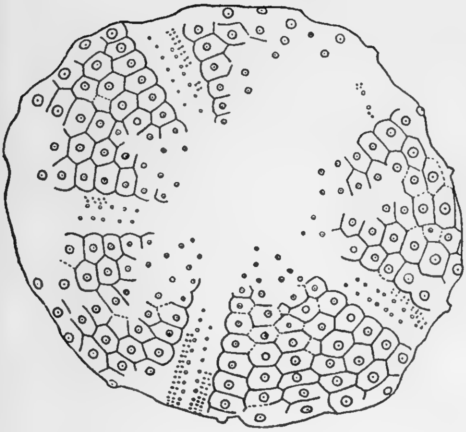
Plate 5B; text figures 6-10

Diagnosis.—Species characterized by four columns of similar plates in each interambulacrum, with five ambulacral plates to each adambulacral plate at midzone.

Material.—There are portions of five specimens present on a slab of irregularly bedded, argillaceous, bioclastic limestone. These specimens are flattened, with some plates shifted from their original position on the tests. Their plates are well preserved, still retaining their microstructure, and with the tubercles still present on their external surfaces.

Shape.—Vertically elongated as indicated by slight curvature of ambulacral margins throughout length.

Apical system.—Three or possibly four genital plates on holotype,



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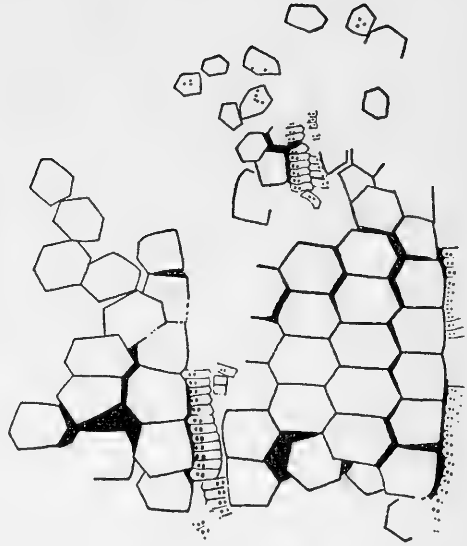

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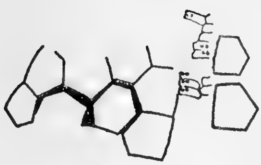

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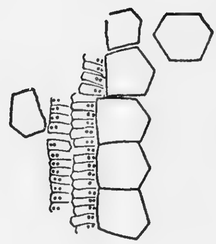

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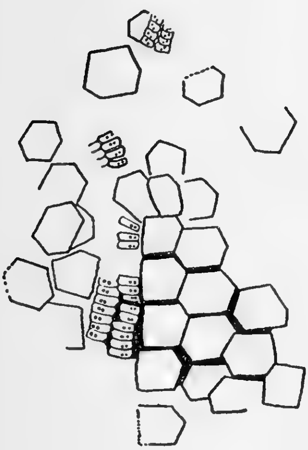

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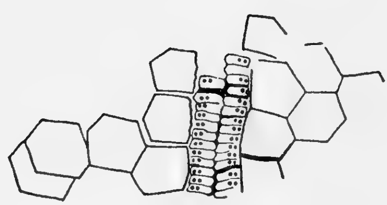

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FIGS. 5-10.—5, *Polytaxicidaris dyeri* Kier, new species: Aboral surface based on cast of holotype, Museum of Comparative Zoology, coll. 3354, × 2. (See pl. 4B, fig. 4.)

6-10, *Palaechinus tetrastichus* Kier, new species: 6, Holotype, U.S.N.M. 136454, × 1.5. (See pl. 5B, fig. 3.) 7, Paratype, U.S.N.M. 136458, × 1.5. 8, Paratype, U.S.N.M. 136457, × 1.5. (See pl. 5B, fig. 3.) 9, Paratype, U.S.N.M. 136455, × 1.5. (See pl. 5B, fig. 2.) 10, Paratype, U.S.N.M. 136456, × 1.5. (See pl. 5B, fig. 3.)

two small, pentagonal, with three pores, third large with five pores, fourth may be genital plate, larger than other three, pentagonal with two pores on one margin of plate, no pores visible on other margin. Several smaller, angular, probably periproctal plates in same region with genital plates.

Ambulacra.—At midzone, 4 to 5 mm. wide, one-fourth width of interambulacra, with two columns of similar primary plates in each area. Five plates to each adambulacral plate at midzone, four near oral, aboral extremities. Plates pentagonal except where hexagonal opposite suture between two adjacent interambulacral plates. Pore pairs in peripodia, uniserial. Four to five secondary tubercles on each plate between pore pair and perradial suture.

Interambulacra.—At midzone, 18-19 mm. wide, four columns in each area. Plates of inner columns hexagonal, much wider than high; adambulacral plates pentagonal, slightly wider than high, notched along adradial suture for ambulacral plates, very slightly beveled under ambulacra. Sutures between interambulacral plates vertical with no indication of imbrication. Approximately 60 secondary tubercles on plate of inner column at midzone.

Lantern.—Not preserved.

Spines.—Several spines on tests and in matrix: narrow, longest 4 mm. long, vertically finely striated.

Types.—Holotype, U.S.N.M. 136454; paratypes, U.S.N.M. 136455-8.

Horizon and locality.—Mississippian (Madison formation, Lodgepole member) at type section of Lodgepole limestone, Little Chief Canyon, Fort Belknap Indian Reservation. Collector: R. M. Stainforth.

Discussion.—Three other species of Palaechinus are known with four columns of interambulacral plates in each area. *P. quadriserialis* Wright from the Lower Carboniferous of Ireland differs in having narrower adambulacral plates, and ambulacra with plates alternately enlarged at adradial margin. *P. globulus* Jackson from the Tournaisien of Belgium is easily distinguished by its spheroidal shape and in having smaller and narrower plates in the inner columns of the interambulacra, and in having eight ambulacral plates to each adambulacral plate as opposed to five in *P. tetrastichus*. *P. visetensis* Jackson from the Viséen of Belgium is easily distinguished by its extremely vertically elongated test with a spiral twist, and by its high interambulacral plates.

Family ECHINOCYSTITIDAE Gregory

Genus LEPIDECHINUS Hall

LEPIDECHINUS COOPERI Kier, new species

Plate 6; text figures 11, 12

Diagnosis.—Species characterized by small size, similar ambulacral plates with four plates to each adambulacral plate, and five columns in each interambulacrum.

Material.—There are many specimens of this species, most of them occurring on slabs. All are flattened except for one slightly crushed test.

Shape.—Spherical to slightly higher than wide.

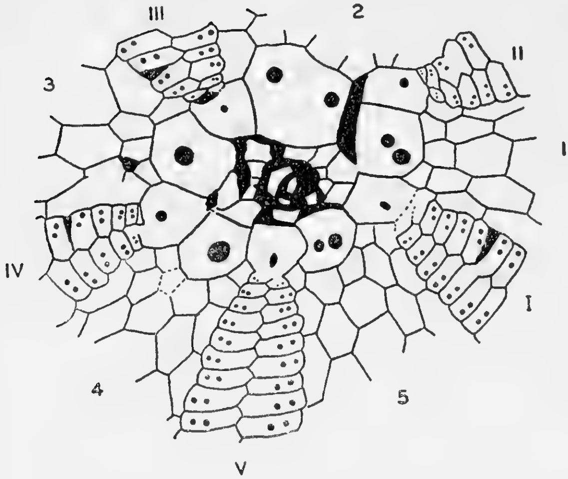
Apical system.—Well preserved in holotype (text fig. 11), portion in paratype U.S.N.M. 136460. Oculars large, pierced by one pore in oral portion of plate, insert except possibly ocular II in holotype being separated from periproct by genitals 1 and 2, separation resulting from displacement of plates during fossilization. Genital plates slightly larger than oculars except genital 2, much larger, approximately twice size of other genitals, not pierced by madreporic pores. Genitals 2, 5, 1 pierced by two pores each, genitals 3, 4 by one. Periproctal plates small, irregular in shape.

Interambulacra.—Five columns of thin imbricating plates in each area; adambulacral plates high, pentagonal; plates of inner columns approximately as wide as high, hexagonal. Plates imbricating aborally, laterally from center over ambulacra. Shape and occurrence of initial plates of columns exactly as shown by Jackson (1896) to be typical of most Paleozoic echinoids, with initial plate of column five (text fig. 12) pentagonal with apex of pentagon pointing orally; initial plate of column three hexagonal, although in some interambulacral areas heptagonal, followed by pentagonal initial plate of column four. Single plate in first row of each area.

Peristome.—Small, surrounded by ambulacral plates with initial plate of interambulacrum separated from peristome.

Lantern.—Small, inclined, foramen magnum deep, braces block-shaped identical to those in *Lepidechinus iowensis* Jackson (1912, pl. 63, fig. 3). Portions of epiphyses and teeth visible, but shape not clear.

Spines.—Test covered with small, striated secondary spines with slightly dilated bases. Each ambulacral plate bearing one spine between pore pair and perradial suture. Approximately 15 spines on each interambulacral plate.



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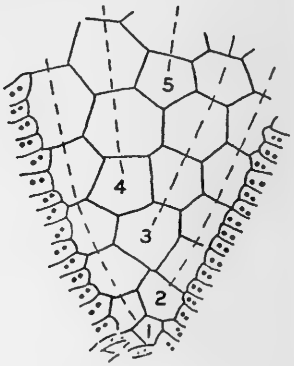

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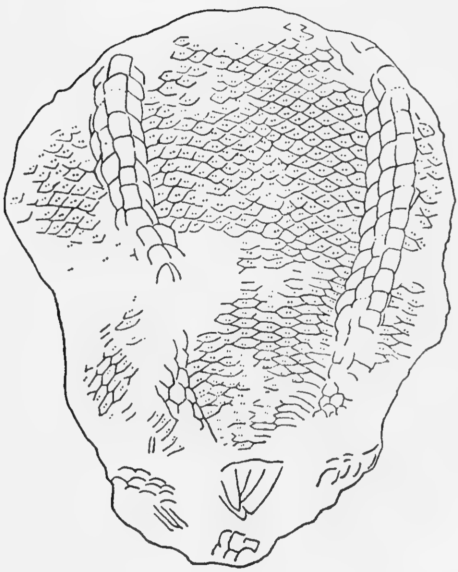

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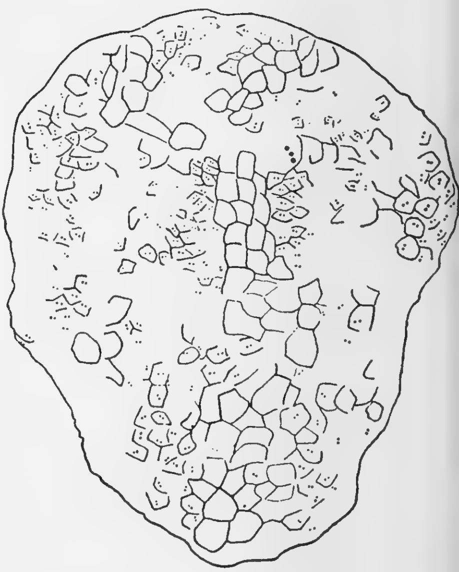

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FIGS. 11-14.—11, 12, *Lepidechinus cooperi* Kier, new species: 11, Apical system of holotype, U.S.N.M. 136458, × 8. (See pl. 6, fig. 1.) 12, Oral interambulacrum of paratype, U.S.N.M. 136460, × 6. (See pl. 6, fig. 4.)

13, 14, *Lepidesthes colletti* White: Both surfaces of specimen U.S.N.M. 136466, × 2. (See pl. 8B, fig. 6.)

Types.—Holotype, U.S.N.M. 136458; paratypes, U.S.N.M. 136459-60.

Horizon and locality.—Mississippian (Kinderhookian—Gilmore City formation) quarries of Northwestern States Portland Cement Co. and Pennsylvania Dixie Cement Co., about 1 mile northwest of Gilmore City, Pocahontas County, Iowa. Collector: L. R. Laudon.

Discussion.—This species is easily distinguished from the other two species of *Lepidechinus* having five columns in each interambulacrum: *L. iowensis* Jackson from the Mississippian of Burlington, Iowa, and *L. belgicus* Jackson from the Viséen of Belgium. *L. iowensis* is much larger, has wider ambulacra, and its ambulacral plates are higher with every third plate in a column much larger than the other two. In *L. iowensis* there are seven ambulacral plates to an adambulacral plate, whereas there are only four in *L. cooperi.* Furthermore, in *L. iowensis* every third plate in a column is considerably larger. The known specimens of *L. belgicus* are so poorly preserved as to make comparison difficult; however, the ambulacra are much narrower in *L. belgicus* than in *L. cooperi.*

Genus LEPIDESTHES Meek and Worthen

LEPIDESTHES ALTA Kier, new species

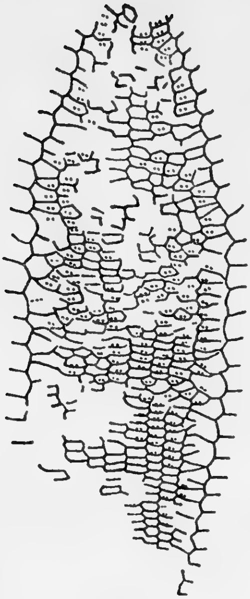
Plate 7; text figures 15-20

Diagnosis.—Species characterized by high test, 3 columns in interambulacrum at midzone, 10 to 12 in ambulacrum.

Material.—This species is based on one silicified specimen, which is for the most part an internal mold, except where the plates are still present in the oral portion of interambulacrum 5, its adjacent ambulacra, and most of the apical system and peristome. The silicification is coarse with the surface details of the plates not preserved. The test is not flattened vertically, but is slightly compressed through its width.

Shape.—Test highly inflated, higher than wide, height 80 mm., average width 60 mm. with greatest width aboral to midzone, narrowing orally. Apical system at apex of test; peristomal region only slightly concave.

Apical system.—Partially preserved (pl. 7, fig. 5) with portions visible of genitals 1, 2, 4; oculars III, IV. Genital 2 approximately twice as large as other genitals, three pores visible, probably five or six originally, presence or absence of madreporic pores not possible to determine because of coarse silicification. Genitals 1, 4 with five, possibly six, genital pores. Oculars insert, nearly as wide as genitals, considerably lower, each with one pore near aboral margin.



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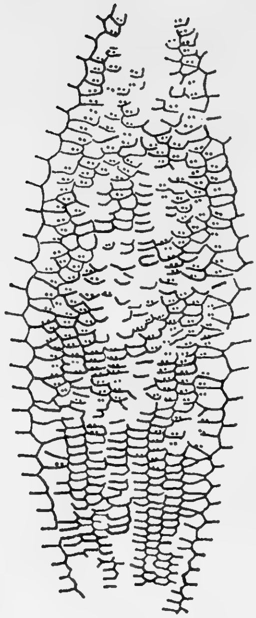

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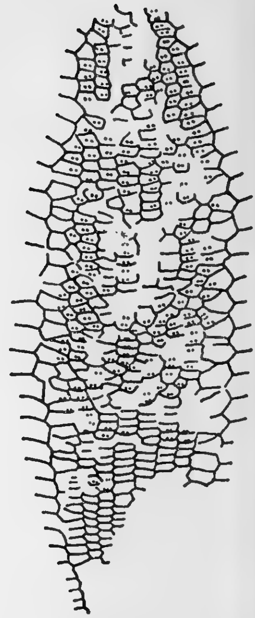

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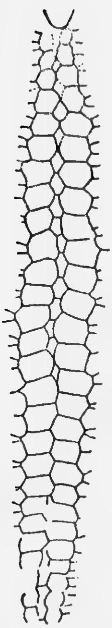

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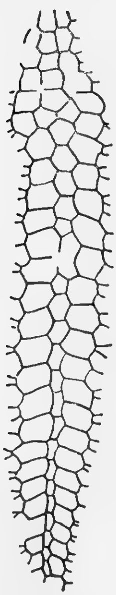

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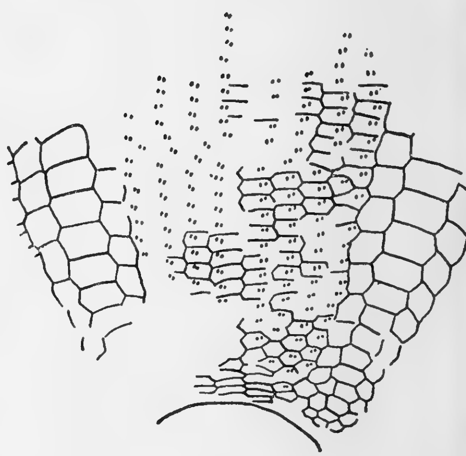

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FIGS. 15-20.—*Lepidesthes alta* Kier, new species: 15-19, Casts of interior surfaces of ambulacra I, II, III, and interambulacra 1, 2, respectively, of holotype, U.S.N.M. 80554, × 1. (See pl. 7.) In these areas of holotype, plates absent, being represented by mold of interior surface of plates. Drawings of casts reversed in order to show plates in proper position as viewed from the exterior. 20, Exterior surface of portion of ambulacrum V and its adjacent interambulacra. In this portion of the holotype, the plates are still represented, therefore showing the arrangement of the plates at the exterior of the test, × 1.5. (See pl. 7, figs. 2, 4.)

Peristome.—Very small, less than 10 mm. in diameter or one-sixth horizontal diameter of test. Bordering area composed of many columns of very low, wide ambulacral plates with at least three or four plates in each column. Interambulacra not reaching peristome, separated from it by ambulacral plates.

Ambulacra.—Average width at midzone 23 mm., nearly twice width of interambulacra. In most of ambulacra I, II, III, V (text figs. 15-17) plates preserved as internal molds, showing different shape, size than would be visible on exterior. On interior, plates of ambulacral columns adjacent to interambulacra larger than those of inner columns, but on exterior, of approximately same size. Exterior of plates preserved only in oral portion, plates low, width twice height, hexagonal with plates of columns adjacent to interambulacra narrower, pentagonal or hexagonal. In small portion of ambulacra IV showing exterior outline near midzone, plates narrower, width equal to height. Actual outline of isolated plate not known. Plates imbricating orally, laterally beveling under interambulacra, 60 to 80 plates in one column. No spinose processes evident on ambulacral plates as described by Cooper (1931, p. 537) in *Lepidesthes warrensis.* Pore pairs situated eccentric of center of plate on side nearest adjacent interambulacra, away from median line of ambulacra, with two inner columns of pores farther apart than others.

Interambulacra.—One-half width of ambulacra: 11 mm. at midzone. Three columns in each area except near peristome (text fig. 20) where four, in arrangement similar to that figured by Jackson (1912, pl. 67, fig. 8) in specimens of his *Lepidesthes wortheni.* Plates of median columns hexagonal, wider than high; adambulacral plates narrower, higher than wide, with rounded adradial border. Plates imbricating aborally, laterally over ambulacra, with plates of median columns beveling strongly over adjacent adambulacral plates, on interior appearing very narrow, in some cases not evident (text fig. 18).

Type.—Holotype, U.S.N.M. 80554.

Horizon and locality.—Mississippian (Meramecian—base of St. Louis or Warsaw limestone), Highland Rim, west of Nashville, Tenn.

Discussion.—This specimen is remarkable as it preserves the original shape of the echinoid. All previously described specimens of *Lepidesthes* have been flattened. Because of its high test, this echinoid must have had some difficulty maintaining an upright position, and it is probable that its tube feet were extremely long, extending from ambulacral plates well up on the test, to reach the sea floor and steady the animal. Presumably it lived in quiet water, as is true of modern echinoids of similar shape (Mortensen, 1935, p. 49).

Of all the species of *Lepidesthes,* this one resembles most *L. wortheni* from the Keokuk group at Crawfordsville, Ind. Both species have three columns of interambulacral plates at the midzone with four near the peristome. *L. alta* differs in having wider interambulacra, and ambulacra with 10 to 12 columns at the midzone as opposed to 8 in *L. wortheni.* Finally, the oral ambulacral plates are lower in *L. wortheni.*

LEPIDESTHES GRANDIS Kier, new species

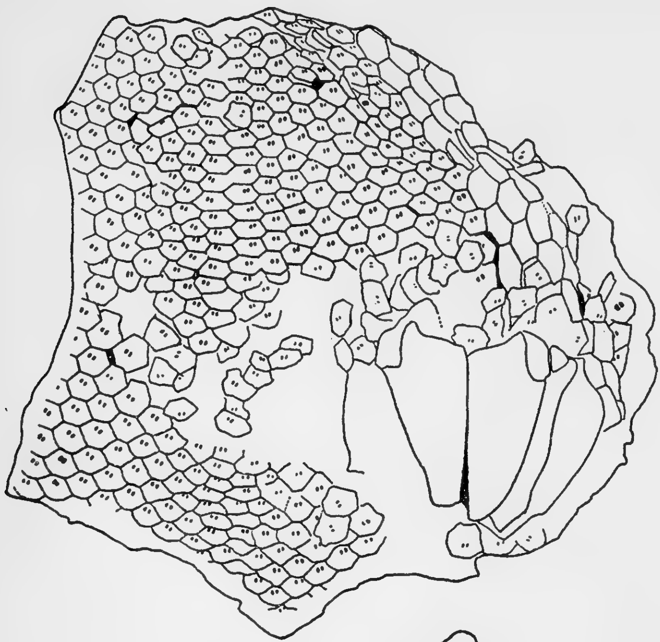
Plate 8A; text figures 21, 22

Diagnosis.—Species characterized by large size, 20 columns in each ambulacrum, four in each interambulacrum.

Material.—There are four flattened fragments. The holotype, the largest, is 90 mm. wide, 85 mm. high, 20 mm. thick, with one surface showing the midzone portion of two ambulacra, one interambulacrum, and a portion of the lantern; the other surface showing the oral portion of an ambulacrum. The other fragments are small, showing portions of the ambulacra, and interambulacra. In all the fragments, the plates are very well preserved with the tubercles, peripodia, and spines present. The aboral portion of the test and the apical system are not preserved.

Shape.—Not known. Test extremely large with an approximated horizontal diameter over 130 mm.

Ambulacra.—Extremely wide, approximately 65 mm. at midzone, five times width of interambulacra; 20 columns at midzone. Plates imbricating orally, with greatest imbrication in oral portion of test, laterally beveling under interambulacra. At midzone, plates hexagonal, wider than high, plates of median columns lower, wider than other plates. Pore pairs in peripodia in upper middle of exposed portion of plates except in median columns where occurring on side of plate away from median suture. Pores oblique to surface with pore pairs on under surface located more orally than pore pairs on upper surface. Edges of plates notched and grooved (see pl. 8A, fig. 3) resulting in interlocking of plates when in original position; imbrication slight. Oral of midzone, plates gradually lose hexagonal shape becoming irregular in outline, with exposed portion of plates considerably wider than high, with curved contacts with adjacent plates. Plates oral of midzone (see pl. 8A, fig. 4) approximately twice as thick as midzone plates, pore pairs located in center of exposed portion of plate immediately below adjacent aboral plate, pores not as oblique as in midzone plates. Imbrication very great with less than one-half area of plate exposed



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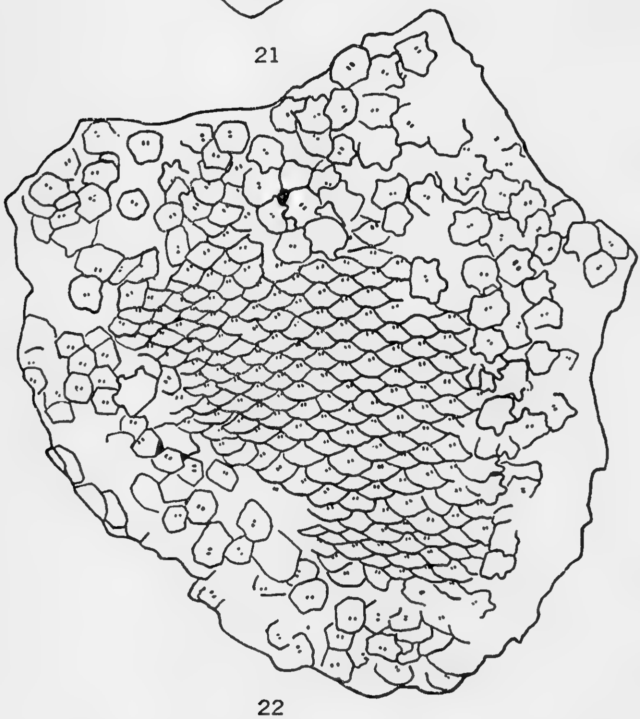

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FIGS. 21-22.—*Lepidesthes grandis* Kier, new species: 21, One side of holotype, U.S.N.M. 136461, showing most of width of portion of an ambulacrum at the midzone and a portion of an adjacent interambulacrum, × 1. (See pl. 8, fig. 1.) 22, Other side of holotype showing portion of ambulacrum oral to midzone, × 1.

to surface, with low angle from horizontal of edge or sutural portion of plates. In many plates aboral portion bilobed (see pl. 8A, fig. 5) with lobes extending on either side of pore pairs on under surface of adjacent aboral plates. Paratype U.S.N.M. 136464 with many low, lathlike plates probably from peristome.

Interambulacra.—At midzone four columns of hexagonal, higher than wide plates imbricating aborally, laterally over ambulacra. Plates notched, grooved, interlocking when in original position. In paratype U.S.N.M. No. 136462, oral portions of interambulacrum visible with plates more imbricate, more rounded than at midzone. Several poreless plates lying near this interambulacrum possibly representing fifth column but due to shifting of plates not possible to be certain.

Lantern.—One pyramid, two half-pyramids, portion of two epiphyses, one brace present on holotype. Lantern large with pyramid 25 mm. high, 22 mm. wide. Foramen magnum shallow, with sides of wide-angled pyramid corrugated for attachment of interpyramidal muscles. Epiphyses cap half-pyramids, extremely wide extending high above upper limits of outline of half-pyramid but not joined, widest epiphyses ever described in Paleozoic echinoid. Outer surface of each epiphysis corrugated where plate joins half-pyramid. Tip of brace exposed between two adjacent epiphyses.

Spines.—Longitudinally deeply striated, expanded bases, tapering, with approximate maximum length of 5 mm. Secondary tubercles on most of surface of interambulacral and ambulacral plates.

Types.—Holotype, U.S.N.M. 136461; paratypes, U.S.N.M. 136462-4.

Horizon and locality.—Pennsylvanian (Strawn group, Millsap Lake formation). Found in wash on old Evans farm, $\frac{3}{4}$ mile south of Dennis, Hood County, Tex. Collector: Mrs. J. H. Renfro.

Discussion.—Having 20 columns in each ambulacrum immediately distinguishes this echinoid from any other known species of *Lepidesthes.* Previously the maximum number of columns known in an ambulacrum of *Lepidesthes* was 16. The great size of its test further distinguishes *L. grandis* from all other species of this genus. The only other echinoid having as many columns in each ambulacrum is *Meekechinus elegans* Jackson, with 20 columns. In *Meekechinus,* however, primary tubercles occur on both the interambulacral and ambulacral plates. These tubercles are the distinguishing feature between *Meekechinus* and *Lepidesthes.*

Morphological notes.—The imbrication of the plates in *Lepidesthes* has always been considered as evidence of former flexibility of the test. While flexibility accompanies imbrication in the Echinothuridae and no doubt in some Paleozoic echinoids, it apparently did not occur in this species of *Lepidesthes,* as it is obvious that no sliding could have occurred along the sutures between the plates. The ambulacral and interambulacral plates at the midzone of the test are notched and grooved along their edges preventing any movement. In the oral portion of the test the ambulacral plates could not have shifted without cutting off the tube feet of an adjacent plate. The imbrication served not for flexibility but rather for strength, with the elimination of a vertical suture. Where the angle of the sutural portion of a plate is low, the sutural area is great with a strong bond resulting between the plates, but where the suture is vertical the thickness of the suture can be no greater than the thickness of the plate. For example, a plate with an edge having an angle of 30 degrees to the horizontal will have twice the sutural area of a plate with a vertical suture. Furthermore, the vertical suture is more susceptible to fracture as it is parallel to the force of a blow upon the surface of the test, whereas the oblique suture is at an angle to the blow with part of the force being transmitted through the plate rather than along the plate surface.

LEPIDESTHES COLLETTI White

Plate 8B; text figures 13, 14

Lepidesthes colletti White, 1878. Proc. Acad. Nat. Sci. Philadelphia, p. 33.

In the U. S. National Museum is an echinoid from the Warsaw limestone at Boonville, Mo., which can be referred to this species. White's holotype, long missing, is now at the U. S. National Museum (135221) (Trumbull, in press) and was available for comparison. The Boonville specimen is similar in all respects to the holotype.

Figured specimen.—U.S.N.M. 136466.

Horizon and locality.—Mississippian (Meramecian—Warsaw limestone), Boonville, Mo.

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EXPLANATION OF PLATES

PLATE 1

Page

Archaeocidaris immanis Kier, new species 3

Aboral view, × 1, holotype, U.S.N.M. 90763. Specimen photographed under glycerine with that portion of specimen showing only matrix later air brushed out by Lawrence B. Isham, scientific illustrator. Pennsylvanian (Dewey limestone), NE¼ sec. 33, T. 23 N., R. 12 E., Washington County, Okla. Portion of interambulacrum visible in upper right-hand portion of photograph depicted on text figure 1.

PLATE 2

Archaeocidaris immanis Kier, new species 3

1, 2, Side views, × 1; 3, oral view, × ½; 4, enlarged view of portion of ambulacrum visible in lower part of figures 1 and 3 of this plate, with drawing of same region on text figure 2, × 3, holotype, U.S.N.M. 90763. Photographed under glycerine.

PLATE 3

Page

A. *Archaeocidaris immanis* Kier, new species 3

1, View of fracture surface across interambulacral plates showing absence of basal terrace, × 1. Photographed under glycerine. 2, View of ambulacral plate showing well-developed flange for perradial overlap, × 8, holotype, U.S.N.M. 90763.

B. *Archaeocidaris agassizi* Hall 7

3, View showing ambulacral plates in place; 4, view showing isolated ambulacral plates after their removal from area shown in figure 3. Note that perradial flange is not visible where plates in original position (fig. 3) but visible where plates separated, × 6, figured specimen, U.S.N.M. S3825. Mississippian (Lower Burlington), Burlington, Iowa.

C. *Archaeocidaris aliquantula* Kier, new species 7

5, Oral view, × 4, holotype, U.S.N.M. 136451; 6, view of interambulacral plates showing coarse radial plications extending from basal terrace to margin of each plate, × 4, paratype, U.S.N.M. 136452; 7, view of ambulacral, interambulacral, plates, and primary and secondary spines, × 4, paratype, U.S.N.M. 136453. Mississippian (Kinderhookian), Gilmore City formation, Gilmore City, Iowa.

PLATE 4

A. *Archaeocidaris blairi* (Miller) 8

1, Aboral view; 2, oral view. × 2, U.S.N.M. S3828. Photographed under glycerine. Mississippian (Warsaw), Boonville, Mo. Drawing of specimen on text figures 3, 4.

B. *Polytaxicidaris dyeri* Kier, new species 11

3, View of oral surface; 4, cast of oral surface; 5, view of aboral surface, × 2, holotype, Museum of Comparative Zoology, Harvard, 3354. Mississippian (Osagean), Borden Group, Crawfordsville, Ind. Drawing of figure 4 on text figure 5.

PLATE 5

A. *Polytaxicidaris dyeri* Kier, new species 11

1, View of paratype, × 2, Museum of Comparative Zoology, Harvard, 3353. Mississippian (Osagean), Borden Group, Crawfordsville, Ind.

B. *Palaechinus tetrastichus* Kier, new species 12

2, View of paratype, × 1, U.S.N.M. 136455; 3, view of slab containing holotype, U.S.N.M. 136454, the large specimen, and two paratypes, U.S.N.M. 136456 (upper right) and U.S.N.M. 136457 (lower left), × 1. Mississippian, Madison formation, Lodgepole member, at type section of Lodgepole limestone, Little Chief Canyon, Fort Belknap Indian Reservation. Drawings of specimens on text figures 6, 8, 9, 10.

PLATE 6

Lepidechinus cooperi Kier, new species 15

1, Aboral view, × 4, holotype, U.S.N.M. 136458. Drawing of apical

Page

system of this specimen on text figure 11. 2, Oral view of lantern, × 4, paratype, U.S.N.M. 136459; 3, aboral view; 4, view of portion of oral side, × 4, paratype, U.S.N.M. 136460. Drawing of oral portion of interambulacrum of this specimen on text figure 12. Photographed under glycerine. Mississippian (Kinderhookian), Gilmore City formation, Gilmore City Iowa.,

Plate 7

Lepidesthes alta Kier, new species.. 17

1-2, Side view; 3, aboral view; 4, oral view; × 1; 5, view of apical system, × 2. Drawings of specimen on text figures 15-20. Holotype, U.S.N.M. 80554. Mississippian (Mermecian), base of St. Louis or Warsaw limestone, Highland Rim, west of Nashville, Tenn.

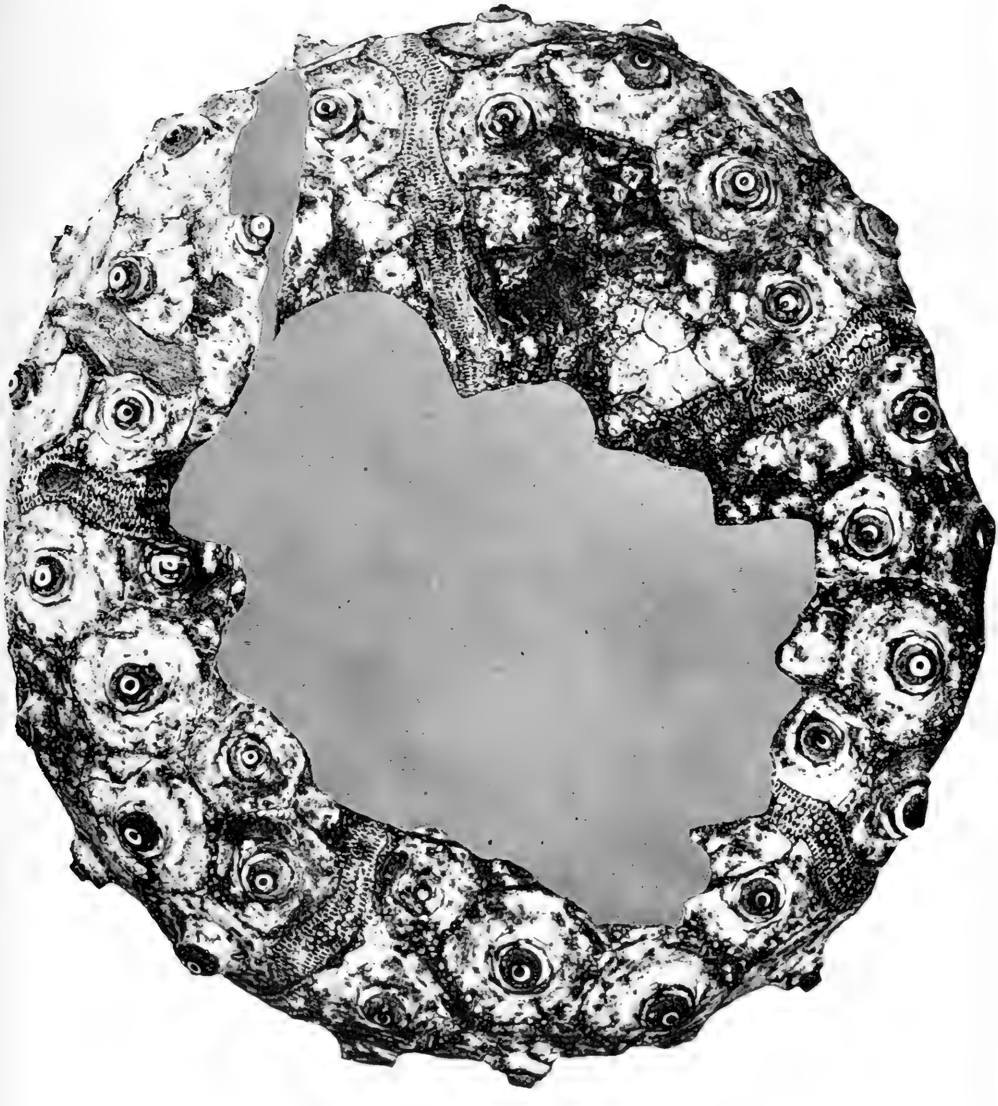
Plate 8

A. *Lepidesthes grandis* Kier, new species................................ 20

1-2, Views of both surfaces of holotype showing in figure 1 the ambulacrum near the midzone with portion of an interambulacrum on upper right-hand side, and in figure 2 portion of an ambulacrum oral to the midzone, × 1, holotype, U.S.N.M. 136461. Drawings of this specimen on text figures 21, 22; 3, surface and edge view of midzone ambulacral plate showing notched sutural surfaces; 4, surface and edge view of two oral ambulacral plates, × 4, plates from paratype, U.S.N.M. No. 136462; 5, enlarged view of plate from ambulacrum of holotype showing bilobed aboral margin, × 4. Pennsylvanian (Allegheny), Strawn Group, Millsap Lake formation. Found in wash on old Evans farm, ¾ mile south of Dennis, Hood County, Tex.

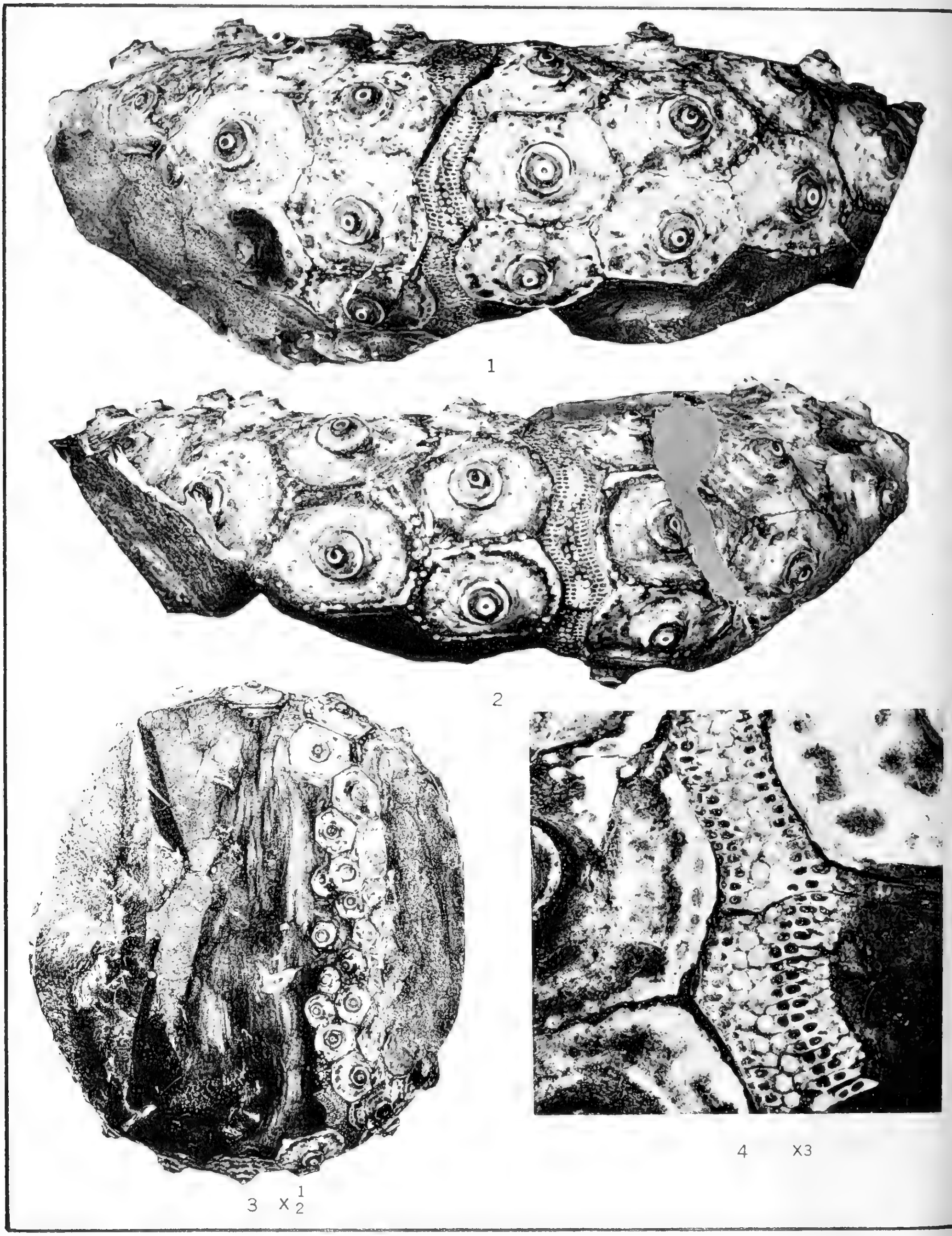
B. *Lepidesthes colletti* White.. 23

6, View of specimen U.S.N.M. 136466, × 1. Drawings of specimen on text figures 13, 14. Mississippian (Meramecian), Warsaw limestone, Boonville, Mo.



ARCHAEOCIDARIS IMMANIS KIER, NEW SPECIES

(See explanation at end of text.)



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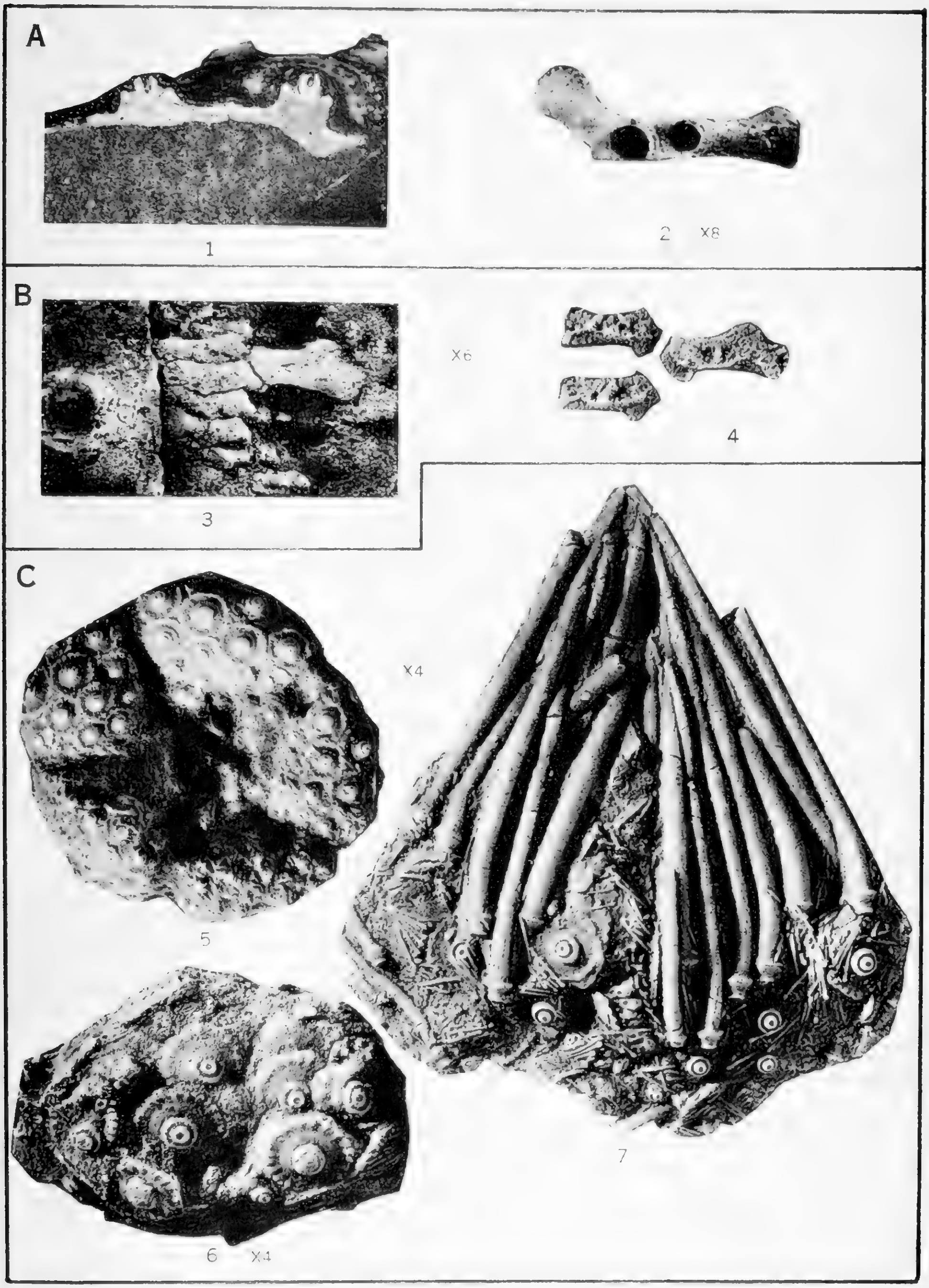
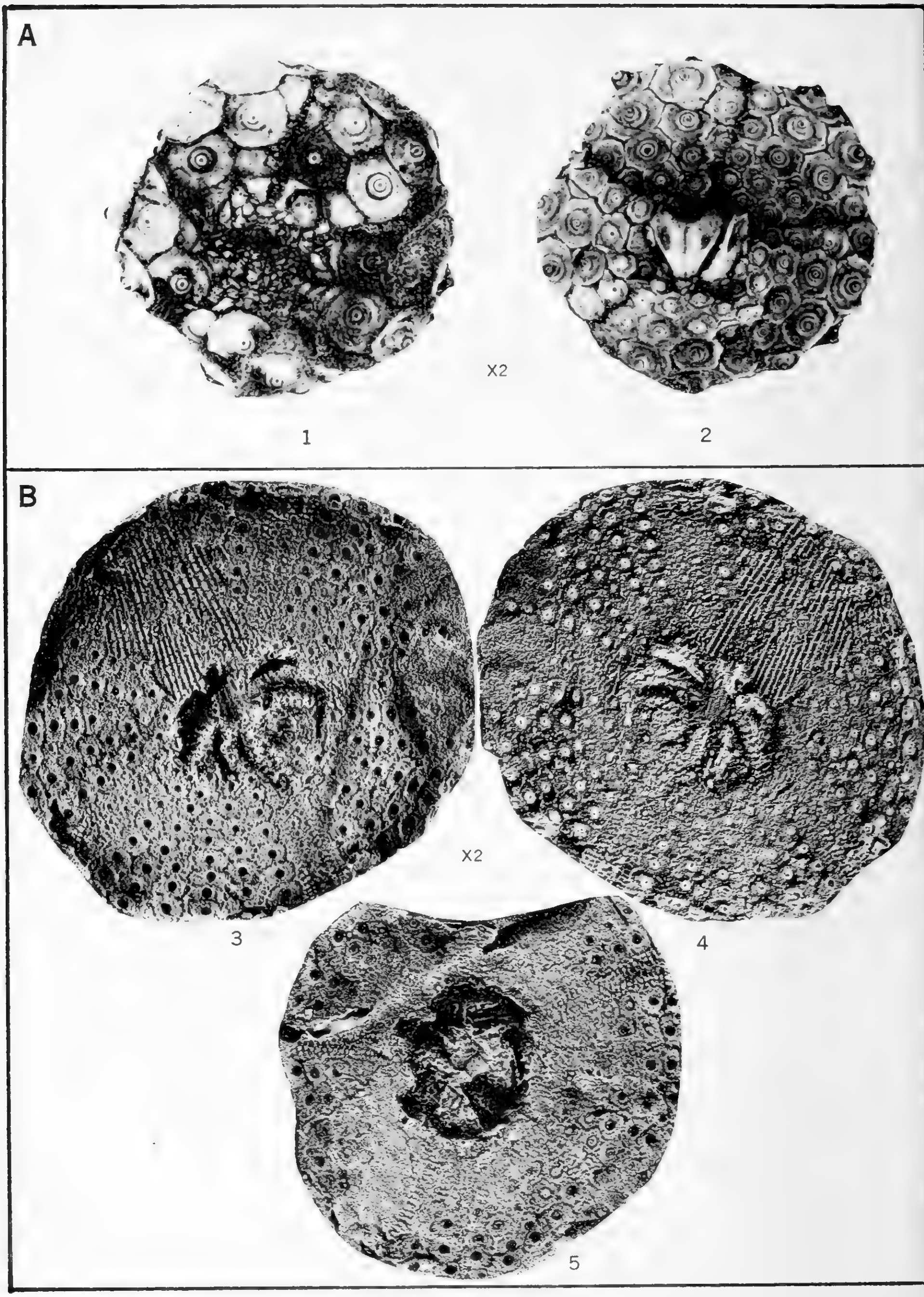


ARCHAEOCIDARIS IMMANIS KIER, NEW SPECIES; ARCHAEOCIDARIS AGASSIZI HALL; AND ARCHAEOCIDARIS ALIQUANTULA KIER, NEW SPECIES

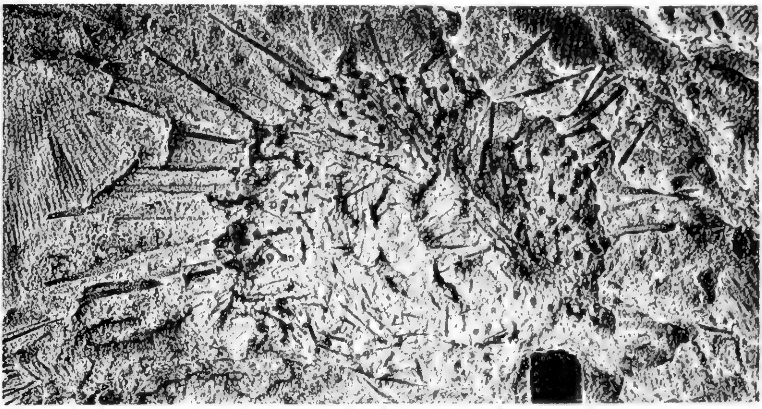
(See explanation at end of text.)



ARCHAEOCIDARIS BLAIRI (MILLER) AND POLYTAXICIDARIS DYERI KIER, NEW SPECIES

(See explanation at end of text.)

A



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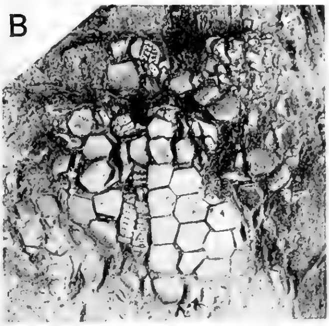

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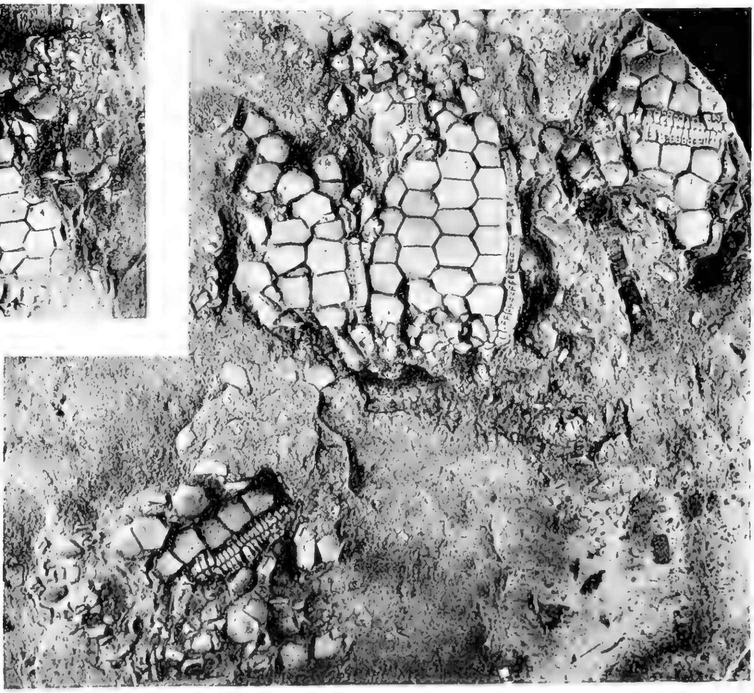

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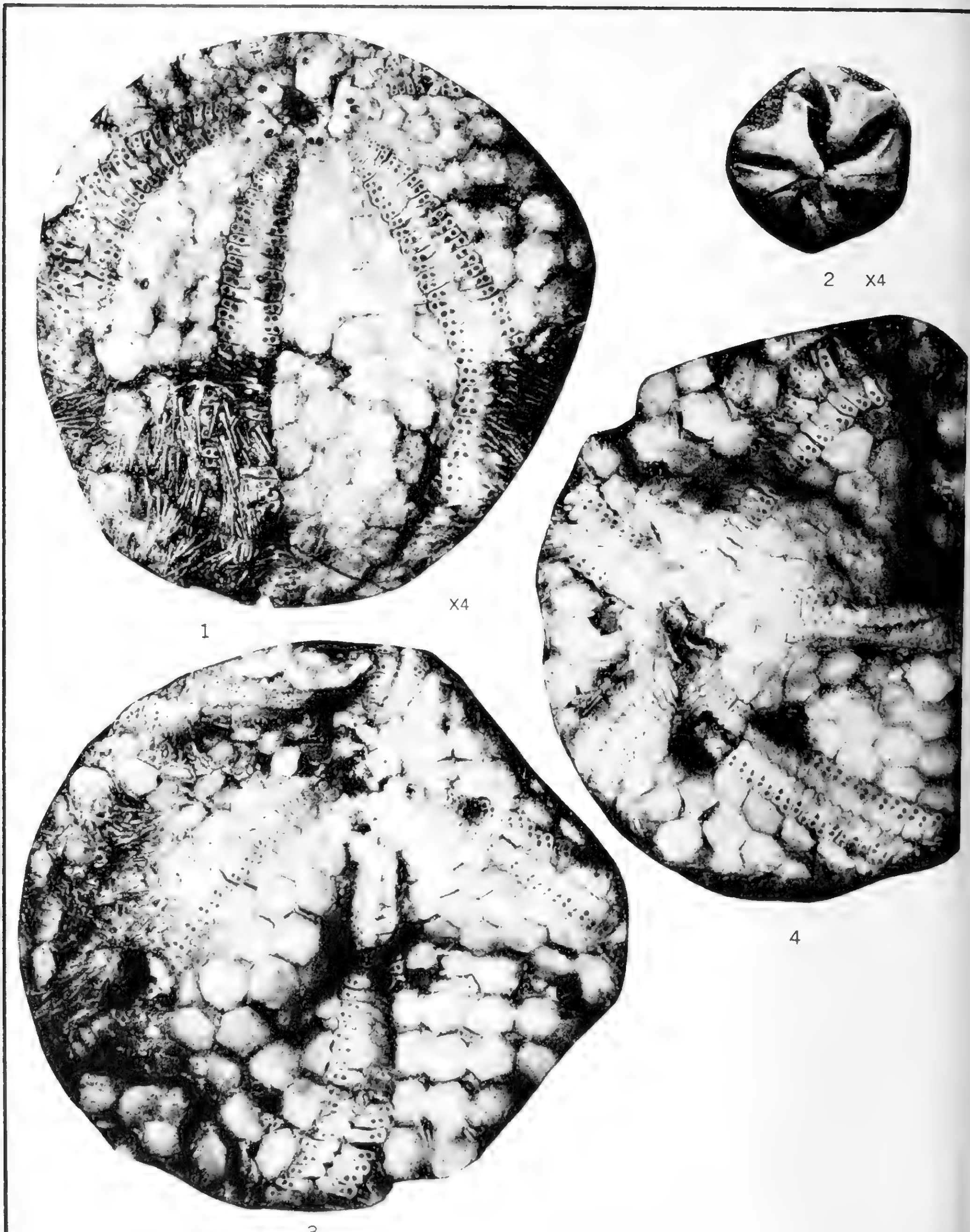
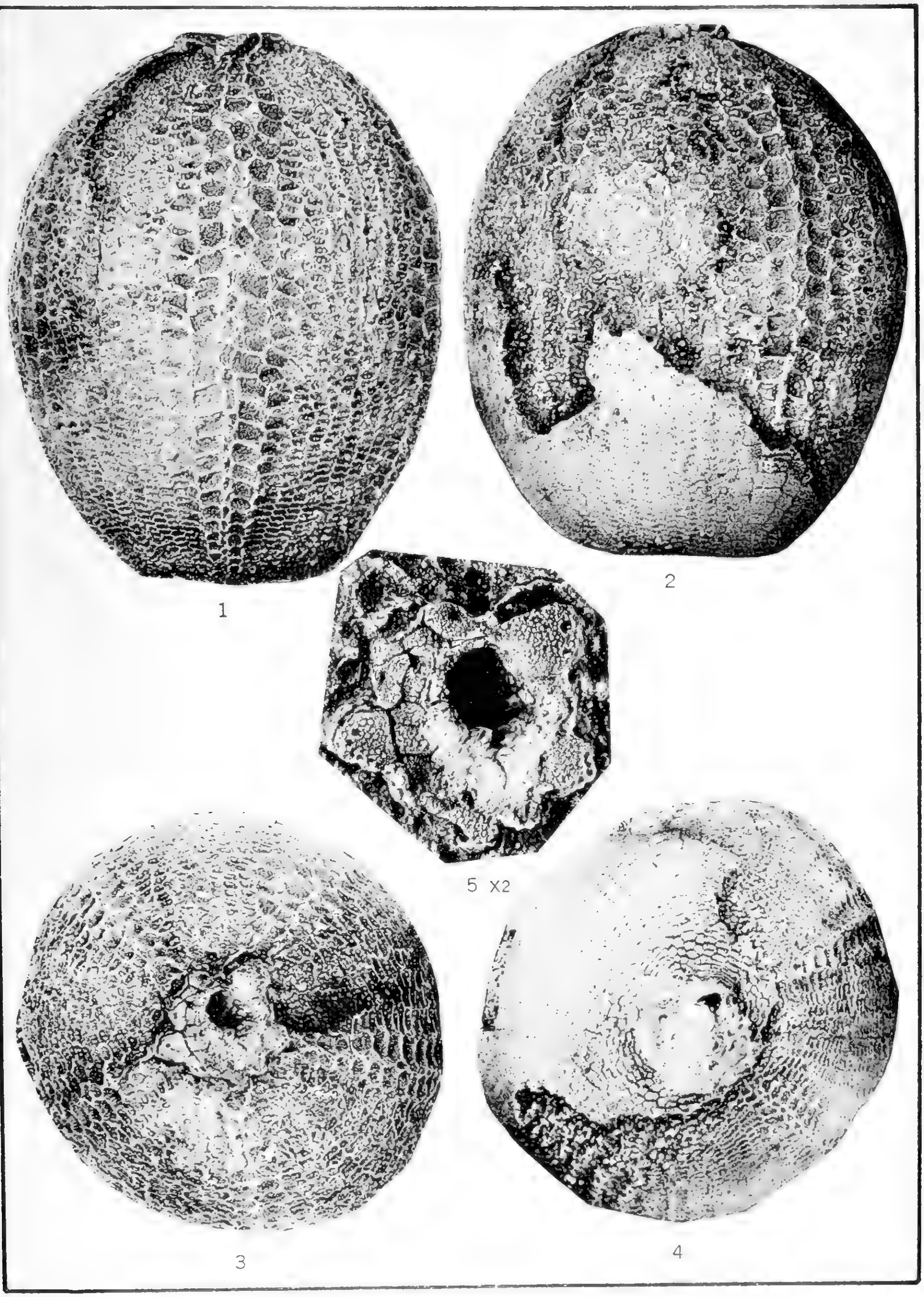
POLYTAXICIDARIS DYERI KIER, NEW SPECIES, AND PALAECHINUS TETRASTICHUS KIER, NEW SPECIES

(See explanation at end of text.)



LEPIDECHINUS COOPERI KIER, NEW SPECIES

(See explanation at end of text.)



LEPIDESTHES ALTA KIER, NEW SPECIES

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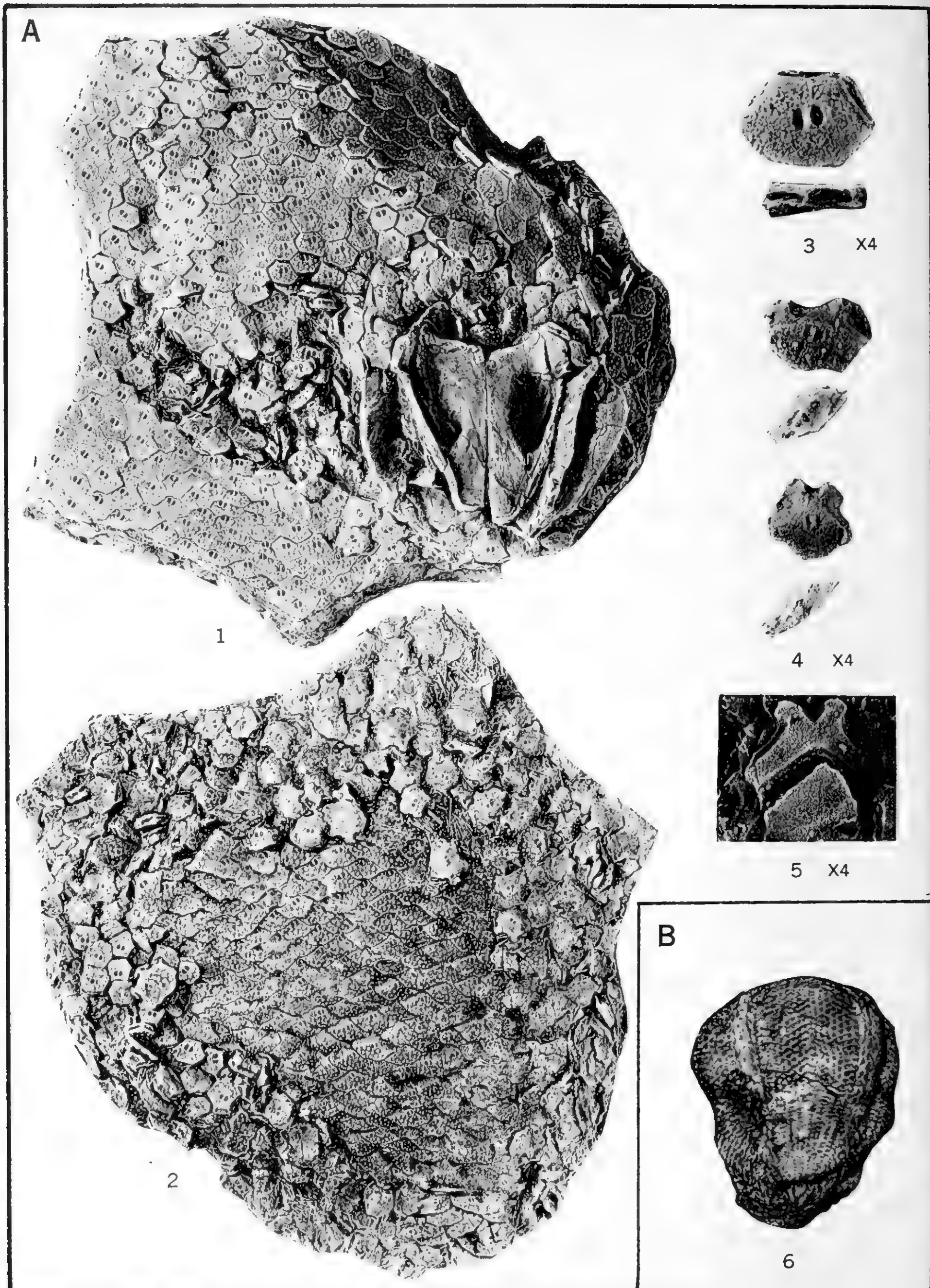

LEPIDESTHES GRANDIS KIER, NEW SPECIES, AND LEPIDESTHES COLLETTI WHITE

(See explanation at end of text.)

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PERIODICITIES IN IONOSPHERIC DATA

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PERIODICITIES IN IONOSPHERIC DATA

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In an earlier paper [1] I gave preliminary figures that indicated periods in ionospheric data which agreed in length with periods in solar variations and in weather. They are integral submultiples of 273 months. In a still earlier paper [2] I showed other relationships appearing to exist between solar variation and ionospheric data. The ionospheric data then available were insufficient to yield fully convincing conclusions on these relationships. With more recent data now available, I return to the subject.

THE MASTER PERIOD

Before going on I will refer to the master period which I assign as 273 months. My friend Herbert Grünhagen has discussed this period with me in correspondence. His own extensive studies of periodic phenomena have led him to prefer 22.6 years, or 271.2 months. Though the difference from 273 months is less than 1 percent, yet in a long series like 90 years a subordinate integrally related period would many times trend in opposite phases, using these two different values. I therefore wished to decide definitely between them. As precise solar-constant values are recorded only since 1920, it is necessary to use the longer records of some related phenomenon. The 10⅑-month period $\left(\frac{273}{27}\text{ months}\right)$ is strong in Washington precipitation, though I believe meteorologists do not yet give it credence. I therefore computed the amplitude of the period, $\frac{1}{27}$ the disputed master period, from Washington precipitation of 1854 to 1957. I made three such computations with $\frac{271.2}{27}$, $\frac{273}{27}$, and $\frac{275}{27}$ months. In these computations I used the precautions I employ in my weather forecasts, as

[1] Smithsonian Misc. Coll., vol. 122, No. 4, 1953.
[2] Smithsonian Misc. Coll., vol. 107, No. 4, 1947.

described in several of my papers.[3] In the tabulations for the present purpose I used only months when Wolf sunspot numbers exceeded 20. These months were 790 in number. The results found were as follows, zero phase, January 1, 1957.

TABLE 1.—*Values in Washington precipitation in percentages of normal*

Period											Range
271.2/27	105.7	103.4	102.5	100.7	100.9	96.3	97.3	97.9	98.0	97.7	9.4%
273/27	95.7	95.8	93.4	96.1	99.3	102.0	103.7	108.0	104.8	101.1	14.6%
275/27	109.8	102.4	103.3	99.3	95.4	92.9	96.2	97.6	98.8	104.5	16.9%

As expected, the phases of the three periods differ. The ranges of the last two are, within the precision of the determination, approximately equal, and are both definitely greater than the range of the first. As it is more convenient in computation to use the integral submultiples of 273 than those of 275, I shall continue to use 273 as the master period.

PERIODS IN IONOSPHERIC PHENOMENA

The periods I am about to consider are exact integral submultiples of 273 months, and are approximately the same I have used in long-range weather forecasts. The list with several recent additional ones was published January 1958 in the Journal of the Association for Applied Solar Energy, at Phoenix, Ariz. Values of the quantity $h'F_2$, published by the Bureau of Standards in "Ionospheric Data," July 1944 to June 1957, were employed. From these tabulations Mrs. Hill computed the daily mean values for the average of the hours 11, 12, 13, and from these the monthly mean values. In a few cases (about 5 in total number), where the observations were fragmentary, monthly values were interpolated harmonious to the trend of the complete observations of similar months.

As I had used these observations for the years 1944 to 1952 in an earlier publication, I employed the mean monthly value 315, then determined, rather than to do that earlier work all over, using the mean from 1944 to 1957. It makes little difference in the departures from the mean, merely altering the whole list of departures by a few units up or down, all in the same direction.

[3] See, for instance, Smithsonian Misc. Coll., vol. 134, No. 1, p. 5, 1956; or Journ. Solar Energy, Sci. and Eng., vol. 1, No. 1, pp. 3, 4, 1957.

Taking the monthly departures of $h'F_2$ from 315, I arranged them in a table by months of the year and found the mean monthly normals and their average departures from the means as follows:

TABLE 2.—*Monthly mean departures of $h'F_2$ from 315*

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−69±9	−60±14	−27±24	+29±30	+88±26	+89±25	+93±19	+73±35	0±11	−52±13	−71±10	−73±9

From these figures the mean average deviation is ±19 and the mean probable error of the monthly mean departures from 315 is ±15. I subtracted the appropriate values in table 2 of the monthly departures of $h'F_2$ from the mean value 315, for the interval July 1944 to June 1957. I then tabulated these departures from the monthly means for many periods up to 20 months, which are integral submultiples of

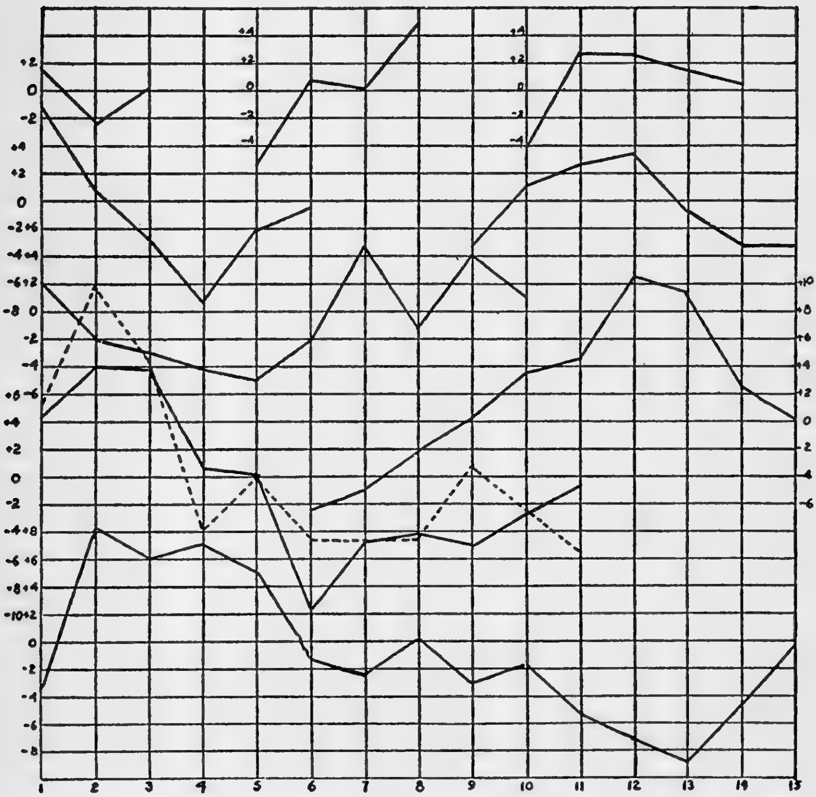

FIG. 1.—Periods in months integrally related to 273 months. Top line: $2\frac{23}{34}$, $4\frac{1}{3}$, $5\frac{1}{18}$ months. Second line: $6\frac{1}{15}$, 7 months. Third line: $9\frac{3}{4}$, $10\frac{1}{8}$ months. Fourth line: $11\frac{3}{8}$ months; dotted curve, preliminary. Fifth line: $15\frac{1}{6}$ months.

273 months. In several cases where small but real amplitudes were expected, the curves carried subordinate overriding periods, integrally related to those sought. I give two instances. The period $8\frac{1}{34}$ months was found to be almost completely comprised of the period $8\frac{1}{34} \div 3$ and another $8\frac{1}{34} \div 4$. So the period $8\frac{1}{34}$ months disappeared. The period $11\frac{3}{8}$ months carries a feeble superrider of $11\frac{3}{8} \div 3$. I show

TABLE 3.—*Periodicities in monthly values of departures in h′F₂*

Monthly periods	March of departures and probable errors							
$2\frac{23}{24}$	+1.6	−2.5	+0.2					
	±1.1	±1.1	±1.1					
$4\frac{1}{3}$	−5.4	+0.7	+0.1	+4.8				
	±1.5	±1.5	±1.5	±1.5				
$5\frac{1}{18}$	−4.2	+2.6	+2.6	+1.5	+0.5			
	±1.6	±1.6	±1.5	±1.5	±1.5			
$6\frac{1}{15}$	+6.9	+2.7	−2.7	−7.4	−2.2	−0.6		
	±1.8	±1.8	±1.8	±1.8	±1.8	±1.8		
7	−3.3	+1.1	+2.6	+3.4	−0.7	−3.3	−3.2	
	±2.0	±2.0	±2.0	±2.0	±2.0	±2.0	±2.0	
$9\frac{3}{4}$	+2.1	−2.9	−4.2	−5.0	−2.2	+4.6	−1.4	−4.4
	±2.1	±2.1	±2.1	±2.1	±2.1	±2.1	±2.1	±2.1
	+3.9	+1.0	..	..	..	..	..	..
	±2.1	±2.1	..	..	..	..	..	..
$10\frac{1}{9}$	−8.5	−7.2	−4.1	−1.7	+1.6	+2.4	+8.5	+7.2
	±2.1	±2.1	±2.1	±2.1	±2.1	±2.1	±2.1	±2.1
	−0.5	−3.9	..	..	..	..	..	..
	±2.1	±2.1	..	..	..	..	..	..
$11\frac{3}{8}$	+4.2	+7.9	+7.8	+0.5	+0.1	−10.0	−4.9	−4.3
	±2.2	±2.2	±2.2	±2.2	±2.2	±2.2	±2.2	±2.2
	−5.1	−2.8	−0.7	..	..	..	..	..
	±2.2	±2.2	±2.2	..	..	..	..	..
$15\frac{1}{6}$	−3.4	+8.3	+6.0	+7.1	+5.1	−1.4	−2.5	+0.2
	±2.3	±2.3	±2.3	±2.3	±2.3	±2.3	±2.3	±2.3
	−3.1	−1.7	−5.3	−7.3	−8.7	−4.7	−0.3	..
	±2.3	±2.3	±2.3	±2.3	±2.3	±2.3	±2.3	..

these two cases in figure 1 and table 3. Figure 1 gives curves for $2\frac{2}{3}$ and $4\frac{1}{68}$ months derived from a tabulation for $8\frac{1}{34}$ months. The dotted curve with $11\frac{3}{8}$ months is the preliminary before removing $11\frac{3}{8} \div 2$. In six other tabulations which I made (not here shown), superriding integrally related periods were entangled with the periods sought, in complexities which I did not take time to ferret out and so I omit those 6 cases. As will appear in table 3 and figure 1, I present nine clear cases of periodicity in the quantity $h'F_2$ not obscured by overriders.

By inspection of table 3 and figure 1 readers will see the march of $h'F_2$ values in the periods integrally related to 273 months. Within the limits of precision indicated by the probable errors, the curves are fairly regular. The ranges of amplitude of the curves are from $1\frac{1}{3}$ to 5 percent of the average monthly value 315. These ranges are only about one-fifth as great in percentage as the ranges of weather periods found in percentages of normal precipitation. Yet they are about 20 times as large as the percentage changes of the solar constant of radiation. All alike, these three varieties of phenomena proceed in periods integrally related to 273 months. A theoretical solution of their correlation would be interesting indeed.