Geology of the Illescas Region, Northern Perú (South America)

Autor(en): **Werenfels, A.**

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Geology of the Illescas Region, Northern Perú (South America).

By A. WERENFELS (Basle).

With 1 plate (XVII) and 4 figures.

A. Introduction.

In May and June 1925 the writer has investigated the Illescas region (see Fig. 1) belonging to the Southernmost part of the Department of Piura, Northern part of the Republic of Perú[1]). The region is situated about 6 degrees to the South of the equator and is bounded to the South and to the West by the Pacific Ocean, to the North by the Bay of Sechura and to the East by the Desert of Sechura. During 1923 Dr. W. HOTZ already undertook a series of geological investigations in the Illescas area. He brought a collection of specimens to the Museum of Natural History of Basle

[1]) We are indebted to the Bataafsche Petroleum Maatschappij in the Hague for the permission to publish this paper.

(Switzerland) of which Dr. A. TOBLER made an investigation and found again the foraminifera genus Helicolepidina[1]) already known from Trinidad[2]), Venezuela[2]), Columbia[3]) and Ecuador.[4]) The writer was also able to examine this collection as well as a map of the region prepared by Dr. HOTZ, for which he is very much indebted to the latter. There is incomplete knowledge of the stratigraphy of the area.[5]) These notes may, therefore, be helpful for elucidating the geology of the region.

B. General Features.

The *Illescas Mountains*, bordering the Pacific Ocean, extend over a distance of 33 kilometres (about 20 miles). They consist of destroyed hills and ridges, the tops of which are rising between 250 and 350 metres (800—1120 feet). These elevations are dissected by narrow and deep V shaped valleys with large alluvium cones spreading out at the base of the mountains over the plains of the desert. These cones unite to form the so-called Breccia-Fan. To the South-West of the Illescas hills high dunes coat the base of the mountain-system. Flat topped table mountains, separated by a valley about 1 kilometre (0,6 mil.) wide, border the centre of the Illescas Mountains to the East. Since the erosion has left very little of the flat tops they are better called „*Mesa-Buttes*" (see Table XVII, Fig. 1).

The *Sechura desert* extends to the East of the Illescas region. It is divided into two terraces by a high cliff (see Fig. 3). This step (Stufe) originates from an abandoned marine cliff. The land has risen as it is indicated by the beach breccia of the *Tablazo* on the slope of the cliff. It extends from Yapate (see Fig. 3) in a general West-Eastern direction for about 12 kilometres (7,5 miles), turns to the South and passes Punta Tarde, lowering gradually down until it reaches the big lagoon in the South. During the flood-year of 1925, another smaller lagoon branched off to the North from this big lagoon, following

[1]) TOBLER, A. Obereocäne Grossforaminiferen der nordperuanischen Küstenregion. Eclogae geologicae Helvetiae Vol. XX. 1927.

[2]) TOBLER, A. Helicolepidina, ein neues Subgenus von Lepidocyclina. Eclogae geol. Helvetiae Vol. XVII, 1922.

[3]) WERENFELS, A. A stratigraphical Section through the Tertiary of Toluviejo, Columbia. Eclogae geologicae Helvetiae Vol. XX. 1926.

[4]) VAUGHAN, TH. W. Foraminifera from Upper-Eocene Deposits of the Coast of Ecuador. Proceedings of National Academy of Sciences. Vol. 12. No. 8, p. 533—535. 1926.

[5]) BOSWORTH, T. O. Geology of the Tertiary and Quaternary Periods in the North-West Part of Perú. London 1922.

the cliff mentioned above, as far as Punta Tarde and reaches the Pacific Ocean again near Sechura. Therefore the whole Illescas region was actually forming an island.

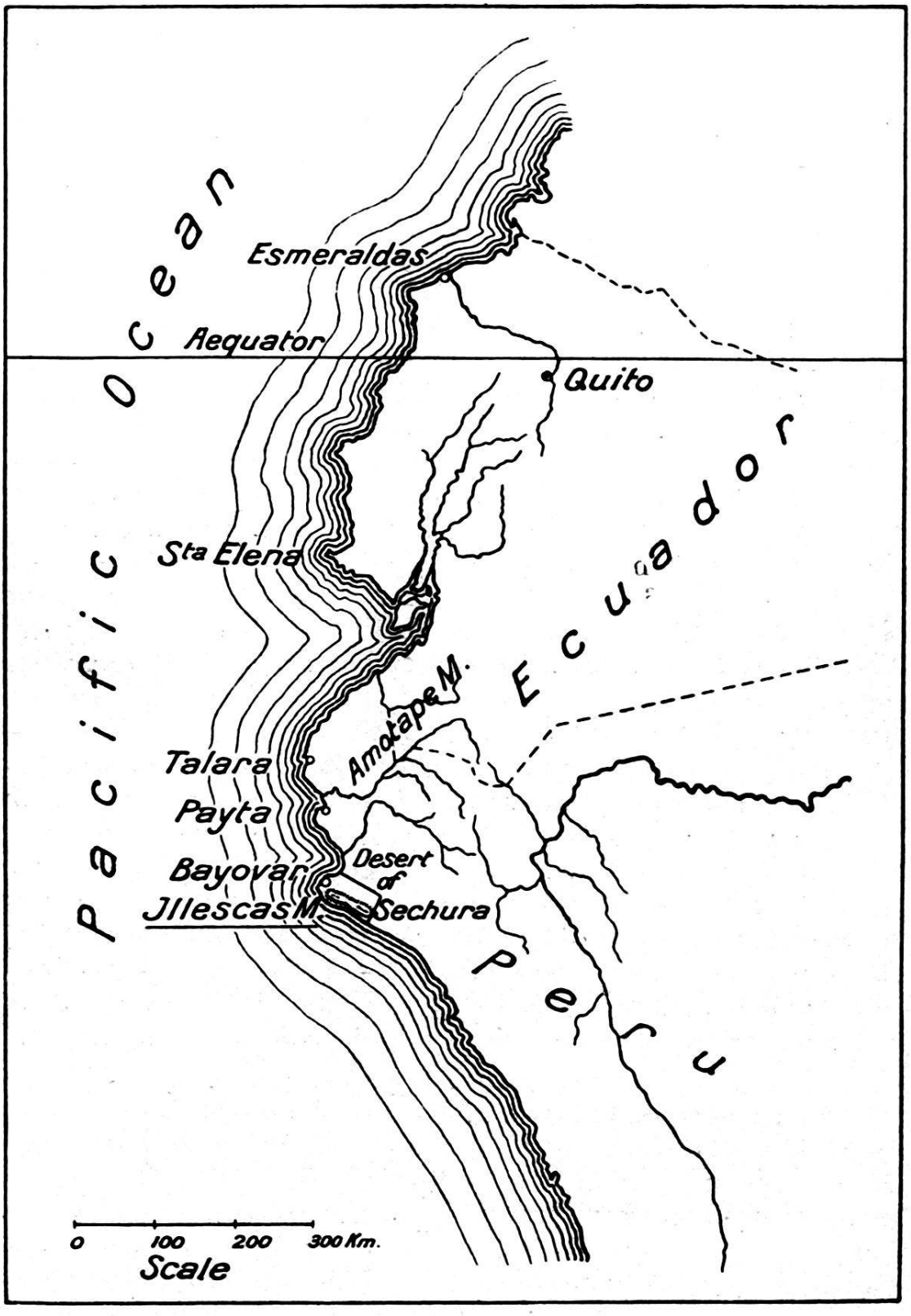

Fig. 1. Key Map.

The lower terrace of the Sechura desert is formed by the so-called *Miniplane* which rises about 10—15 metres (32—48 feet) above the sea-level. It shows a terrace of Tablazo, following the top of the actual wave-cut cliff of the Bay of Sechura. The greatest part of the Miniplane is covered by sand and desert deposits.

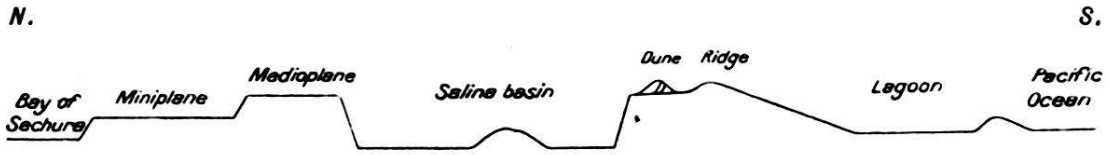

Fig. 2. Sketch of Topographical Section.

The upper terrace of the Sechura desert is occupied by the *Medioplane,* also topped by a Tablazo cliff, descending about 15 metres (48 feet) to the Miniplane (see Fig. 2). Large parts of the Medioplane are covered by living sand-dunes, some of them reaching to heights from 50—60 metres (160—190 feet). The large Salina basin is lowered down in this Medioplane below the level of the sea. The basin is apparently cut down by wind erosion.

The remains of the third Tablazo-terrace are found on the slopes of the Illescas Mountains to the South of Bayovar (see Fig. 3). There are small masses of horizontal Tablazo-breccia about 155 metres (390 feet) above sea-level, forming the remains of a *Maxiplane* of that height.

The *climate* of this area can be described as semi-arid, as that of a subtropical desert, with a medium temperature of 5—6 degrees centigrades (10 F.) less than it ought to be according to its latitude. The cool, antarctic Humbold stream of the Pacific accounts for this fact as well as for the rainlessness of the Peruvian coastal areas. During 34 years no rain has fallen in the Illescas region; 1925—26 however brought a large amount of precipitation which caused the overflood of the Salina basin as well as the enlargement of the big lagoon.

The poor *Vegetation,* consisting of some Algarrobo-trees (Prosopis), very little grass and a sort of Convonvulus, receive their humidity from the very dense fogs during summer-time. These even may condense to rain in the Illescas Mountains, as it is indicated by some permanent springs. These waters however do not reach the foot of the mountains. The whole region is completely uninhabited. Some ten years ago a sulphur mine was worked at Reventazon (see Fig. 3), a railway, now partially covered by sand-dunes, connected Reventazon

with Bayovar, then used as a harbour. During some time of the year the salt deposits of the Salina basin are worked. Owing to the flood the mine has been abandoned during 1925.

C. Stratigraphy.

The greater part of the area herein considered except the Illescas Mountains is masked by Quaternary deposits: Tablazos, sand and gravel. Most of the outcrops of the subjacent beds are to be found near the foot of the Illescas Mountains and also along the cliffs of Yapate-Punta Tarde and of the Salina basin. There are sufficient exposures to determine the principal features of the region as well as to recognize more details of the structure by plane-table work, which however could not be done by our field party.

1. Palaeozoic?: Igneous rocks, Schists and Slates.

The samples collected by Dr. W. Hotz and the author included: Granite, Gneisses, real Orthogneisses, Andesite and Kersantite. These Gneisses are steeply inclined and are cut by numerous Andesitic dikes. Three of them are several metres thick, forming prominent, wall-like ridges which can be followed uninterruptedly across hill and dale of the Illescas Mountains from their Eastern foot to their Western foot over a distance of 20 kilometres (12 miles). Besides these persistent Andesite dikes a number of shorter and thinner ones exist of the same rock, with the same trend N 60—80° E, dipping 80° S-vertically. These dikes also traverse the schists and slates, which will be mentioned below, but no Tertiary or younger sediments are invaded by them. There also exists a Kersantite dike on the Western slope of the Illescas Mountains, with a trend N 20° W dipping 60° E, which was found by Mr. C. M. P. Freylinck. Besides these dikes numerous Quartz-veins are encountered, they are cutting gneisses and schists with a general trend N 8° E. About the age of these dikes and veins can only be said that they are older than Eocene and younger than those gneisses and schists of probable Palaeozoic age. The same can be stated of the granite intrusion to the South-West of the mountain-system.

The Schists and Slates of the Illescas Mountains occupy the North-Eastern corner of them (see Fig. 3). The granite, granitic-gneisses on one hand and the schists and slates on the other can roughly be divided by a line running from Charaos to Quebrada San Andres. The schists consist of black mica-

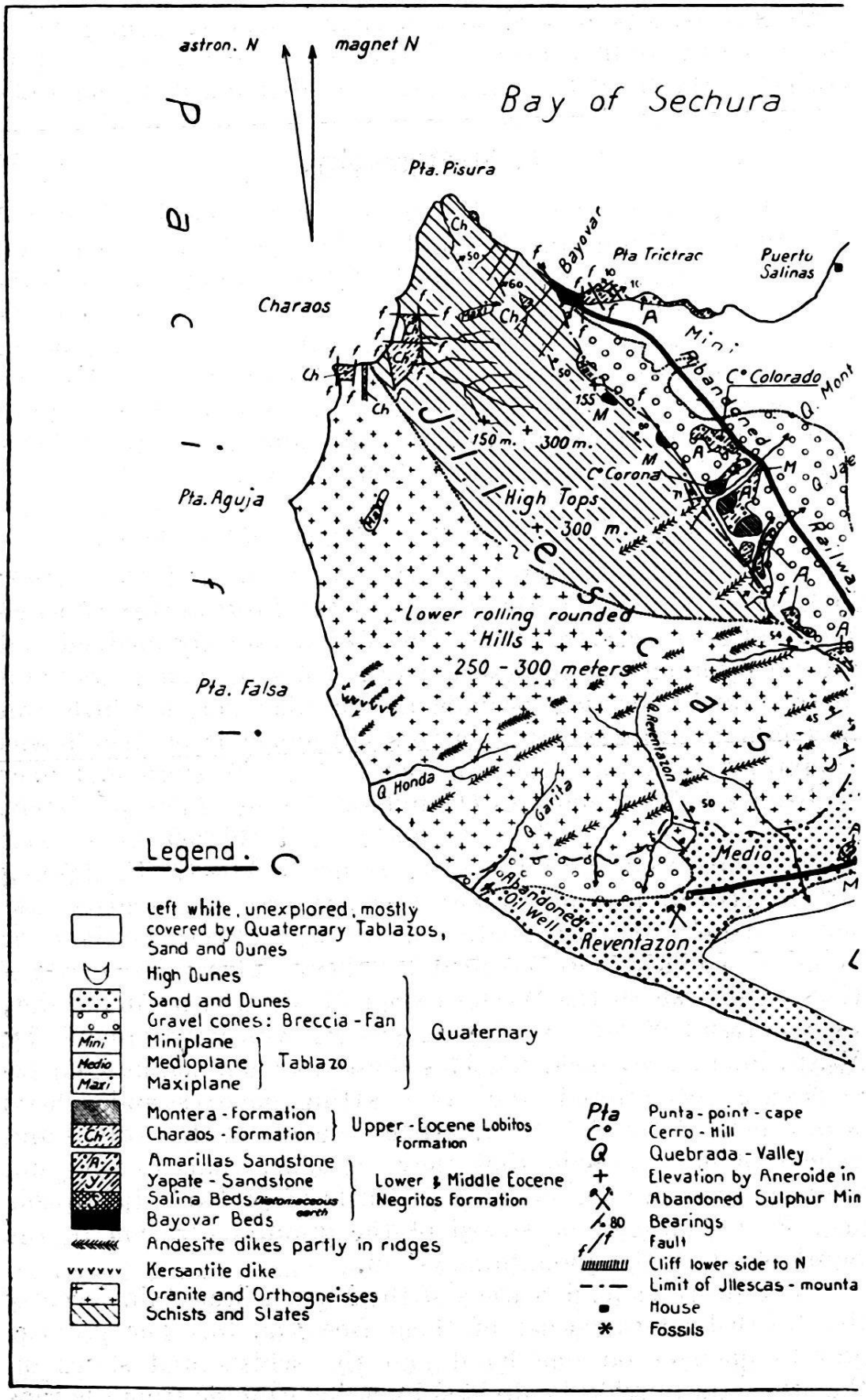

Fig. 3. Geological Map of the Illescas Region, Northern Perú (South
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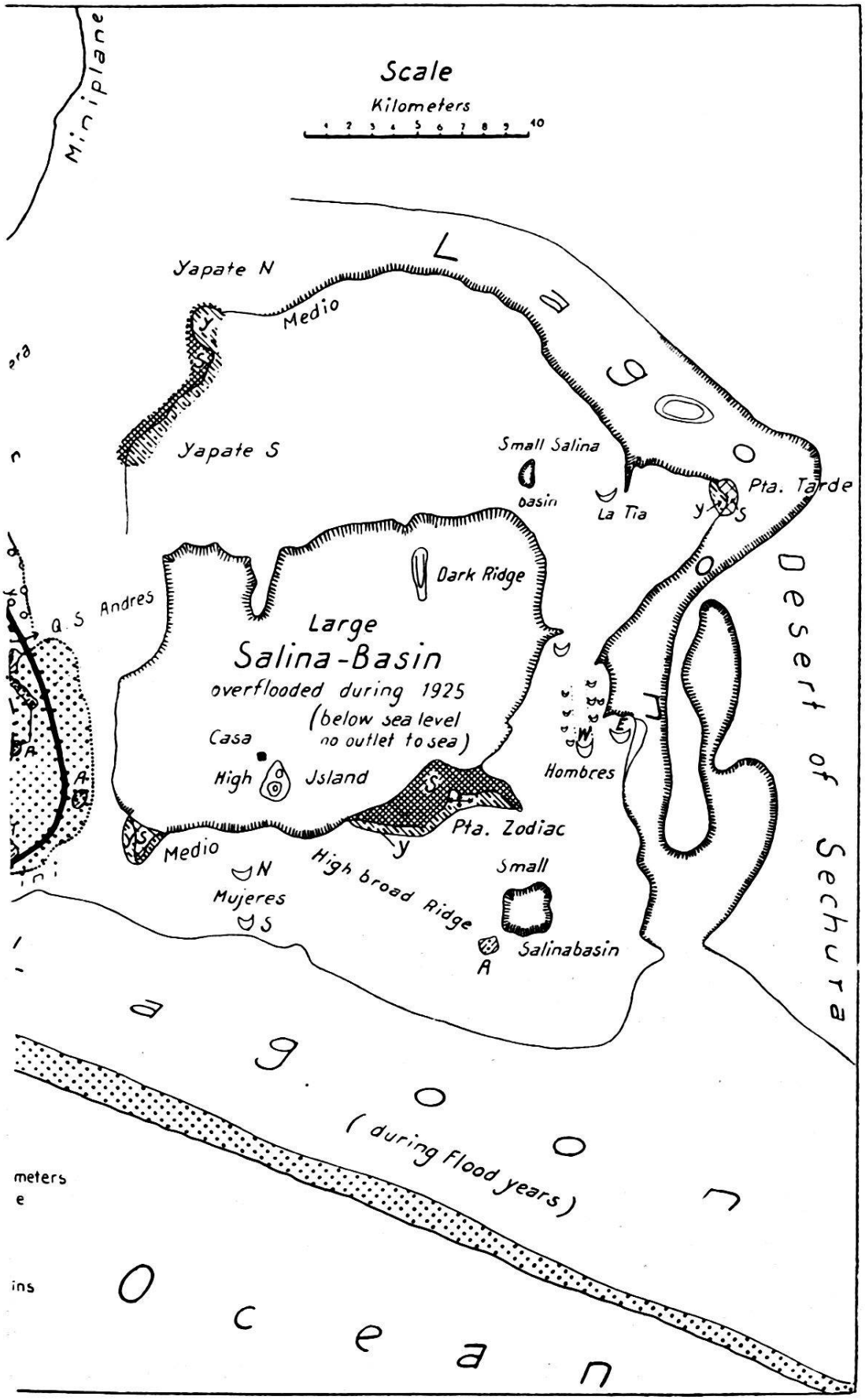

America). Compiled from Maps of Deustua, Freylinck, Hotz and the A. Werenfels.

schists, chlorite-schists, quartz-schists and mica-quartzites. The whole series could be confounded with the Casanna-schists of the Alps. Besides these schists a phyllite was found which is identical with the „Roofing-slates" of the „Schistes lustrées." The general trend of the schists is N 30° W, steeply inclined. It must be stated here, that the metamorphism of both schists and slates is considerably greater than that of the Amotape Mountains (Cerro Pricto) (see Fig. 1), as the writer could see himself by studying a sample of the collection of Dr. Hotz. Therefore there is little doubt about the Pre-Cretaceous age of this Illescas series. As no similar metamorphosed Triassic nor Jurassic is known from the Peruvian Andes, the Palaeozoic age of the series is probable.

2. Tertiary.

All the sediments, with the exception of the Quaternary deposits, exposed in the Illescas region certainly belong to the Tertiary. The lower part is assigned to the Negritos formation of Bosworth's[1]) division of Eocene of North-Western Perú. The higher parts belong to the Lobitos formation = Upper Eocene of the same author's denomination.

a. Bayovar Beds. The oldest strata outcropping in the area under consideration probably are the Bayovar Beds (see Fig. 3 and 4). They form a body of white to brown marls, with interbedded thin layers of sandstone and limestone. Fish teeth and bones are frequent throughout the whole series. A marly limestone proved to contain foraminifera in the form of "Polymorphina", which are completely unfit for the determination of the age of the beds. As the underlying strata are unknown, the thickness of the Bayovar Beds cannot be determined, however, the exposed thickness is over 100 metres (320 feet).

b. Yapate Sandstone and Salina Beds. The Yapate Sandstone and the Salina Beds are thought to be the equivalent of the Bayovar Beds. The three formations are apparently older than the Amarillas sandstone (mentioned below). Re the Bayovar Beds there exists no field evidence which stands for this presumption, whilst the Yapate and Salina formations are overlaid by the Amarillas sandstone, as it is indicated by the exposure in the ridge to the South of the large Salina basin (see Fig. 3). This outcrop shows Amarillas sandstone which is apparently in a higher topographical position than

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[1]) Bosworth, T. O. op. cit. p. 17.

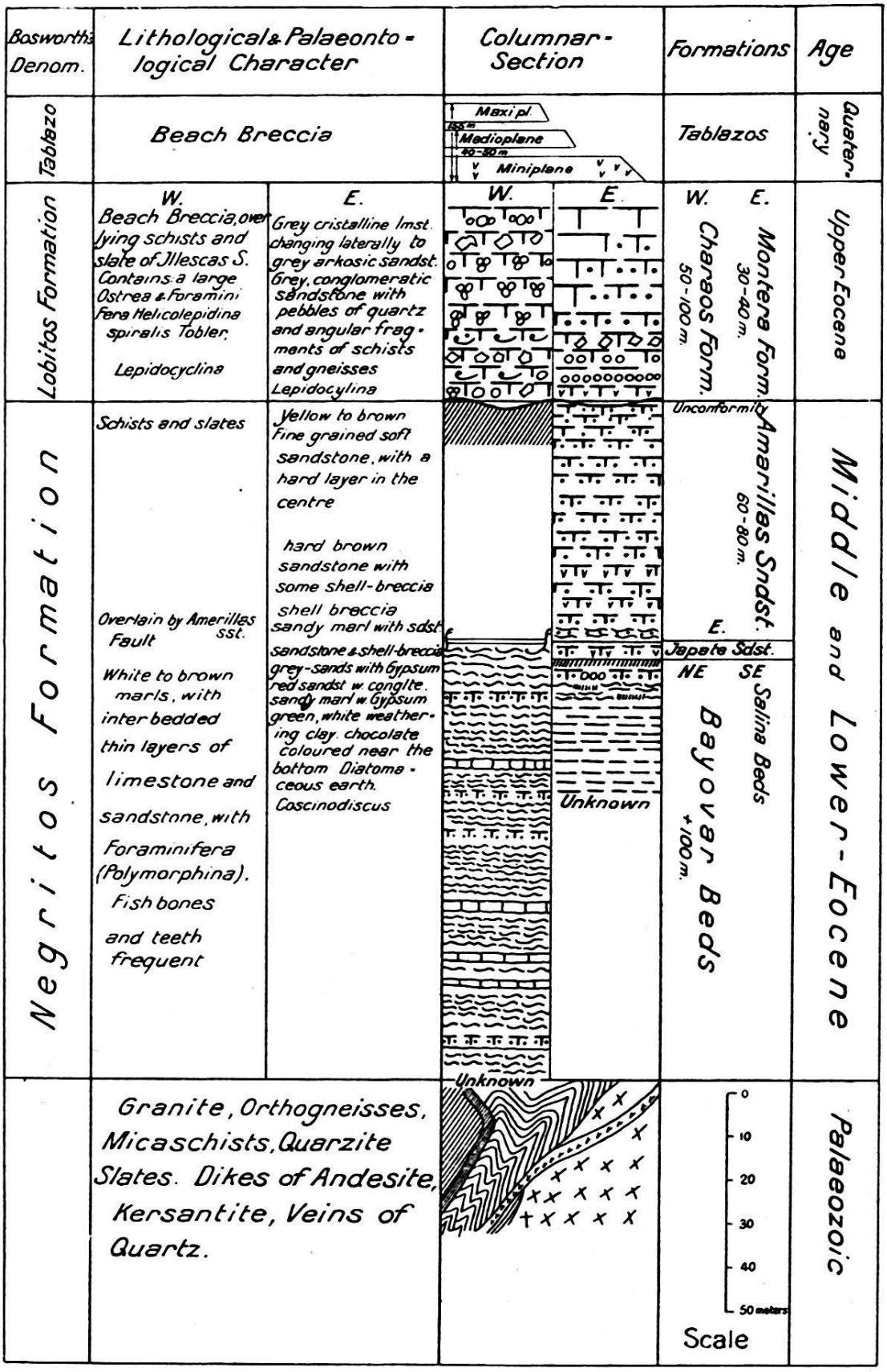

Fig. 4. Stratigraphical Section of the Illescas Region.

the Yapate sandstone and the Salina Beds to the North. As all the strata are horizontally, the Amarillas sandstone also ought to be stratigraphically higher.

The Yapate sandstone crops out along the cliff Yapate—Puntà Tarde and may be followed to the South. It is also found around the Salina basin, where the Salina Beds are exposed as well. The Yapate sandstone is a grey, medium grained arkosic deposit, changing in parts to a limy shell-breccia, with remains of Turitella, Ostrea and Venericardia planicosta; the presence of the latter stands for the Negritos formation. The thickness of the Yapate sandstone is about 4 metres (13 feet).

The Yapate sandstone overlies the Salina Beds at many places. From the bottom to the top they are built up of the following sediments:

Chocolate coloured clay (Diatomaceous earth) overlaid by a green, white weathering clay. The rock of this series tests salty; it is of unknown thickness, as the underlying strata are not outcropping. About 20—30 metres (64—96 feet) are exposed. The top of the Salina Beds consists of white, sandy marl, inter bedded with reddish sandstone and sand-lenses with Gypsum. These beds of the top measure from 10—15 metres (32—48 feet), and on most parts they are overlaid by the Yapate sandstone. The whole series of Salina Beds is completely free from macroscopical fossils. A careful test of the chocolate Diatomaceous earth has shown no foraminifera. However, the beds contain a diatomacea, as the author has already shown.[1]) A renewed investigation and comparison with a specimen of Monterey shales permits me to declare the diatomacea identical with *Coscinodiscus oculus iridis Ehrenberg* of the Miocene of California.

c. Amarillas Sandstone. The Amarillas sandstone is overlying the Yapate and Salina Beds as stated above; it is brought together with the Bayovar Beds by a fault. This fault extends 1 kilometre (0,6 miles) to the South-West of Pta. Trictrae. The Amarillas series is believed to overlie the Bayovar Beds, but no field evidence stands for this presumption. The sandstone is exposed in the "Mesa-Buttes" near the centre of the Illescas Mountains and also at different places to the South-East corner of them.

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[1]) WERENFELS, A. Diatomeenerde im Eocän von Perú. Eclogae geologicae Helvetiae. Vol. XIX, p. 630—31. 1926.

The Amarillas sandstone is made up of a series of yellow-brown, fine grained, soft sandstone, with a layer of hard brown sandstone near the centre and some shell-breccia near the bottom, where also some sandy marl occurs. Fossils are very abundant throughout the whole deposit; near the bottom of the exposed series petrified wood is very common. The following fossils were found by Dr. HOTZ, Mr. C. M. P. FREYLINCK and the author: *Venericardia planicosta auct., Turitella spec.?, Ostrea Buski auct., Ostrea spec.?, Meretrix Bosworthi auct., Mytilus spec.?, Cardium spec.?.*

This list of fossils stands for the **Negritos formation**[1]), to which most probably belong the Amarillas sandstone as well as the Bayovar Beds, Yapate sandstone and Salina Beds.

As the underlying strata are unknown near those "Mesa-Buttes", the thickness can only be estimated, the exposed thickness amounts to about 60—80 metres (190—250 feet).

The Salina Beds and the Bayovar Beds are thought to be two facies of the same off-shore deposit, laid down previous to the existence of the Illescas Mountains. The uplift of the latter is probably indicated by the shell-breccias of the Yapate sandstone and the Amarillas sandstone as well.

d. Charaos Formation. At Charaos, on the North-Western slope of the Illescas Mountains, about 6 kilometres to the South of Punta Pisura a beach breccia overlies directly the schists of the Illescas series. The breccia consists of large fragments of schists and slates of the Illescas series, and of pebbles of quartz and big shells of *Ostrea*, held together by a calcareous sandstone. The latter proved to be a real "lumachelle" of foraminifera, which Tobler[2]) found to contain *Lepidocyclina spec., Lep. ("Isolepidina") cf. trinitatis, H. Douv., Orthophragmina (Asteriacites, Asterodiscus) spec. and Helicolepidina spiralis Tobler.* No doubt this fauna is of Upper-Eocene age and belongs to the **Lobitos Formation** of Bosworth's[3]) Eocene division.

This beach-breccia is named Charaos Formation after the type locality where it outcrops to the South of Punta Pisura.

e. Montera Formation. The same beach-breccia like the Charaos Formation, unconformably laid down upon the schists of the Illescas Mountains, is exposed on the Eastern slope of the Illescas to the West of Colorado Hill see Fig. 3.

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[1]) BOSWORTH, T. O. op. cit., p. 17.

[2]) TOBLER, A. Obereocäne Grossforaminiferen etc. op. cit., p. 416 to 417.

[3]) BOSWORTH, T. O. op. cit., p. 17.

According to TOBLER[1]) this breccia contains *Lepidocyclina ("Isolepidina") cf. trinitatis H. Douv.* A very similar bed to this beach-breccia becomes a member of the section of the Corona Hill (see Fig. 3). The brown, fine grained sandstone of the Amarillas series of this hill is overlaid by a grey conglomeratic sandstone with pebbles of quartz and angular fragments of schists and gneisses, forming big bands and lenses in a sandy limestone. This conglomeratic sandstone is covered by a grey arkosic sandstone changing in lateral extent to a grey-white cristalline limestone, which contains remains of Mollusca shells. The conglomeratic and the arkosic sandstone, respectively the limestone as well as the beach-breccia are forming the *Montera Formation* (after Quebrada Montera [see Fig. 3] to the South of Corona Hill). The Montera Formation is thought to be a facies of the Charaos Formation. The Montera Formation forms the top of the "Mesa-Buttes" (see Table XVII, Fig. 1 and 2) as well as the top of the whole Eocene Formation of the Illescas region. The thickness of the Montera Formation is about 25 metres (80 feet).

The unconformity between the Charaos Formation and the Illescas series is easily found, as there is a pronounced change in the character of the beds as well as in the angle of dip. The break of sedimentation between the Amarillas sandstone and the Montera Formation however is not sharp: there seems to be doubt about the existence of a regional unconformity between the Lower and the Upper Eocene. From the exposed strata of Eocene age a thickness may be detected of about 250 metres or 800 feet.

3. Quaternary.

The Quaternary deposits of the Illescas region are made up of Tablazo, Breccia-fan, Sand, Dunes and the Sulphur sands of Reventazon.

a. The Tablazos, already mentioned, differ widely from Tertiary Beds. They are composed of different ingredients, their texture is different and they contain a different fauna; they are thin sheets of sediments lying over the Tertiary and Pre-Tertiary rocks. They can be described as belonging to raised sea-floors, as marine terraces with perfectly well preserved beaches. These terraces differ in altitude from 10 metres to 155 metres (32—490 feet). The highest Tablazo is the oldest one, belonging probably to the earliest Quaternary time. The

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[1]) TOBLER, A. Obereocäne Grossforaminiferen. Op. cit., p. 417—418.

Tablazos are the result of repeated subsidence and uplift movements of the coastal areas of this part of Perú. They consist of a beachbreccia formed by pebbles and immense quantities of marine fossils; the cementing material is calcareous grit and limestone. Although the quantity of fossils is enormous, the number of species is very small. The shells are not yet mineralized, and even the colouring is often preserved. Among the most conspicuous fossils are: Pectens, Oysters and Turitellas. All of these fossils are large and are so strong that they have not been smashed up by the heavy breakers of the sea. As already stated the Tablazos occupy three terraces, we may say flat table-lands. Two of them, the Miniplane and the Medioplane, form large parts of the Sechura desert, while the third one, the Maxiplane, only consists of small relicts on the Eastern and Western slope of the Illescas Mountains.

b. Large parts of the Miniplane and the Medioplane are covered by the "Breccia-fan", the principal accumulation of the desert formed during Quaternary time. This fan surrounds the Illescas Mountains, from which great torrents of mud and stones sweep down the mountain sides whenever flood-years like 1925 and 1926 occur. The torrents pour out from the mouth of every mountain-valley on to the plain where they spread wide their deposits. It is worth of notice that the Breccia-fan itself is much dissected, the deposits of each former flood being eroded by the succeeding floods.

c. A considerable part of the Medioplane as well as of the South-Eastern foot of the Illescas Mountains is covered by Sanddunes. They are heaped up by the steadily blowing trade-wind from the South-East; some of these dunes attain heights of 60 and more metres (— 190 feet) above the level of the Medioplane.

d. At Reventazon and in the Quebrada Jaen (see Fig. 3) sulphur deposits were worked from 1904—1914.[1]) The workings are open cuts in a sand at Reventazon, and in a talus breccia at Quebrada Jaen (see Table XVII, Fig. 3). Both rocks are poorly consolidated by impregnation of the sulphur. The impregnated zone reaches a depth of 8 feet with an average grade of 10 to 20 per cent. This did not prove to be sufficient for a commercial proposition.

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[1]) MARSTERS, V. F. Informe Preliminar sobre la Zona petrolifera del Norte del Perú. Boletín del Cuerpo de Ingenieros de Minas del Perú, No. 50. Lima 1907. Cit. by: Miller and Singewald: The Mineral Deposits of South America, New York 1919.

The rocks are apparently of Quaternary age. The origin of the sulphur is not clear, but Marsters thinks it had been liberated from petroleum.

D. Structure.

1. The Illescas Hills are sharply folded mountains, which are penetrated to the South by a granitic intrusion. The main mountain-building uplift is apparently folding, but faulting played also a rôle, as it is indicated below. Folding has ocurred during Pre Upper-Eocene time, probably during Lower-Eocene; faulting took place in Post Upper-Eocene, partly in Quaternary time, as it is indicated by the faulted Montera Formation and the raised relics of the Tablazo Maxiplane. Intrusion of granite seems to be older than folding and faulting, it occurred certainly in Pre Eocene time.

2. The desert of Sechura is a flat basin. From its margin near the Illescas Mountains beds are dipping under a low angle of 2 and less degrees against the centre. Around the Yapate and Salina region the bedding of the strata is already horizontal or subhorizontal; the dips are certainly less than 1 degree and could be taken only by transit. The margin of the basin against the Illescas Mountains is formed by a normal fault, with a throw not over 50 metres (160 feet). The hanging wall consists of the Illescas series, the foot wall is formed by the Montera Formation and the Amarillas sandstone. Small faults with throws ranging between 5 and 30 metres (16—100 feet) are abundant in the table mountains bordering the Illescas Mountains. These faults are a proof of the extensive role which faulting played in the mountain-building uplift of the region.

Manuscript received July 2, 1927.

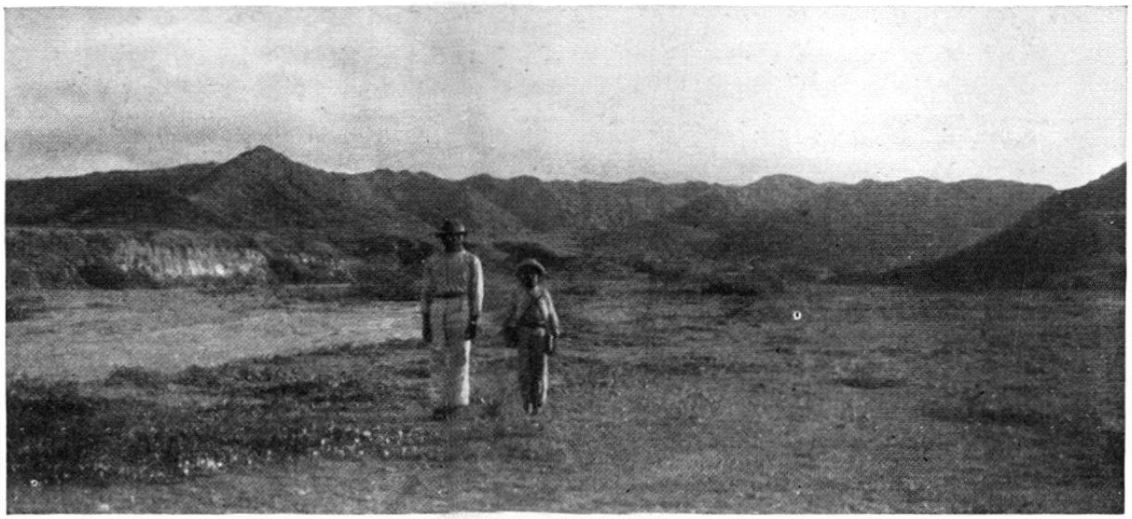

Fig. 3. Quebrada Jaen with Illescas Mountains from the East. Left: Cliff of Amarillas Sandstone.

Fig. 2. Quebrada Montera from the East. Corona Mesa butte, Right in the Background, Cliff. Left: Amarillas Sandstone Bordered by Algarrobo Trees. Illescas-Mountains in the Background.

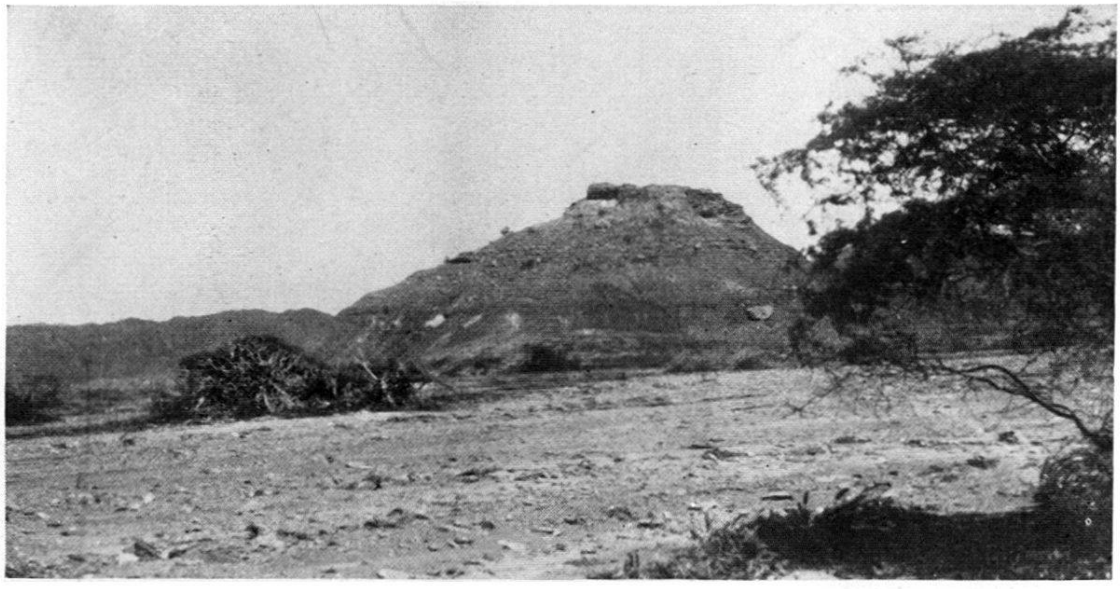

Fig. 1. Corona Mesa butte from North-East Amarillas Sandstone topped by Montera Limestone.