(e) Cerro Guajolote, the southernmost neck, 500 m in diameter, on the Aquismón-Tancanhuiz trail. The rock seems to be a gabbro or diorite and has metamorphosed the Mendez Marls at the eastern contact.

All these necks and plugs are later than the Mendez and probably than the Chicontepec. Judging from their state of preservation, they may be younger Tertiary or Quaternary, and partly seem to be related to the basalt mesas.

6. Basalt Mesas. They are widely developed in the region between Xicotencatl and Lavín, near Ciudad Victoria. Their average elevation is 350 m, or 250 m above the plain. The mesas are indicated approximately on our map, and in Pl. XVII, sections 5—6, but extend farther east near the Victoria railway. (On the topogr. map 1:100000 of Mexico, these flat mesas are drawn like folded mountains.) The thickness of the basalt at Mesa Josefeña was estimated at about 50 m. It usually lies on a eroded surface of Mendez Shale. The extrusion and erosion may be placed near the end of the Tertiary. Since then, slight uplift must have occurred to allow dissection of the mesas and to aggrade the present alluvial plain, 200—250 m below, processes which probably took place chiefly during the older Quaternary.

7. Basalt Streams. Two long but narrow streams of subrecent basalt have been encountered (Plate XVI).

One follows the small Rio Boquilla which crosses the two eastern ranges and ends, after several interruptions, in the eastern Tamabra gorge. In the cascades of the western or Chamal Range, the lava has slightly metamorphosed the immediately underlying Tamabra limestone.

The other stream probably derived from the same source west of Sierra de Chamal. It followed the synclinal valley of Nuevo Morelos through the channel of Rio Mesillas which now runs along the western side of the lava stream. This stream has been followed for more than 50 km upwards of its termination. The lava must have been extremely hot and liquid to flow on such a distance in a valley so slightly descending. These lava streams are much younger than the basalt of the mesas and may have flown in historic time.

IV. Structure.

The structure is reviewed by natural divisions:

The Huizachal Anticline.

The main structure of the first range between Victoria and the broad Jaumave Valley is the gentle Huizachal Anticline, 15—20 km wide and 2—3 km in structural height. At Huizachal Ranch, on the crest of the Anticline, erosion has stripped the sedimentary mantle down to the gabbro. In the next canyon to the north, that of Novillo, west of Victoria, even gneiss is exposed. While the main anticline's axis runs N-S, the vertical layers of the gneiss and amphibolite strike NW to WNW, thus making an angle of 45 — 75° with the later folding. At Peregrina, the gneiss seems to be cut off by a pre-Cretaceous NNW-SSE fault from the fossiliferous Peregrina Beds.

The anticline is associated to the east with numerous minor anticlines, with local contortions and steep dips. They are secondary folds on the easterly limb

of the main anticline and dye out like waves towards the great synclinal plain of Ciudad Victoria. These secondary anticlines change rapidly:

Anticline *a* (Pl. XVII, Sect. 3), well exposed in Juan Capitan Canyon, forms a regular arch; the western limb dips 55°, the eastern limb 80°. Anticline *b*, on the north side of the same canyon, is less symmetrical. Anticline *c* has a steep easterly dipping limb south of El Tenagón; it is overturned slightly, north of Tenagón. Anticline *e*, of the Sierra de la Boca, is the most prominent of these minor folds traversed by the Arroyo Juan Capitan. The top of the anticline forms a regular arch. Anticline *f* occurs at the land-mark of El Tecolete (a prominent white rock in a syncline overturned to the east).

The common feature of all these minor folds is the steeper eastern limb. Anticlines *a*, *b*, *c* strike NNW, flattening to the north. Anticlines *e* and *f* strike N and pitch 5—12° in that direction, disappearing under the plain, 4—5 km north of Arroyo Juan Capitán, before reaching Victoria. The steep westerly dip of the Mendez Beds, east of the church of Guadalupe, proves that the folding continues there at greater depths.

The Front Folds north of Llera.

Passing southwards, the bend in the railway at Victoria (Pl. XVI) is caused by the projection of the mountains into the plain for more than 20 km. It was formerly thought that this projection is due to a sharp change in the fold-axes. Our observations show that the principal cause is a general axial rise of the minor folds east of the Huizachal Anticline (Pl. XVII, Sect. 4).

The anticlinal axis of the Sierra de la Boca rises to the south and then pitches again south at about 10° towards the Rio Guayalejo. Nearer the plain follow smaller brachy-anticlines. That of La Mina is the most easterly one and shows a core of Tamaulipas Limestone. Then follow five anticlines in San Felipe strata in the Prada-Las Cruces region, pitching north or south from an axial centre WSW of Lavin. Finally there is the Santa Juana Anticline in Mendez Marls, near the station of Lavin.

This general axial rise of the frontal folds has no equivalent in the Huizachal Anticline. It rather corresponds to an axial depression of the latter.

The Front Folds south of Llera.

The Rio Guayalejo, west of Llera, crosses the ranges in a general axial depression of the folds, also indicated by the re-entrant angle of the plain and by Chicontepec Beds within the mountains at Llera, 15—20 km inland from Lavin.

At Guadalupe, on the trail from Llera to the abandoned ranch of Las Adjuntas, a perfect, upright anticline in San Felipe Beds, is exposed on the south bank of the Rio Guayalejo (Pl. XVII, Sect. 5). Going inland, the next anticline forms a range with an irregularly folded core of Tamaulipas Limestone (800 m elevation), the Adjuntas Anticline. It pitches gently to the north and is replaced by the anticline of the Sierra de la Boca north of the Rio Guayalejo. The broad region of gently folded San Felipe Beds, west of Las Adjuntas, was not studied.

Following these frontal folds southwards, the Guadalupe Anticline forms a long chain of hills, before pitching beneath the Mendez at San Antonio. The next fold to the west continues farther south. At Monte Cristo, on the west flank of the Front Ranges, and in the San-Juanito-Carmen region on the east flank, the

mountains are no more inaccessible. The Sierra Prieto, the highest of the Front Ranges rises to 1200 m. As shown in Pl. XVII, Sect. 6, it consists of four folds:

(a) The eastern one is overturned to the east and disappears on the eastern slope owing to a southerly pitch. (b) The second one, at Fortunas, some 10 km away, is the highest, but also pitches to the south. (c) The two western anticlines were only mapped approximately, but it is certain that at Libertad, farther south, the third anticline also pitches south, at an angle of 5—10°.

Thus, we have a repetition of the type of structure found north of Llera, viz., a second culmination of the frontal folds. At Lavin, however, the outermost folds do not rise again to form mountains, being indicated only by dips in scattered outcrops of San Felipe beds in the vast expanse of Mendez Marls (El Terrero, La Flor, Cerrito, Poza).

The Foreland from Xicotencatl to Guerrero.

To pass outside the region equivalent tectonically to the front folds of Lavin, one must go as far as Xicotencatl, which stands on a gentle syncline of Tamesí Beds (Pl. XVII, Sect. 7). The persistence of deeper folding around Xicotencatl is indicated by dips up to 45° in Mendez Marls, like those west of Lavin.

The most important anticline in the region north of Xicotencatl is that of Poza (sect. 9 on Pl. XVIII), which possibly extends southwards to the Mendez of Peñita. In a similar position is the Canoas or San Juarez Dome, situated in the great alluvial plain which, in the rainy season, becomes an almost impassable swamp. The lower Mendez and upper San Felipe rise with a maximum of 10° to a low hill, 15—20 m high. On the whole, the surface corresponds with the structure.

West of Canoas, on the Rio Mante, another dome-like structure of San Felipe rises above the plain. Finally, there is a small outcrop of San Felipe Beds, dipping 5—7° SE, at Huiches, 4 km east of Guerrero.

The region from Xicotencatl to Guerrero, outside the Sierra Madre, is therefore a plain of denudation and widespread alluvial deposition: but it does not imply an unfolded basement.

The Main Anticline from Monte Cristo to Chamal.

The front folds of the Sierra Prieto are paralleled on the west by the deep syncline of Mendez Marls on which stand the ranches of La Flor and La Soledad (Pl. XVII, Sect. 6). From here, the main mountain-range rises with a uniform slope to at least 2100 m. The top of the flat summit can only be reached along a trail from Monte Cristo village (elevation 500 m) to Jaumave. Four kilometres before reaching Carabanchel, a huge plateau of Tamabra with rudistid-beds is traversed. It is due to an extremely broad warping, which may be called the Carabanchel Anticline, apparently the southern extension of the Huizachal Anticline (Pl. XVII, Sect. 6).

As seen by telescope from Carabanchel ranch, the entire mountain-range seems to be formed by this huge anticline. It is more than 20 km wide, and shows a dip-surface pitching a few degrees north. On the trail south of La Flor, on account of the pitch of the adjacent Soledad Syncline, the westernmost anticline of the Sierra Prieto appears to amalgamate with the great Carabanchel Anticline. But this syncline is well exposed again at Gomez Farias, separated from the plain of

Xicotencatl by the Tamabra of the Sierra Pequeña Anticline (Pl. XVII, Sect. 7). The latter pitches 5—10° S, flattens out and disappears, so that the eastern slope of the Carabanchel Anticline now forms the border of the mountains.

In the Chamal region, most interesting changes in structure occur. The wide syncline at this village lies exactly on the southern prolongation of the Carabanchel Anticline. The wide Tamabra-built mountain gradually descends to the south, the anticlinal crest being transformed into a syncline,

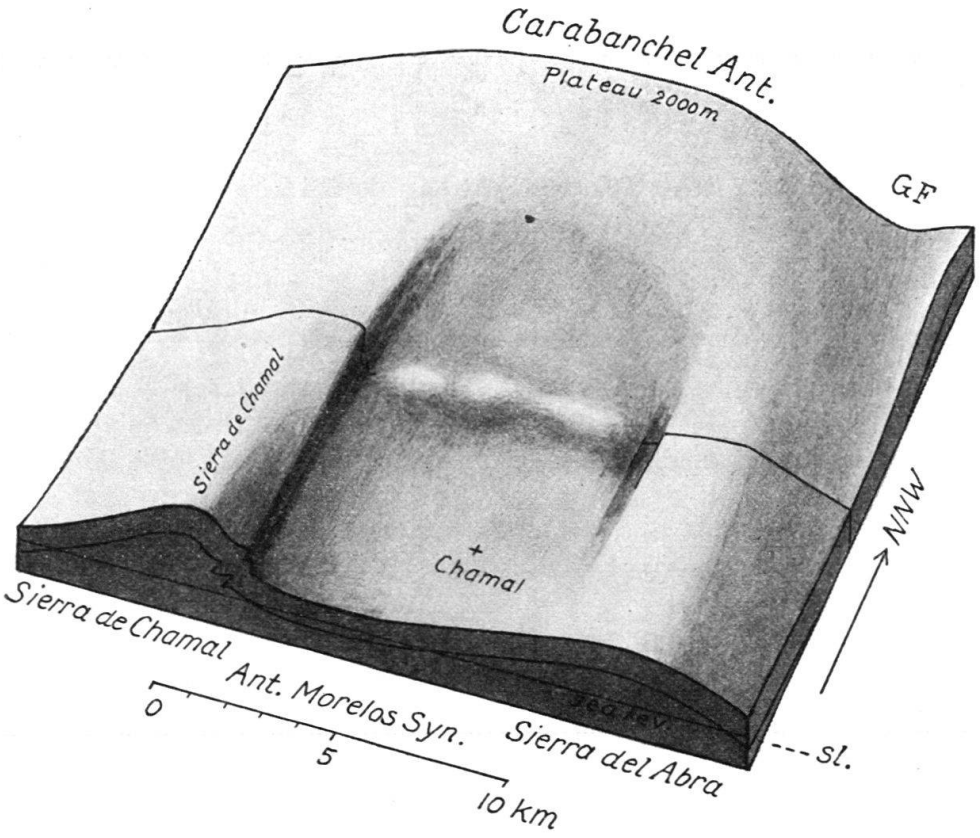

Fig. 7. *Replacement of the Carabanchel Anticline by the Antiguo Morelos Syncline.*

Block-diagram in natural proportions drawn after a model of the reconstructed Tamabra surface.

GF: Gomez Farias syncline.

and the flanks into lateral anticlines. But the transformation is complicated by a distinct cross-fold, just where this transformation takes place. It is an anticlinal barrier of Tamabra (Textfig. 7). A third structural peculiarity in this locality is the little synclinal peak, called Chamalito, with its basalt-cap overlying folded Mendez Beds, and the little graben to the south-east of it (Pl. XVIII, Sect. 8). But Chamalito is not only situated on a faulted syncline of normal trend. A N-S section also shows a synclinal structure. Thus, tectonically, Chamalito is on a faulted structural basin.

The Sierra del Abra from Chamal to the Rio Tampaon.

The road to Chamal crosses a low symmetrical anticline in Tamabra, developed from the eastern limb of the Carabanchel Anticline (Pl. XVIII, Sect. 8, 9). From here, the monotonous El Abra front-range extends for 110 km, with an average elevation of only 300 m and a maximum of 500 m. The El Abra Range, however, is not a single, simple anticline, but is composed of several secondary folds which merge into one another. Beauitful springs issue from the cavernous rudistid-limestone all along the east side of the range. The largest, north of Quintero, is the source of the Rio Mante (Pl. XVI).

A complete cross-section is afforded by the Rio Boquilla, where the crest is slightly faulted. The trail from Quintero to Antiguo Morelos crosses a structure similar to that of Chamal (Pl. XVIII, Sect. 10). Thereafter, the Anticline widens and its western limb is thrown into secondary folds, while the eastern limb steepens to 30° and, at Nombre Dios, even to 50 and 80°. At Taninul station, the eastern dip is again very gentle (Pl. XVIII, Sect. 13), but it steepens once more on approaching the Rio Tampaon. Here the folded Abra Limestone pitches 5—10° southward under the river.

Instead of giving a good section of the Tamabra structure, the Rio Tampaon escapes from the mountains through an axial depression in the Front Folds. South of the river, the Abra Limestone again comes to the surface, but in separate domes. The first and widest lies between the Rio Tampaon and Tantobal, is flat-topped and has peripheral dips of 5—10°. The next is at Salsipuedes[5]). It has a gently dipping, western slope, but a steep dip (60° NW) along Salsipuedes river, due to a cross-fold, plainly visible above the big spring. No fault was seen. A third dome is represented by the San Felipe Beds of the Santa Isabel well (Pl. XVIII, Sect. 14).

In earlier reports the eastern border of the Sierra del Abra from Quintero to beyond the Rio Tampaon was mapped as a fault. Such a fault may be present locally, e. g., at Quintero, between Mante and Cantón. But wherever there are good outcrops, no such fault was visible, the Tamabra dipping normally under San Felipe or Mendez Beds. The absence of the San Felipe in the latter case is a stratigraphical phenomenon.

The Antiguo Morelos Syncline.

The little town of Antiguo Morelos lies in a synclinal valley between the first and second ranges of that region. It is 10—12 km wide. As a rule, the synclines of this region are much broader than the anticlines. Along the Rio Boquilla, the San Felipe Beds, or those passing into the Mendez, reach the surface, showing that the syncline is very shallow (Pl. XVIII, Sect. 9—10). South of Antiguo Morelos, secondary folding with low dips becomes more general (Pl. XVIII, Sect. 11). The deepest part of the Syncline gradually moves westwards, until at Valles it is 13 km away from the El Abra Anticline.

The Sierra Nicolas Perez.

This long mountain-range starts NW of Chamal as the Sierra de Chamal. Anticlinal structure is developed in the Tamabra along the road to Ocampo. Here the eastern limb is intensely crumpled, while farther north, west of Coahuila,

[5]) The name means " Pass if you can ". Once, indeed, we could not and lost a day.

this eastern limb has a sharp, right-angled knee, with high, vertically stratified walls (Pl. XVIII, Sect. 8).

South of Ocampo Pass, the range mapped as the Sierra Nicolas Perez culminates in twin peaks called the Peña Romana (approximately 1300 m). The structure of the eastern foot of this range is complicated, minor anticlines pitching north. The prominent white wall north of Peña Romana, ending west of Caimán, consists of overturned Tamabra Limestone, dipping 45° W, and underlain by Xilitla and crumpled San Felipe Beds. The corresponding normal limb forms the twin summits of Peña Romana. The crest of the Sierra Nicolas Perez is thus a Tamabra anticline overturned towards east (Textfig. 8; Pl. XVIII, Sect. 9).

For several kilometres east of Peña Romana there runs a rough ridge of broken Tamabra Limestone which was identified as a large rock-slide (Pl. XVI). From Peña Romana, the Sierra Nicolas Perez Anticline swings off to the SSW, and pitches under the valley of Nuevo Morelos, another anticline rising from the western part of the syncline at Peña ranch. A few kilometres to the south, the eastern limb becomes vertical. In places, the San Felipe Beds are even overturned, while the dip of the western limb remains very gentle. This anticline may be called the Morelos Anticline, since it forms the pass between Antiguo and Nuevo Morelos (Pl. XVIII, Sect. 10). The eastern limb is associated with several minor anticlines in San Felipe and Mendez Beds, with dips reaching over 70°. The largest is traversed by the Morelos trail, the N-S axis pitching away from it in both directions.

South of this Pass, Tamabra miliolinid-limestone outcrops on both flanks of the Range, the top being capped by Xilitla and San Felipe Beds. Between Benadito and Tanchachil, the anticline bends abruptly, first plunging to the southeast and then swinging sharply SSW. From here on, the Range is a broad anticline in San Felipe Beds (Pl. XVIII, Sect. 11), ending finally at the hills of Chantol, NW of Valles. There the structure plunges under the plain of Mendez Beds, as is seen from San Mateo railway-station (Pl. XVIII, Sect. 12). Thus the two great synclines of Antiguo and Nuevo Morelos become joined (Pl. XVI).

The Nuevo Morelos Syncline.

Like that of Antiguo Morelos, the Nuevo Morelos Syncline is broad and asymmetric, the deepest part lying to the west where secondary folding occurs (Pl. XVIII, Sect. 10—11). One of the most prominent features of the flat, synclinal valley is the extremely long, sub-recent, basalt lava-stream which follows the Rio Mesillas for more than 50 km.

The Sierra Colmena and its Continuation.

At Colmena, west of Nuevo Morelos, Dr. JENNY reported the structure to be a complex anticline, overturned to the east (Pl. XVIII, Sect. 10). In Section 11 he shows a complicated thrust of folded Tamabra over a sharp fold in San Felipe Beds, which is still overturned farther south.

The fine section along the Micos River (Pl. XVIII, Sect. 12) is incorrectly described by BÖSE (1906 B, p. 13) as follows: "Tout près de la sortie se voit une fracture." Actually, there is an unfaulted, inverted series of beds. The Tamabra of the high walls above Micos Falls dips 80° W and must be overturned, for farther west it is underlain by the complete Xilitla-San Felipe-Mendez series, dipping 40—60° WSW (Pl. XVIII, Sect. 12). South of the railway, between Jopoy and

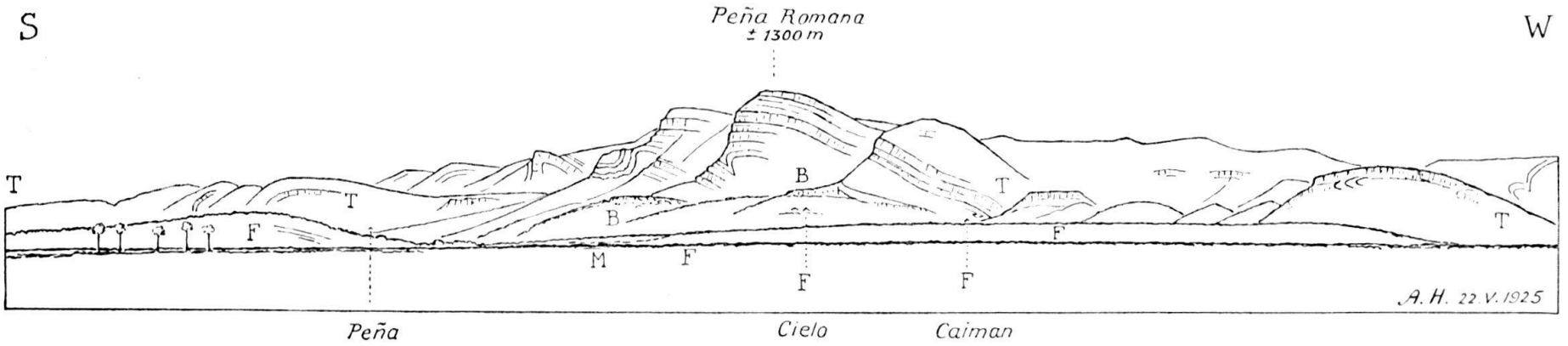

Fig. 8. *The Sierra de Nicolas Perez, pitching south-west, seen from the NE.*

Asymmetric folds in Tamabra and replacement of anticlinal ranges by new structures. Beyond Rancho Peña, the new anticlinal range of the Sierra Morelos commences. The low hills in the great synclinal valley in the foreground are made by secondary anticlines in San Felipe Beds. Above Rancho Caimán is a local thrust of Tamabra over San Felipe.

T: Tamabra Limestone; F: San Felipe Beds; M: Mendez Marls.
B: Mountain-slide.

Agua Vieja, the complete, reversed series is again found, dipping 35—50° W. Below it appears a new secondary anticline in San Felipe Beds, pitching north. Another succeeds farther south. At La Pila both join the large Tamabra outcrop of the range. The front is still overturned.

The whole range is crossed by the Rio Tampaon (Rio Santa Maria on the 1:100000 map), but only the lower end of the tremendous gorge is accessible by canoe from Paliguau. Here the Tamabra is overturned, with dips of 50—70° to W. The same overturned front is seen farther south on the trail between San Francisco and Sabinal. As usual, the western limb is the more regular and gentle. Near Tanchanaco, the Sierra Colmena anticline terminates in the shape of a broad anticlinal arch, pitching 5—10° SSE.

The Sierra de Aquismón.

The border of this fourth range is seen above Pubiche, west of Tanchanaco. The sharp " knee ", with vertically bedded walls of Tamabra, recalls that of the Chamal-Coahuila region. The associated Mendez and San Felipe Beds dip east under this wall, showing that a slight overturn also exists along this mountain-front. Above Aquismón, the Cabeza Aureca shows an anticline. Following it south to Santa Barbarita, the frontal arch is absent and the western limb is thrust over a zone of west dips in scale-like folds of San Felipe (Pl. XVIII, Sect. 14). But at Tocomón, the Tamabra of the Aquismón Mountains pitches south-eastwards under the valley with a normal cover of San Felipe, as if no overthrust were present.

South of Tocomón, vertical Tamabra Limestone again forms the western walls of the valley excavated in Mendez marls. They are part of an internal flexure of the Sierra de Aquismón, which continues farther south-east. At Tampachal, farther inland, Dr. JENNY reported minor overthrusts of the Tamabra over the San Felipe (Pl. XVIII, Sect. 15). The next mountain-trail to the south, from Huichihuayan to Xilitla, again crosses a simple border. The Tamabra dips normally under the Xilitla Beds at 30—45° NE. On the whole, the mountain-structure between Huichihuayan and Xilitla is that of a broad anticline, 5 km across, with local complications (Pl. XVIII, Sect. 16).

At Tlamaya, NW of Xilitla, the stratification of the rudistid-limestone is hard to see and highly confused. Xilitla town stands on the south-western limb of a fine symmetrical syncline (Pl. XVIII, Sect. 16), which can be traced to Cruztitla and farther to the south-east. To the south-west comes another low Tamabra anticline, and then a second syncline (Agua Buena—Tatetla). The latter is scarcely recognisable south-west of Xilitla, but deepens rapidly to the south-east. The axes of these folds strike exactly NW-SE. Finally, at Barranca and Ahuacatlan, we reach a third, broad, gentle Tamabra anticline, with gentle minor structures.

Returning to the eastern border of the limestone-mountains of Xilitla, we find a wall of horizontally bedded Tamabra, ending abruptly above Cristiano. Below it are San Felipe and Mendez Beds which dip towards the wall, so that the Tamabra must be locally thrust over them. This frontal region of Cristiano and Tenexcalco is also characterised by the broadening of the border valley in Mendez Beds and by the appearance of new folds, rising SE, all with steeper or inverted NE limbs.

The Overthrust of the Sierra de Xilitla.

West of Xilitla rises the flat-topped Peña de San Antonio (about 1500 m) with its magnificent needle peak Silleta. It is the abrupt, south-eastern end of the Sierra de Xilitla. The prominence of this Sierra is due to its extraordinary stratigraphic and tectonic position. It is chiefly built of Tamasopo Limestone (Lower Senonian). At the base of this thick series are Lower Xilitla Flags, thrust over Upper San Felipe Beds. The contact west of Xilitla is hidden by boulders, but the absence of a front-fold and the difference in facies can leave no doubt on the presence of an overthrust. To the south-west, the thrust series becomes strongly developed, forming a 200-m wall of white, black, and yellow rocks above Xilitla (Pl. XVIII, Sect. 16).

Tamazunchale.

This old town stands on Upper San Felipe Beds, dipping generally eastwards and overlain normally by Mendez, Tamesí and Chicontepec Formations. The trail running west along the Rio Moctezuma passes a tremendously crumpled fold on the south side of the first mountain (Pl. XVIII, Sect. 17), where San Felipe limestone and black layers, like Xilitla Beds, striking NNW, are folded on a core of dense, cherty limestone. Near the ferry at Tacial, north of the river, typical San Felipe Beds are exposed in the normal limb of a crumpled, overturned fold. Then follows the zone of Tenestipa, about 2 km wide, with Tenestipa Limestone upon cherty Pimienta Beds. Just west of Tenestipa, in a little side-canyon, this limestone is crushed and marmorized along a minor thrust-fault. A more important thrust occurs some 200 m above the ferry. This apparently indicates thrusting of the Jurassic mountains over the Cretaceous front-fold (Pl. XVIII, Sect. 17).

Beyond the narrow belt of Tenestipa Limestone, just before La Vega, the limestone retreats up to the higher slopes and an extensive mountain-area follows formed entirely of fossiliferous Tamán Beds (Kimeridgian). Pl. XVIII, Sect. 17 shows the details. The Tamán Formation forms an anticlinorium, 8—10 km wide, trending north and north-west, with numerous minor folds. The main axis passes through Tamán village. The Indian huts at Pimienta stand on the chert beds of the western limb, dipping 30—60° W. Then follows the Pimienta Syncline in Tenestipa Limestone, symmetrical like the synclines of Xilitla, but more crumpled. Dr. Fehr followed the creek NW of Tamazunchale and found the Jurassic with some secondary folding, but not thrust over the San Felipe. Hence the Jurassic of Tamazunchale shows only local thrusts and belongs to the normal deeper part of the autochthonous folds.

The Chicontepec Mountains North of the Rio Moctezuma.

South of the Rio Tampaon, in place of the El Abra Range rises a well defined mountain-region, 40 km wide and with a maximum elevation of 600 m, composed entirely of the Chicontepec Formation, mainly Tanlajás Sandstone. Towards the low peneplain to the north, the Chicontepec sandstones are cut off by denudation. To the west and south-west, they are separated from the Cretaceous ranges by the long Aquismón-Matlapa valley, cut in the Mendez and Tamesí Marls. The eastern and north-eastern limits are also determined by erosion.

In the distance the Chicontepec Mountains appear as a plateau with slight tectonic disturbance, but closer study reveals irregular folding and crumpling. Along the western border, south of Tacanhuitz, the Tanlajás sandstones dip 25—75° E and NE, away from the Cretaceous mountains.

The Axtla River exposes an overturned anticline with a gentle western limb. NE of it follows the Axtla Syncline. A second anticline occurs at Choteco, flanked by the Chalma Shale-syncline, of Chenico. The third anticline southwest of Tampamolon is more gentle and symmetrical and would appear favourable for drilling if the Tanlajás Sandstone should contain oil-sands. Between Tancanhuitz and Tanlajás, the Chalma Shale is absent, indicating a general axial rise to the NW. The village of Huehuetlan stands on flaggy sandstone, with a uniform dip of 12° SW. It forms the north-eastern limb of a broad gentle syncline (Pl. XVIII, Sect. 15). Nevertheless, the folding may become more intense locally anywhere, and vertical bedding is common. From Tancanhuitz northward to La Cuesta, the trail crosses a small, sharp anticline in Tamesí Beds, overturned somewhat to the north. A similar steep fold occurs at Tancolol, while the wide region to the south, between San Antonio and Tanlajás, is a flat syncline.

The San Pedro Valley, with its oil-wells, is topographically an inlet of the Tampico Plain. Geologically, it is an anticlinal valley eroded down to the Mendez shales. They are surrounded on three sides by Chicontepec mountains.

It is significant that the gentle anticlinal dips, on both sides of the San Pedro Valley, are suddenly interrupted by steep secondary anticlines. Hence the width of the anticlinal zone of oil-accumulation is not more than about 4 km (Pl. XVIII, Sect. 15). Moreover, the Mendez Beds at the apex of the anticline just south-east of San Pedro village are folded transversely. Farther north-east, the folds seem to flatten out towards the Tampico Plain.

Summary and Conclusions.

South of Victoria the outermost folds of the Sierra Madre Oriental are represented by about ten anticlines over a breadth of 20 km. They are either upright or bent over the to east and diminish gradually, though irregularly, towards the plain. Apart from a general zone of culmination, this group of folds pitches to north (Victoria Plain) and south. Then follows a general depression of the fold-axes along the Rio Guayalejo (near Llera). The largest anticlines are those of the Sierra Boquilla to the north and the Sierra Prieto to the south of that river.

From Xicotencatl southwards, there is no more range corresponding to the Front-Ranges of the Victoria region. But exposures of San Felipe Beds in the great plain prove the continuation of more subdued folding at greater depths.

West of the Front Folds of Victoria comes the great Huizachal Anticline, 15—20 km wide, which seems to pass southwards into the Carabanchel Anticline of equal or greater width, but lesser tectonic height.

North of Chamal, 90 km south of Victoria, this anticline pitches south and changes into the long, shallow Antiguo Morelos Syncline. This is followed on each side by lateral anticlinal ranges developed from the limbs of the Carabanchel Anticline. A remarkable cross-anticline occurs at the point of transformation. From there, the low El Abra Range, east of the Antiguo Morelos Syncline, forms the mountain-front for 120 km, as far as the Rio Tampaon. It is a complex low Tamabra Anticline with the steeper limb facing the plain. Pitching with subdivisions below the Rio Tampaon, it rises again south of this river in the shape of three separate domes (Tantobal, Salsipuedes, Santa Isabel).

The second range begins in the north as the Sierra de Chamal and continues as the Sierra Nicolas Perez for 100 km. The detailed structure is complicated and not that of a single anticline. The chief structural change occurs north of Antiguo Morelos, where the easterly overturned Peña Romana Anticline turns off and pitches SW, while the Morelos Anticline, with a gentle western limb and a steep eastern, continues the general trend of the range, until it pitches under the plain. Thus the two synclines of Morelos merge north-west of Valles.

The third range, followed from Nuevo Morelos for 100 km, shows an inverted series of beds all along its eastern border, except at the southern end where the Sierra Colmena pitches as an upright anticline. As in the Sierra Romana, the structure is complicated. At least two Tamabra anticlines occur at Micos. South of the railway new secondary anticlines rise from the eastern flank and join the main Tamabra outcrop.

The fourth range, the Sierra de Aquismón, is still larger and more complicated. Its front is partly anticlinal, partly thrust. The inner part involves several minor thrusts. At Tocomón, the north-eastern part of the range ends by pitching.

At Xilitla, more regular folding with exactly NW-SE strike, produces two synclines in the San Felipe-Mendez strata, subdividing the broad mountain-area of Tamabra. At the outer margin the Tamabra is slightly thrust over the San Felipe. Four or more new anticlines rise in the broadened valley of Mendez Beds.

Finally, at the Rio Moctezuma, appears in the southeastern continuation of the Xilitla region the Tamán Anticlinorium of 10 km width, with many minor complications and an overthrust eastern border.

Over the autochthonous mountains of Xilitla, the Tamasopo Limestone of the Peña de San Antonio is overthrust, forming the Sierra de Xilitla. The nearly horizontal overthrust from the west explains the sudden change in facies.

Here, in the south, east of the Cretaceous ranges extends the great mass of the Chicontepec Mountains above the buried Cretaceous Front folds. Although no unconformity was observed at the contact with the Cretaceous along the western border, the folding in the Chicontepec Mountains is unlike that in the Cretaceous ranges. The difference in structure may be partly due to the difference in sediments. The most important anticline of the Chicontepec region is in the San Pedro Valley, where Mendez Beds reach the surface.

The strike of the Chicontepec Formation is NW-SE, corresponding as a whole to that of the Cretaceous ranges to the west, but not in harmony with the termination of the El Abra Range nor of the Cretaceous domes north of Tacanhuitz. The structure in the narrow valley from Aquismón to Tocomón makes the impression that the folding of the Front Ranges found some obstacle in the Chicontepec region, and that the former continued to be pushed against the latter even after the erosion of the Tocomón Valley.

The general type of folding in the Sierra Madre Oriental is that of the Jura Mountains of Switzerland or of the Lebanon-Antilebanon. The anticlines are upright or overturned to the east. No case to the contrary was found. While the frontal El Abra Range shows regular, smooth, anticlinal forms, the structure becomes more complicated towards the inner ranges. The southern part of the latter is also the region of small overthrusts. This is in contrast to the Jura Mountains, where the outer folds are the more intensely thrust. The folding and thrusting of the region has taken place as a horizontal movement towards the Gulf of Mexico.

Special attention was paid to faulting. Several minor faults have been described and others may have been overlooked. But in comparison with other similar ranges, the absence of longitudinal and transverse faulting of any importance is striking.

The Chicontepec Mountains partly excepted, all the mountain-ranges correspond to anticlines or anticlinal thrusts, the valleys being synclines in Mendez Marls. Thus the anticlinal structure is visible in the distance, as is the case with the young Iranian Ranges along the Persian Gulf.

V. Summary of Geological History.

We recognise the following phases in the history of the Sierra Madre Oriental:

1. Pre-Mississipian orogeny.
2. Denudation and submergence.
3. Deposition of the marine Peregrina Formation (Carboniferous). Filling of the basin with continental sandstones and conglomerates of the Red Beds (Permian).
4. Pre-Jurassic uplift and denudation. Removal of part of the Red Beds. So far as known, no intense folding took place, the contact with the Mesozoic strata showing only local unconformities.
5. The Mesozoic submergence seems to have occurred earlier in the south (Tamazunchale), where the fully marine Jurassic sediments accumulated in great thickness. In the north (Victoria) they are differently and poorly developed. The gypsiferous lagoon-beds of Nuevo Leon are regarded as Jurassic by BAKER, and this may be the case with the Olvido Formation of Victoria. Marine Jurassic is known farther north in Nuevo Leon, and the Victoria region may have been an island or peninsula during part of Triassic and Jurassic times. W. STAUB (1939, p. 348) calls it the Peregrina Horst.
6. In Lower and Middle Cretaceous times the sea spread all over the area, with striking facies-variations. By itself, the Tamaulipas Limestone with its rare ammonites would be taken for a deep-water deposit, as by MUIR (1936, p. 94), while the rudistid-facies is certainly a warm, shallow-water deposit. But in the region of mixed facies, the two types alternate so much that it would be hard to explain the difference on the basis of varying depth alone. Here we meet the same problem as in the Upper Jurassic of the Swiss Alps *(Quintnerkalk-Troskalk)* (ARN. HEIM in ALB. HEIM 1916—1919, II, p. 287).
7. Above the Middle Cretaceous, a break of sedimentation separates the Tamabra from the overlying beds over a large part of the area. In the north, the inner and southern ranges, where the San Felipe is fully developed, the break is not uniform and might be explained by interruption of sedimentation without emergence. But on the eastern border of the Front Ranges, for 125 km between Gomez Farias and the Rio Tampaon, there is a gap, corresponding to Turonian and Coniacian, with the Mendez Marls resting on a roughly weathered or solution-eroded surface of rudistid-limestone (Textfig. 4). If the Tamabra here showed the Tamaulipas facies, we might suppose the gap to be due to submarine solution. But the coincidence of the break with the neritic, sub-reef facies of the Tamabra, and with overlying conglomerates and breccias, clearly points to shallow-water and emergence during part of Turonian-Coniacian times. The same phenomena are presented by the well-records of the great Dos Bocas-Alamo oil-fields (Southern Fields).