Geology. — *On the age of the serpentines in Cuba.* By L. RUTTEN.

(Communicated at the meeting of April 27, 1940.)

In 1933 the author has explored with four students of the Utrecht University different parts of Cuba. The results of these studies have been published in four academical theses (4, 8, 9, 12), in which the geology of Pinar del Rio, of North and South Santa Clara and of a large part of Camaguey has been described. In these four areas serpentines have been found. The data obtained in Pinar del Rio were not sufficient for fixing the age of the serpentines in this province. The serpentines of Santa Clara and Camaguey are pre-upper-cretaceous. The same can be stated with great probability for the serpentine of Guanabacoa, E. of Habana, which the author studied almost twenty years ago (7). The arguments are the following:

Northern Santa Clara. There occur dikes and other intrusions of quartzdioritic rocks in the serpentine, which therefore must be older. Pebbles of quartzdioritic rocks are found in the upper-cretaceous Habana-formation: the Habana-formation, therefore, is younger than the quartzdioritic rocks. The serpentines, being older than the quartzdiorites, are pre-upper-cretaceous.

Southern Santa Clara. Serpentine has been found: 1. as serpentine-schist, intercalated in the schists of the Trinidad Mountains; these schists are jurassic or older; 2. in a very small exposure, comparable with the serpentines of Northern Santa Clara.

Camaguey. The serpentines are older than quartzdioritic rocks, which are intrusive in the serpentines. Pebbles of quartzdioritic rocks occur in the upper-cretaceous Habana-formation. Pebbles of serpentine have been found in the Habana formation and in the eocene Cubitas-limestone. The serpentines are pre-upper-cretaceous.

Guanabacoa. A dike of quartzdiorite in serpentine has been found. It is therefore supposed — by analogy — that the serpentines have the same age as in Santa Clara and Camaguey.

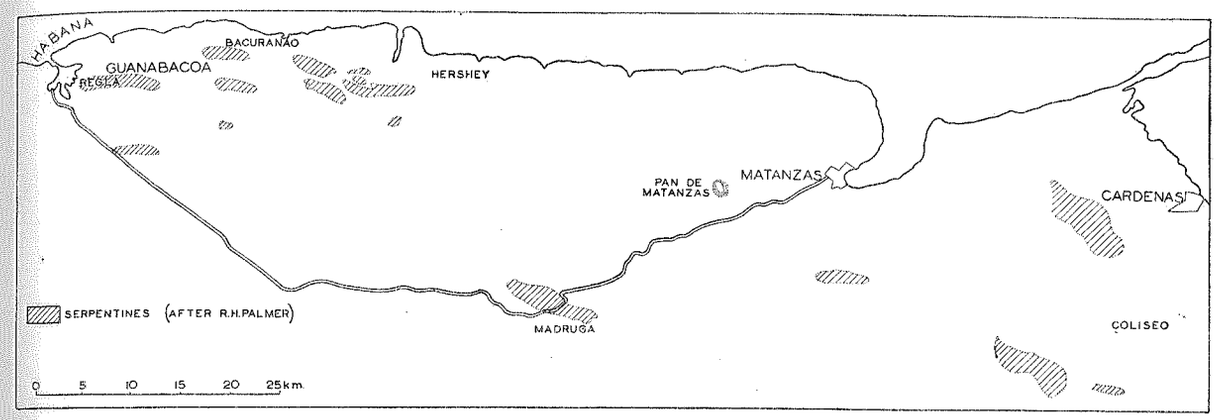
In 1939 the author studied with six students of the Utrecht University large areas in E. Santa Clara and W. Camaguey, and in E. Camaguey and Oriente. Again we met with many areas of serpentine. The study of the rock-collections has hardly begun, but it is possible to state, on the base of our field-observations, that all the serpentines are pre-eocene and very probably pre-upper-cretaceous.

There are other geologists who feel certain that at least part of the Cuban serpentines is much younger, and more specially that some serpentines in Matanzas are post-miocene (post-"Güines-limestone"). The spokesman of these geologists is R. H. PALMER (6). Dr. PALMER, whom I had the pleasure to know already in 1933, was so kind as to accompany me in 1939 to two localities in Matanzas where, according to him, strong proof was to be found for the youth of the serpentines.

On the base of the field observations and still more on the base of the study of the collected rock-material I have reached the conviction *that these serpentines are certainly pre-miocene.*

The first locality lies about 10 km to the South of Matanzas, on the automobile-road from Matanzas to the S. PALMER gives the following description:

"At kilometer 13.5 on the highway a serpentine intrusion crosses the road. This is a locality of considerable importance as the contact relationships between the serpentine and the Güines limestone are in evidence. It may be noted that the Güines limestone is fractured in the vicinity of the contact, that limestone fragments are imbedded in the serpentine and that near the serpentine the limestone is crystallized in contrast to its amorphous condition 100 yards distant from the intrusion. This locality is taken as evidence that there are post-lower Miocene serpentine intrusions" (6).



We could not find fragments of limestones, imbedded in the serpentine. We collected samples of the serpentine and of the limestones quite near to the contact; moreover we took samples to the North of the contact at different distances, and as far as about 100 m. The description of the samples follows here. The contact is to be seen in a small quarry. W. of the highway.

The serpentine passes near the contact into a rock which contains totally weathered and rounded serpentine-fragments in a "groundmass" of dolomite. I suppose that this rock is the basal conglomerate of the Güines limestone; it is, however, very strongly weathered, and I leave it therefore out of consideration.

A rock, resembling the former, but containing less serpentine, has been sampled at a distance of 0.25 m above the former.

A white, crystalline dolomite, poorly porous, and containing fine rhomboëdrons, proceeds from a zone, 0.75 m higher than the former.

A porous, brown dolomite with a limonitized crystal of magnetite and with *rounded grains of serpentine* has been sampled 0.50 m higher in the section.

The last sample of the section, from a zone, about 1 m above the former, is a strongly porous dolomite, which contains many beautiful rhomboëdrons.

As an isolated fragment there has been collected in the quarry another brown, porous dolomite, *containing a small inclusion of serpentine.*

A dozen samples have been taken along the roadside at distances of about 2, 12, 25,

30, 42, 50, 55, 65, 80, 84, 96 and 100 m to the N. from the contact. The first 7 samples are porous dolomites, which always present in the slide beautiful sections of numerous rhomboëdrons; they are very similar to the last mentioned samples from the quarry. Farther to the N. the rocks become less dolomitized and pass into normal limestones.

Thus, it is indeed true that the crystallinity of the carbonatic rocks diminishes from the contact with the serpentine to the N., but this has apparently nothing to do with contactmetamorphism. It is a phenomenon, we meet with in all limestone-areas with intercalated dolomitized zones, even if intrusive rocks are absolutely absent (f.i. Dalmatia, Ardennes, Jura). *There is no trace of contact minerals in the dolomite close to the contact, and the occurrence of rounded grains of serpentine in the dolomites proves that the Güines-limestones are younger than the serpentine.*

The occurrence of the very thin layer of poorly porous, white dolomite close to the contact is rather remarkable; it was formed probably by descendant carbonatic solutions, from which the dolomite crystallized near the contact with the impermeable serpentine.

The second contact of serpentine and Güines limestone which we visited, is on the automobile-road from Matanzas to Habana, about 25 km to the W. of Matanzas. PALMER (6) writes with regard to this outcrop:

"Observers are not in accord as to the nature of this contact. On one side it is said that the limestone shows incipient crystallization next to the serpentine and that small pyrite crystals occur in this narrow zone, both of which are taken as evidence of contact metamorphism and further there is no trace of serpentine pebbles in the contiguous limestone as would be expected if the limestone were deposited on a serpentine base. The opponents of this theory deny there is any trace of contact metamorphism....."

At this locality the serpentine is separated from the limestone by a more or less sandy layer of 1—2 m thickness. We have taken a sample of the sandy layer and two of the limestones.

The limestone nearest to the serpentine is greyblue; its colour becomes brown in consequence of weathering. In the slide it presents itself as a very finely crystalline rock with small veins of calcite.

The limestone farther from the contact is more strongly crystalline; thus there is apparently no relation between crystallinity and distance from the contact.

Various slides of the sandy rock have been made. It appears to be a calcareous sandstone which contains numerous well-rounded grains, belonging to the following rocks: 1. strongly weathered groundmass of porphyrites, 2. quartz, 3. mikropegmatite, 4. ?talc and 5. strongly weathered *serpentine* [1]).

Thus, the sedimentation of the Miocene begins here with a basal sandstone which contains grains of serpentine; the Miocene is therefore certainly younger than the serpentine.

Dr. PALMER mentions another serpentine-mass, to the S. of Cardenas, which he also considers apparently as intrusive into the Güines-limestone.

[1]) The slides of the above-described rocks in the Utrecht collection have the numbers 19200—19225.

He does not give, however, any arguments for this locality. As I did not visit it, I cannot discuss it here.

PALMER seems to be of the opinion that all the other serpentines in the provinces of Habana and Matanzas are post-upper-cretaceous {post-Habana-formation (6)}. He mentions repeatedly the existence of serpentine-intrusions in the belt of Cretaceous between Habana and Matanzas. He says of a serpentine-mass under the Pan the Matanzas:

"one large intrusion running in a northwest-southeast direction passes under Pan de Matanzas and from the air appears to have elevated this prominent hill" (6).

Describing the aspect of Yumurí-valley from an elevated point he writes (6):

"The floor of the valley is upper Cretaceous interrupted by long, narrow tongues of serpentine intrusions".

And from Barreras, to the E. of Habana he says:

"Beyond Barreras a few tongues of serpentine intruding the Cretaceous cross the road".

Here, again, PALMER's opinion does not harmonize with our results in Santa Clara, Camaguey and Oriente. I am sorry not to have been able to visit the different serpentines between Habana and Matanzas, but I have restudied the slides of the cretaceous [1]) rocks which I collected long ago to the East of Habana Bay.

At the S. side of the serpentine of Guanabacoa (E. of Habana Bay) there is a visible contact between serpentine and cretaceous limestone. The latter dips strongly to the S. It contains (slide 8444) Camerina dickersoni and Gumbelina; *it does not show the slightest trace of contact-metamorphism.*

A sandy limestone at the S. side of the serpentine of Guanabacoa (slide 8450) contains *rounded grains of serpentine.*

A calcareous sandstone, collected at a small distance to the N. of the serpentine of Guanabacoa (slides 8861, 8863) contains tuffaceous material and moreover *grains of serpentine.*

A limestone from Regla, at the E. side of the Bay of Habana, (slide 8849) contains Camerina dickersoni, Gumbelina and *rounded grains of serpentine.*

A sandy limestone with Vaughanina cubensis from Luyanó, S. side of the Bay of Habana, contains *rounded grains of serpentine* (slide 8843).

A sandy limestone from Bacuranao (slide 8479), about 15 km to the E. of Habana Bay, contains *rounded grains of serpentine.*

All these observations prove that the serpentines which occur E. of Habana Bay, are pre-upper-cretaceous.

In consequence there is no evidence for a different age of the serpentines of the provinces of Habana and Matanzas and those of Santa Clara, Camaguey and Oriente. It would, indeed, be very remarkable, if such rare

[1]) In my publication of 1922 (7) I made a blunder in considering the cretaceous rocks of the Habana formation as Older Tertiary. I found Camerina's and what I considered to be Lepidocyclina's. The first are "cretaceous Camerina's" (C. dickersoni), the second are Lepidorbitoides, Orbitoides and Vaughanina. See also (5).

and "aberrant" rocks as serpentines had been formed in so small an area as Cuba in two different geological periods.

It has been advocated that a relation exists between the distribution and age of the West Indian serpentines and problems of fundamental geological importance. H. H. HESS (2) has established the existence of a belt of strong gravity anomalies in the West Indies, quite comparable with the well-known belt of negative gravity anomalies in the East Indies. The existence of such a belt in the Antilles had already been made probable by VENING MEINESZ (10, 11). It needs not to be said that this discovery is of very great importance; the present author feels certain that in some way these zones of negative gravity-anomalies will play a great part — as they have already done — in speculations on orogenetic processes. He cannot, however, agree with H. HESS, who has tried to find a plausible relation between the zone of gravity-anomalies, the origin of the serpentines and orogenetic processes. The ideas of HESS may be summed up about as follows (1, 2). The zone of negative gravity anomalies is explained by him — in harmony with VENING MEINESZ (10, 11) — by a downward buckling of the earth's crust to a depth of 40—60 km. Strong folding of the crust's superficial layers will come into existence above the down-buckle, and peridotitic-serpentinic magma will be squeezed-up and form intrusions in the neighbourhood of the axis of the downbuckle. For the West Indies this would have the following consequences: 1. the serpentines are to be found on the axis of the down-buckle or very near to it, 2. the strongest deformations are to be found on the axis of the down-buckle, 3. the serpentines must be younger than the strongly folded formations. Now, the following may be observed.

Serpentines are well-known from Cuba and Porto Rico. In Cuba they are indeed more or less clearly localized on the axis of the zone of negative gravity-anomalies, which, however, is not well-pronounced on the island. In Puerto Rico (3), the serpentine-mass of Mayaguez which is the only important one, is situated at the enormous distance of about 150 km from the axis of negative-gravity-anomalies.

It is not possible to check for the West Indies, whether the zone of strongest crustal movements coïncides with the axis of the gravity anomalies as, for the greatest part, this axis passes over the sea.

According to HESS the negative strip originated in the Eocene. As we have seen that the serpentines of Cuba are pre-upper-cretaceous it is clear that the mechanism, constructed by HESS, cannot have any reality, at least, not in its present form.

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