

ON THE GEOLOGY OF THE NORTHERN, WESTERN AND SOUTHERN BORDERS OF THE ORDOS, CHINA.

BY TEILHARD DE CHARDIN AND F. LICENT.

During the last summer (1923), the authors of this paper were sent by the National Museum of Paris and by the French Ministère de l'Instruction publique for a geological mission in Inner Mongolia. Leaving from Pao T'ou, the geologists crossed the Oula Shan, took a view of the Scheiten Oula (eastern part of the Lang Shan), and, moving southward, reached the Ordos desert near the Christian Mission of San Tao Ho. From this point, the party went along the border of the Ordos, first southward up to Houng Tch'eng (on the south of Ning Hia), and then eastward from Houng Tch'eng to Siao K'iao Pan (in the eastern Ordos, near Ts'ing Pien). A short trip was also made to You Fang T'ou, in the loessic land of northern Shensi,

A full account of the geological and palæontological results of this journey will appear in the publications of the Museum of Paris, under the direction of Prof. M. Boule. In this communication we intend only to outline roughly some observations which may be more immediately useful to the Chinese geologists.

1. Relations between the Ordos platform and the folded surrounding chains on the North and the West.

It is well known, from the work of Obroutchev and the more recent investigations of the National Geological Survey of China, that, along the northern and western segments of the great loop of the Hoang Ho, Palæozoic rocks are folded respectively southward and eastward in such a way that the Ordos seems to have acted, during the last orogenic movements, as an "avant-pays".

In two new places, viz., in the Scheiten Oula and in the Arbous Oula, we noticed this very important feature clearly exposed.

The text-figure 1 gives a section of the Scheiten Oula which was taken near Oula Houtong, a small place about 20 kilometers east of Ta Chen T'ai. In that locality, the front of the Palaeozoic (pre-Cambrian) rocks has the shape of a large "pli couché", stretched out towards the south and lying on the crystalline strata which dip south about 80 degrees. Between the crystalline and Palaeozoic rocks the contact is very sharp, but the unconformity very slight: no crushed rock at all. Tectonically the crystalline series of the

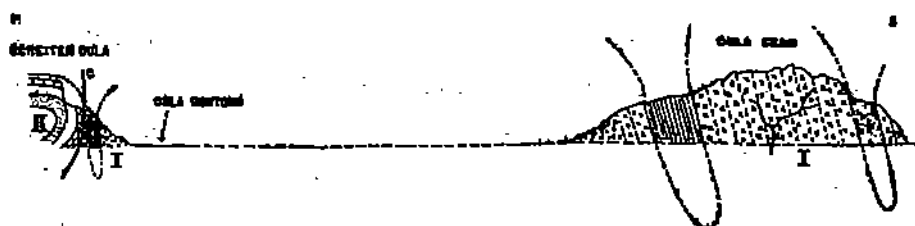


Fig. 1. Ideal section through the Oula Chan and the Scheiten Oula. I, Wu tai system (crystalline rocks and marbles). II, Palaeozoic (pre-Cambrian?). C, surface of Contact.

Scheiten Oula is just the same as the Oula Chan. The latter seems to form essentially a central, highly crystalline and anticlinal mass between two synclines of white marble and garnetiferous mica-schists. (1)

In the Arbous Oula region (text-fig. 2), the folding of the Palaeozoic rocks towards the Ordos platform is very conspicuous. Both the Arbous Oula



Fig. 2. Ideal section through the Arbous Oula and the Yinze Chan. I, Wu Tai system II, Palaeozoic (chiefly pre-Cambrian? quartzites and limestones). o, Ordovician slates. c, Stephanian sandstones and conglomerates. m, Mesozoic sandstones. M, sheet of pre-Cambrian limestone and mylonite. Q, thrust surface. G, Tsouze Chan ("Genghis enri").

and Yinze Chan form anticlines, steepening eastward. The contact between the Palaeozoic "nappe" and the crystalline series, as it was observed by us at the northern extremity of Arbous Oula, is a decidedly abnormal one,

(1) Near Oula Houtong occur frequently large blocks of rhyolite, in recent alluvium derived from the North. One of them was full of rather large amygdaloids (4-9 centimeters in diameter).

marked by a splendid mylonite. A large sheet of blue limestone (300 long and 30 m. broad) was noticed in the front of the range, completely wrapped by the micaschists, and bordered on both sides by a true mylonite zone from 40 to 20 m. broad.

Between Yinze Chan and Arbous Oula runs a very broad and shallow syncline, in the middle of which Stephanian and Mesozoic sandstones lie in an almost horizontal and tabular condition (1). In two places, along this syncline, on the border of the Yinze Chan, we found middle Ordovician slates with Graptolites (*Climacograptus teilhardi* Grabau (sp. nov.), *C. licenti* Grabau (sp. nov.), *Dicellograptus* sp. and *Didymograptus euodus* Lapworth) (2). A single specimen of *Endoceras* and some *Gywanella* were also collected in isolated blocks of blue limestone.

On the whole, the structure of Arbous Oula and Yinze Chan, as shown by text-fig. 2, is very simple. According to Obroutchev and to the observation of M. W. H. Wong and of F. Licent, the Ala Shan's structure is essentially the same. But, in the Ala Chan, the folding is much stronger than in Arbous Oula and Yinze Shan, and the Carboniferous rocks contain some marine intercalations (3). On the other hand, one could say, perhaps, that the Ordos platform has the same constitution, but on a much larger scale, as the tabular syncline between Arbous Oula and Yinze Chan. Thus, the Arbous Oula's district is a very transitional one.

In the syncline of the Ardous Oula, we have said, post-Carboniferous sandstones dip in concordance with the Stephanian rocks. Thus, the age of the last foldings is of at least Mesozoic.

In the Arshan Oula (so named by Obroutchev), a small range siting immediately on the South of Houng Tch'eng, Palæozoic rocks are almost entirely covered by the Pontian and Quaternary deposits. Nevertheless,

(1) They are overlaid, in place, by a thin flow of basaltic rock.

(2) Kindly determined by Prof. Grabau.—The horizon is I aver Leandelle. A good locality for collecting Graptolites is the foot of the rocky mass on which the lamasery Wambara ssen (near Chen Tchoui Zou) is constructed. This rocky mass rises up at the very point where the Yinze Chan anticline bends most sharply from the N-S. to the E-W. direction.

(3) Near Hin Ying Zou (20 kilometers on the South of Chen Tchoui Zou) blocks of a yellow limestone containing specimens of *Philipsia* were collected this year, in a stone quarry. Near a pottery furnace, by a missionary, F. de Wilde.

emerging out of those younger alluvial deposits a ridge (no broader than 20 meters) of crushed pre-Cambrian limestone, running from the North to the South, can be followed for four or five kilometers. This curious formation is to be compared with the topmost part of mylonitized limestone which we have mentioned as occurring in the front of the Arbous Oula.

2. Occurrence of Pliocene (post-Pontian) beds on the western border of the Ordos.

In two places along the western border of the Ordos (viz., in the desert, exactly opposite the San Tao Ho mission,—and along a stream, some 5 kilometers to the West of Ts'ing Choei Ying, a small fortress on the Great Wall at 30 kilometers east from Houng Teh'eng); we met fossiliferous beds of probably Pliocene (post-Pontian) age.

Near the San Tao Ho (text-fig. 3), the beds in question occur at the top of a thick series of red clayey sands and greenish marls (probably Pontian)

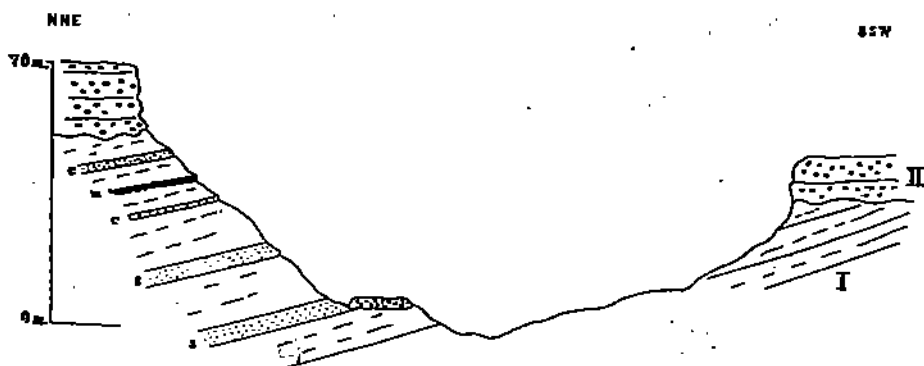


Fig. 3. Section through the Pliocene beds in the desert before the San Tao Ho. I, dipping red clayey sands. II, horizontal Quaternary gravels. n, white fossiliferous sands. c, beds of conglomerate (of small calcareous nodules). m, manganese-bearing layer.

dipping 20° to the North. Fossiliferous horizons are chiefly formed by white fluviatile sands, in which, besides the remains of Fishes, Turtles and Crocodiles, there are numerous mammalian bones: *Mastodon*, *Rhinoceros*, *Chalicotherium*, *Hyaena* (a small species), *Felis*, *Tragulus*, and many Rodents (3 gen.). In that first locality, as shown by the section, the Pliocene formation is rather thick; but its beginning is marked by no distinct disconformity.

Near Ts'ing Choei Ying, on the contrary, the Pliocene beds are very thin, but their stratigraphical relations with the Pontian below is absolutely clear. In that point (text-fig. 4), Pliocene is represented by 2 or 3 meters of sands and conglomerate (chiefly composed of small limestone nodules washed out of the red earth underlying) depositing on the eroded surface of the

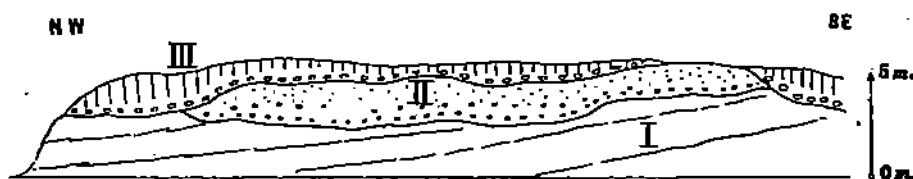


Fig. 4. Section through the Pliocene beds near Ts'ing Choei Ying. I, red gypsous clay (Pontian). II, fossiliferous sands and conglomerate (Pliocene). III, Quaternary gravel and loess. (identical with the Palaeolithic loess of the Choei Tong K'ou).

Pontian clay. In these sands and conglomerate are remains of *Rhinoceros*, *Tragulus*, *Rodents*, very similar to the specimens collected in the desert of the San Tao Ho.

In both cases (near Ts'ing Choei Ying and near the San Tao Ho) Quaternary gravels are seen overlying disconformably (and even, in the San Tao Ho at least, unconformably) the Pliocene beds.

Detrital beds, quite identical both in lithological characters and stratigraphical position with the Ts'ingchoeiying formation, have been observed by us on the eastern side of the pre-Cambrian rock of the Arshan Oula, and, along the Hoang Ho, on the top of a red promontory some 30 kilometers to the South of Chou Tchouei Zou. But, in these two places, indeterminate bones only were collected.

In short, Pliocene (post-Pontian) beds, in the Ordos, seem to correspond with a period of torrential character. But, they seem much more clearly connected with the red earth below than with the loessic formations above.

3. Succession of the Mesozoic and younger formations in Northern Shensi.

In the loessic district in the South of Yu Lin (especially near the small locality of You Fang T'ou), we had good opportunities for studying the series of continental and horizontal formations of northern Shensi. From

the base to the top, the succession of the beds, is, invariably, as follows (text-fig. 5):



Fig. 5. Ideal section through the loessic lands of N. Shensi and the S. E. corner of the Ordos. I, Mesozoic rocks (green coal-bearing sandstones, marls with Fishes, crossed red sandstones). II, Pontian red sands and clay, with basal conglomerate. III, loess (torrential, freshwater, eolian loess). IV, beds of the Sijia Oaso Gol.

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|---|-------------------|
| a) Green shales and limestones, with coal seams. | } <i>Mesozoic</i> |
| b) Reddish marls, with jasper nodules (4-5 meters?). | |
| c) Thick red sandstone, with crossbedded structure. | |
| Strong disconformity. | |
| d) Red sands and clay, beginning with a thick basal conglomerate. | <i>Pontian.</i> |
| Strong disconformity. | |
| e) Loess, beginning with a thick basal conglomerate. | |

In the green shales (a), we collected many plants (*Ferns*, *Equisetum*, *Pinus*.....) of a Wealdian type, and, in the reddish marls (b) remains of ganoid Fishes¹⁾. The red sandstone is unfossiliferous.²⁾

Near You Fang T'eu, Pontian beds are highly fossiliferous. A species of *Aceratherium* with tusk-like lower canines in the male is noteworthy, and seems rather common in the red earth of this locality.

In the whole region, the structure of the loess was found extremely constant, and formed, everywhere, by the three following formations.

1) This very year, M. T. C. Wang, of the National Geological Survey of China, exploring the same district, but more to the North, found exactly the same Mesozoic series. In the reddish marls he collected beautiful specimens of Ganoids, and coproliths of Sharks.

2) Much further westward, at some 20 kilometers on the West of the town of Hoa Ma Tcheu (80 km. east from Ning Hia), a thick series (about 100 meters) of foliated beds (red, white and green sandstone and psammites, red clays), containing some *Etheria*, *Cypris*, and scales of Ganoids, can be seen along the Great Wall. Topographically, these beds lie higher than the red sandstone (c), on which Hoa Ma Tcheu is constructed. But they are possibly older geologically, and elevated by a fault.

- 1) Basal conglomerate (0-10 meters) (torrential loess).
- 2) Stratified beds (more or less developed, containing shells of *Limnaea* and *Planorbis*..... (freshwater loess).
- 3) Massive and true loess, with *Helix* and *Pupa* (up to 100 meters)....
..... (?eolian loess).

Much more to the South, near K'ing Yang Fou (Kansu), in 1920 F. Licent had noticed exactly the same composition of the loess. The "freshwater loess" was there specially developed, and contained shells of *Unio*.

4. The Quaternary beds of the Sjara Osso Gol.

During our journey, particular attention was paid by us to the Quaternary beds which the gorges of the Sjara Osso Gol river cut to a depth of 56 meters in the southeastern corner of the Ordos.

These beds (1) (yellow and bluish sands, with intercalations of blue clay) are of fluvial, and perhaps eolian (sand-dune) origin. They lie directly on the Mesozoic red sandstone, and pass laterally southward into the "freshwater loess" of northern Shensi. From palaeontological point of view, they are extremely interesting on account of their richness in mammalian remains. Not far from Siao K'iao Pan, whole skeletons of *Rhinoceros tichorhinus*, *Hemione*, *Buffalo*, etc. occur in the blue clay; and many scattered bones together with palaeolithic remains were collected in the sands (2).—But we shall return to this subject in a next communication.

5. The gravel terrace of the western Ordos.

In the whole western border of the Ordos, the more recent geological formation consists of very thick gravels, which usually build extremely regular terraces around the folded chains (Arshan Oula, Arbous Oula and Yinzo Chan, Ala Chan, Oula Chan, etc.) (3). We did not succeed in determining the age of those deposits. In many cases (viz. in the region of Houg

(1) Already noticed by Obroutchev, *Central Asia and Northern China*, chap. VII.

(2) Cf. the Bulletin of the Geological Society of China.

(3) The gravels derived from the Arbous Oula extend, in very considerable thickness over the Pliocene beds, before the San Tuo Ho (text-fig. 3).

Tch'eng) they seem to be identical with the basal conglomerate of the loess. But, elsewhere (for instance in the synclinal of Arbous Oula, and in the terrace of Pao T'eu), on the contrary lie above ?loessic formations, and afford proof of a very important post-loessic erosion.

Because of the extent of these gravel terraces, it would be very interesting for Chinese geologists to determine the question of their exact antiquity.