

THE BASE OF THE PALÆOZOIC IN SHANSI. METAMORPHISM AND CYCLES.

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I had recently an opportunity for observing, along the western border of the northern Hoshan (Central Shansi), at the base of the Palæozoic, a particularly clear section, in which several interesting features seem to be worth mentioning.

This section, illustrated in the text-figure 1, was taken at the entrance of the deep canyon in the north wall of which the picturesque Mienshan temple is boldly located¹. Lying over a good exposure of Archæan granite, come, in regular succession, thick quartzitic sandstones, red Manto shales, oolitic limestones, and then the classical Cambro-Ordovician limestone.

In this complex, two facts are especially noticeable: the crystalline condition of the oolitic limestone, and the cyclic distribution of the sediments.

1. METAMORPHISM OF THE OOLITIC LIMESTONE.

The whole mass of the oolitic limestone is more or less crystalline: sometimes slightly, the rock being still dark in colour; sometimes strongly, the limestone being whitish, or white, and decidedly marmorized. I could not, on account of the steepness of the wall, locate exactly the horizon of the best marmorized beds. But huge angular blocks of it, several cubic meters large, are commonly found in the canyon.

In order to explain those conditions, my first thought was to search for some intrusive granite. But I could not see any trace of them. On another hand, a similar crystalline state of the basal Palæozoic limestone (in absence of any intrusive rock) is observed in S. Shansi, in the very locality (Kentingshih) from which I have described, recently, the curious *Biconulites grabau*². At this latter place (where the general section is *identically* the same, although thinner, as in the Mienshan) the dark lower *Biconulites* layer is strongly crystalline.

1 The locality is easily reached, from the motocar-road, a few kilometers north of Lingshihhsien.

2 Teilhard de Chardin, P. On an enigmatic Pteropod-like fossil from the Lower Cambrian of Southern Shansi. Bull. Geol. Soc. China, Vol. X, p. 179, 1931.

Struck by this coincidence, I suspect that the marmorization of the oolitic limestone, in the two mentioned localities, corresponds to a special phenomenon of "auto-metamorphose" (pressure? mineralisation *per descensum*? slow

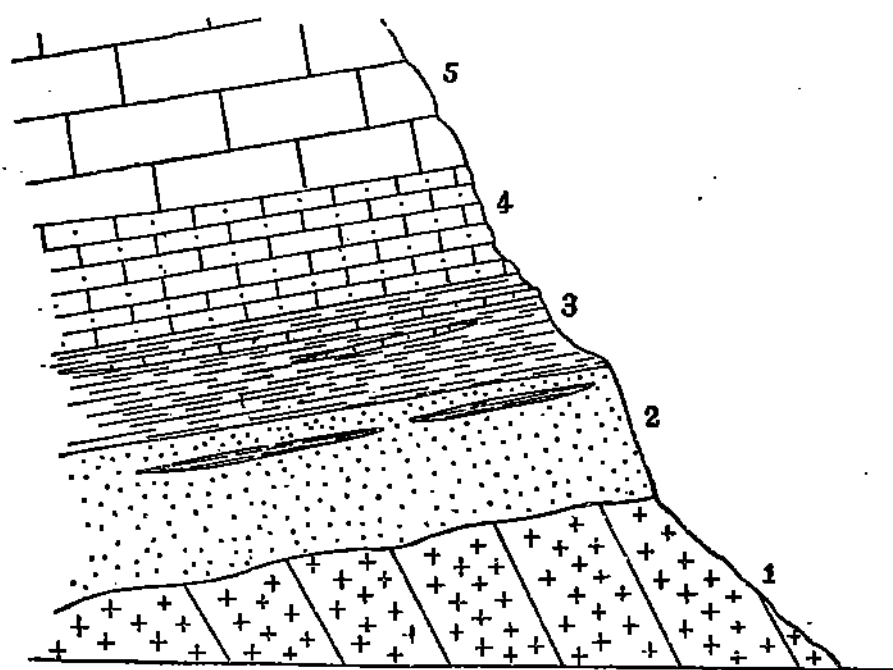


Fig. 1.—A section of the Palaeozoic cliff, at the Mienshan (Shansi). 1, Archæan granite. 2, Quartzitic sandstone (Cambrian?) with shaly layers at the top, 60 meters. 3, Red shales (Manto shales) with oolitic limestone intercalations, 30 meters. 4, Oolitic limestone, partly crystalline. 5, Cambro-Ordovician limestone, great wall.

action, *per ascensum*, of deep seated emanations?) likely to take place whenever a thick sedimentary series overlies, even in a normal sedimentary contact, a large granitic mass. More examples of this fact should have to be researched elsewhere in China.¹

¹ Connected with the crystallisation of the limestone is possibly the frequent mineralisation of the basal Palaeozoic beds (galena, pyrite...) in Shansi, Colorado, Kansas (Ozark), etc.—The Cambrian oolitic limestone is also crystalline in S.E. Shansi and in Shantung.

As a confirmation of those views, the fact has to be noticed that in the Great Colorado Canyon, where the geological sequence is essentially the same as in the Shansi, the crystallisation of the limestone, in absence of any intrusion or strong folding, is exactly the same. In the places in which I crossed it, this summer, the great Carboniferous limestone series (the Red Wall) is completely marmorized. And such is also, although more slightly, the Algonkian *Collenia* limestone (Vishnu) below. Both in Shansi and in Colorado, the tectonic conditions are rather quiet,—and the maximum of metamorphism does not correspond necessarily with the base itself of the limestone.

2. CYCLIC DISTRIBUTION OF THE SEDIMENTS.

A second interesting feature to be mentioned in the Mienshan section is the typical sedimentary cycle expressed in the series. Here (as in Kenting-shih¹) the red Manto shales are gradually introduced by a series of clayish layers visible at the top of the sandstone; and, similarly, several thin layers of oolitic limestone occur at the top of the shales, announcing the terminal development of the limestone.

Some disconformity is likely to be discovered in the upper limestone itself, between the Cambrian and the Ordovician (both of which can hardly be put in a same cycle, in spite of strong appearances). But, so far the basal beds are concerned, no doubt is possible: to place any stratigraphical break between the sandstone and the oolitic limestone would be utterly artificial.

Consequently, it has to be admitted that, in Shansi, the Cambrian beds form a complete and regular sedimentary cycle, including basal quartzitic sandstone. And consequently, also, any recognition of the Sinian series exclusively based on the presence of a quartzite above the Archæan would be unsafe, and has to be confirmed by further considerations.

3. OTHER EVIDENCES OF PALÆOZOIC CYCLES IN THE SHANSI.

Perfectly symmetrical with the Mienshan section is another section, of the basal Palæozoic observable at the northern base of the Fenghwangshan

¹ Teilhard de Chardin, P. and E. Licent. On the basal beds of the sedimentary series in SW. Shansi, Bull. Geol. Soc. China, Vol. VI, pp. 61-64, 1927. See fig. 2 (non 4; the legends of fig. 2 and 4 are interverted).

(S. Shansi), near Yühsianghsien, close to the Salt Lake. Here¹, overlying a remarkably weathered (and reconsolidated) surface of Archæan granite, some 200 meters of quartzitic sandstone, and about the same thickness of red shales², and finally a powerful siliceous limestone, build a typical sedimentary sequence. This is a *Sinian cycle*, parallelizing and foreshadowing strangely the Hoshan Cambrian cycle³.

Quite at the opposite end of the Shansi, between Chinglo and Kolan (NW. Shansi), I have seen, with Dr. C. C. Young, a fourth remarkable sequence, expressed in the figure 2 of this paper. Here, over a folded syncline of Wut'ai rocks, exhibiting the characters of a somewhat complex, but clearly recognisable sedimentary cycle (conglomerates, slates, andesites and amphibolites,



Fig. 2.—Section along the Chinglo-Kolan road, between Haimafangchen and Chinerhying (NW. Shansi). 1, Arkoses, siliceous slates and quartz-conglomerate. 2, Nodular or spotted slates. 3, Altered (epidotised, ouralitised and albitised) andesite. 4, Amphibolitic rocks. 5, Thick, hard, quartzite. 6, White and pink micaschists. 7, Basal conglomerate. 8, Quartzitic sandstone. 9, Cambro-Ordovician limestone. Between 8 and 9, shales are probably present, but were not actually observed. 1-6, Wut'ai cycle. 7-9, Palæozoic cycle. Approximative length of the section, 10 kilometers. Ch. Chinerhying. AB, fault?

- 1 Teilhard and Licent, loc. cit., 1927, p. 61 and fig. 4 (*non* 2). The real presence in this section of a Cambrian cycle overlying, south-east, the Sinian cycle, is evidently a very important point to be verified.
- 2 Those shales would be one of the most promising points I know for the research of Sinian fossils.
- 3 Such a parallelism is clearly supporting the idea of Dr. A. W. Grabau that the Sinian has to be included in the Palæozoic.

quartzite, micaschists), another cyclic Palæozoic series (conglomerates, quartzitic sandstones, shales?, limestone) is lying almost horizontally¹. It would be highly important to prove that this latter cycle corresponds (at least by its lower part) to the Sinian Yühsianghsien (and not to the Cambrian Mienshan) cycle: since we would have here a clear evidence of unconformity between the Sinian and the Wut'ai. But I am unable so far to decide the question.²

In any way, those few remarks will help to show how, in Geology, it becomes ever more important, after separating the formations, to distribute them in *their natural cyclic association*. As emphasized by Dr. Grabau in his "Pulsations Theory", the natural stratigraphic unit (in the case of the great marine belts as well as in the case of the continental basins) is *the sedimentary cycle only*.

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- 1 This practically horizontal state of the Lower Palæozoic is a striking feature. The general appearance exhibited in this place by the Palæozoic transgression is impressively the same as observed in those parts of E. Africa (Abyssinia and Somaliland) where perfectly horizontal Jurassic sandstones and marine limestone extend over the thick metamorphosed sediments building the African platform.
 - 2 We could not ascertain, by lack of time, whether the slates and andesites, south of the line AB (fig. 2) pass really under the quartzites. Another probability is that (as admitted by C. C. Wang, Geological Map of the Shansi) they represent a different group, corresponding to the Sinian. So that, in this section, *three cycles* would be represented: Wut'ai (5-6), Sinian (1-4), Cambrian (7-9).