THE STRUCTURE OF SACRED OMEISHAN, SZECHUAN

(Preliminary Notes)

With 1 Section and 4 Photographs

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INTRODUCTION

The following notes are rapidly written as part of the result of a five days excursion. It has been made on a geological expedition to Szechuan during the summer of 1929, executed under the auspices of the Sunyatsen University of Canton and of the Geological Survey of Kwangtung and Kwangsi. The writer was accompanied by Messrs. Chang Min Shao and Lee Tien Chen, Geologists of the Geological Survey. He is much indebted to His Excellency Taichitao, Minister of Examination Yuan and President of Sunyatsen University of Canton, and to Professor Dr. Chuchiahua, Civil Governor of Chekiang, Vice-President of Sunyatsen University and Director of the Geological Survey of Kwangtung and Kwangsi. Further thanks are expressed to General Liu of Chengtu and to the Officers and Professors of the Union Mission University of Chengtu, where our party found the kindest receptions and help.

Omeishan is one of the four most celebrated Sacred Mountains of China, and probably the most wonderful in nature. It is frequently visited by Buddhist Pilgrims, who undertake the hardship of climbing the thousands of stone steps.

The elevation of Omeishan is not yet surveyed. On English maps, it is usually given as 11.000 feet (3355 meters); Stieler's Hand Atlas shows 3380 meters. According to the boiling point, Y. T. Chao only measured 2730 meters. In the section given herewith, I have accepted my personal barometric readings of 3200 meters, which was controlled at Kiatingfu.

No topographic map yet exists of Omeishan. The approximate location however is shown on every good general map of China.

On the Japanese Atlas 1:200.000 (see literature), part of the mountain along the main trail is mapped. The contour lines of 20 meters interval look

very pretty, but are entirely unreliable. In the place of Szeba River for instance, high mountains are indicated.

The geological field work thus had to be based on a sketch worked out subsequently by myself while going on. It was made difficult on account of some days of rain and fog, and furthermore by the deviation of the compass on the basalt. The sketch made in 1: 100.000 will be published later, if possible after completion in the field.

The summit of Omeishan is situated in a straight line about 40 Kilometers west of Kiatingfu. On the first day, the city of Omei Hsien NNW of Kiating, or one of the temples on the foot of the mountain (Paogoasze), is reached by foot or chair. Then follow two days of climbing along gorges and over crests with many romantic roundabout ways. The traveller is welcomed by the Buddhist priests in every of the numerous Temples on the Pilgrim trails. There he finds primitive shelter and food for reasonable prices.

To reach the top on a clear day is an event which a scientist will never forget. More fascinating even than to look down over more than 2000 meters of precipices is the *scenery of snow mountains* in the far distance. Those to the North, West of Chentgu, remind us strikingly the famous Alps of the Bernese Oberland in Switzerland, while those to the West, situated south of Tatsienlu, even excell them much in grandeur and elevation. Many small hanging glaciers are seen with the telescope, and two large glaciers flowing down towards the Tungho Valley to elevations of 3000 meters or less (according to levelling with the alidade from the top of Omeishan). The mountains themselves are thought by Edgar[1] to reach 30.000 feet and to be the highest of the world[2].

The writer hopes to approach these sublimest mountains of China on a next expedition. The aim of this paper is only to give a brief account of the geological structure of Omeishan itself, the prominent mountain which rises high over the Red Bed Hills of the surrounding country.

PREVIOUS GEOLOGICAL PUBLICATIONS.

Until recently, the geology of Omeishan was almost unknown.

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1 J. H. Edgar, Note accompanying Sketch of the Gang Ka, Journal of the West China Border Research Soc. 1922-23, p. 58.

2 According to newspapers, dated New York, March 30, 1930, J. F. Rock, leader of the National Geographic Society's Expedition, recently has confirmed this conception by measurement from a base-line.

In the famous work of my venerated master von Richthofen Omeishan is mapped as an oval space of Older Igneous (Aeltere Eruptivmassen) within the Red Beds (Deckenschichten), the elevation of Ngomeishan being indicated as 3900 meters. He himself had not visited the mountain.

On the *Japanese Atlas* 1: 200.000[1] Omeishan is mapped with many details, the stratigraphy and structure however being completely misunderstood. The synclinal Red Beds, for instance, are indicated as Silurian with a dip of 20° towards NE, cut off by a double fault line drawn over mountains and valleys.

Some interesting details have been published later by C. L. Foster[2], formerly Professor at the Union Mission University of Chengtu, to whom however the structure remained obscure, and who seems not to have known the Japanese work.

The first clear light thrown on the geology of Omeishan is due to Y. T. CHAO, the brilliant young geologist of the Geological Survey of China who has been killed by bandits in Chaotung, Yunnan, on Nov. 16th 1929, one month after we had travelled together from Tseliutsin to Suifu. With his wide experience in the stratigraphy and paleontology of China he was the first to recognize and to determine *the complete series* of formations of Omeishan.

His last field report, published by the Geological Survey of China under the Directon of Dr. W. H. Wong[3], however contains some errors of tectonical interpretation. Mr. Chao certainly would have changed his general deductions. Indeed, after a discussion held with him at Tseliutsin, Szechuan, after my return from Omei (Oct. 8, 1929), Mr. Chao acknowledged having overlooked the anticline with its granitic nucleus and the younger granite in place of his fault, where he passed in bad weather. He further admitted not to have sufficiently studied the contact of the Red Beds with the older formation. On the other hand my tectonical observations[4] were greatly helped by the

1 Tokyo Geographical Soc., 1917, Geology by G. Kobayashi, Sheet 9.

2 C. L. Foster, Notes on Szechuan Geology, Journal of the West China Border Research Soc., Chengtu, 1922-23, p. 47-51.

3 Yatseng T. Chao, Geological Notes in Szechuan, Bull. Geol. Soc. China, Vol. VIII, No. 2, 1929, p. 137-144.

4 Arnold Heim, Zeitschr. Ges. f. Erdkunde Berlin,

An Excursion on Sacred Omeishan, with geol. Section and 2 phot. Sunyatsen University, Canton, 1930.

stratigraphic results of Mr. Chao, who was kind enough to leave me a sketch before I went to Omei. The recognition of the Cambrian, especially, of which I had no previous field experience, would probably have escaped me.

STRATIGRAPHICAL SUCCESSION.

PRE-SINIAN GRANITE

The oldest rock of Omeishan is the granite (G' in Fig. 1) which forms he nucleus of the great Omei-Anticline. Different varieties are found, from coarse to fine grain, and from red to gray. In some places, red orthoclase is surrounded by green quartz.

An unusual fact is the *stratification* of the granite in form of layers around 1 meter each, which underlie the Sinian limestone nearly conformably. These beds, although varying in the size of the grain and the colour, remain massive in themselves, i. e. the phenocrysts are placed irregularly in all directions.

A dyke (D) of green fine-grained basic rock was found, being cut off by the overlying limestone.

SINIAN LIMESTONE.

This important series is called Hungchunping Limestone by CHAO, after the temple of this name (Hungtsoengping in Fig. 1). This new name seems not to be necessary, the identity with the Sinian Limestone of Ichang on the Yangtse or Toengying Limestone being out of question[1].

As much as could be worked with the pick and hammer, this limestone overlies the granite directly. The latter was found to be not more weathered on the upper contact than further below, and seems to be smoothly worked off at the surface. This might be caused by glacial erosion during the Pre-cambrian Nantou Ice Age. The Lower Sinian known under the name of Nantou Formation from the Yangtse Gorges is absent at Hungtsoengping.

The Sinian Limestone is of ash gray to white colour and different in aspect from the younger limestone formations. The white colour however is usually hidden by an extraordinary growth of evergreen foliage which covers even nearly vertical walls. (Pl. II Fig. 2)

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1 J. S. Lee, Geol. of the Gorge District..., B. G. S. China Vol. III, No. 3-4, 1924.

According to Y. T. Chao, "the base is not exposed in the district surveyed, but the exposed thickness alone must be over several hundred if not thousand meters".

Indeed, the base is not exposed along the trail of the pilgrims which, at Hungtsoengping, remains 110 meters above the gorge. But the granite is widely exposed at the bottom, reaching 50 meters above the water. The contact could be opened in a little side-ravine. The total thickness as deducted from the sketch-map thus is estimated as 1100-1200 meters (Fig. 1).

Kiulaotung Series.

This name is introduced by Chao after the temple of Kiulaotung (Tshulotung). The characteristic sediment is a thin-bedded to slaty, fine grained sandstone, easily splitting into even plates, of gray and black colour, also purplish according to Chao. The thickness is estimated around 250 meters.

No fossils having been found, it is uncertain if the Kiulaotung series belongs to the Upper Sinian, as regarded by Chao, or to the Basal Cambrian;

Cambrian to Silurian

This series between the Kiulaotung and the Permian is divided by Chao into:

a) Yusiensze Series,

b) Hsihsiangchih formation,

both being regarded as Cambrian.

In the Yusiensze Series Chao has found *Redlichia* and *Obolus* which enabled him to correlate it with the Shipai shale of the Yangtse Gorges above Ichang.

The thickness of a + b of over 800 meters as given by Chao seems to be overestimated, apparently by not taking account of the northerly pitch of the anticline.

According to my preliminary observations, the lower Paleozoic is divided into the following divisions:

a) lower, characterized by sandstones with red and green clay-shales, of several hundred meters

b) upper, characterized by gray slates and marls, of 80-100 meters (shinkaisze). It is apparently this upper division which has furnished a Monograptus found by Foster. Thus, Silurian might be present, especially an equivalent of the Lungma shale of the Yangtse Gorges[1]. Further studies are necessary.

Permian Limestone.

As already recognized by Chao, the lower Palæozoic is concordantly overlain by a series of limestone with Fusulinidae including Neoschwagerina, Brachiopods and Corals. The paper of Chao gives an excellent account.

The thickness on the top wall of Omeishan is estimated as 150-200 meters, but reaches about 400 meters on the east limb of Omei Anticline (Liushinsze, Shinkaisze). Here, strongly bituminous black layers are found in the lower and upper part of the limestone series, with a smell of asphalt.

Omeishan Basalt.

Porphyritic basalt of about 100 meters thickness forms the black top wall of Omeishan and of its gentle eastern slope, in wide extension. It is found again all along the NE limb of Omeishan-Anticline (Tsinyinko-Shinkaisze), and furthermore in the gorge of the Szebaho on its traverse of the Front Range. The thickness at these latter places seems to reach about 400 meters.

The magnetic needle of the compass on the basalt is badly affected. Deviations of azimuth as much as 12° have been measured between Tshintin and Wanfutin on the top of Omeishan. This is a great obstacle to topographic surveying.

Basalt forms also the top wall of the imposing table of Washan 3200 m, SW of Omeishan.

The Basalt is known all along the Tibetan Front Ranges from beyond Omeishan towards south into Yunnan[2], and is generally considered as Upper Permian. It is found on the contact with the lower part of the Triassic red beds below Liangfunggang in the Gorge of Szebaho (Fig. 1)

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1 J. S. Lee, Geology of the Gorge District of the Yangtze. B. G. S. China Vol. III No. 3-4, 1924 p. 374

2 Geological Atlas of Eastern Asia..1: 2.000.000, 1929

Purple Shale and Limestone, Triassic.

Again we owe to Y. T. Chao the first recognition of Triassic sediments on Omeishan. He distinguished:

a) Feisienkuan Limestone made of purple shale, about 350 meters

b) Chaohua Limestone (called after the city in North Szechuan), about 500 meters.

These two subdivisions seem to pass into each other, the purple shale taking up beds of white and yellowish limestone (Fig. 2, Pl. III).

In addition we can distinguish:

c) Gray marls, about 80 meters, with abundant fossils at the top, especially flat Pelecypods and some Ammonites. This new horizon is in course of palæontological study by Professor A. W. Grabau of Peking.

Coal Bearing Sandstone, Jurassic.

This is called "Kuangyuan Coal Series" by Chao. Obviously, it is equivalent to the Hsiangchi series of the Yangtse Gorges, which are generally regarded as Jurassic, on account of plant remains.

On the trail along Szebaho Gorge, Chao has observed thin coal seams within the sandstone, with impressions of Podozamites. However he has overlooked the contacts at the base and at the top, which can be opened with the aid of an ice-pick. The thickness thus was found to be about 250 meters. Owing to the reversion of the series, some tectonical reduction has to be taken in account, the normal thickness thus being guessed as 300 meters (Fig. 1).

Red Beds, Cretacic.

The Red Beds fill out the great Red Basin of Szechuan, with a thickness of about 4000 meters.

Near the base, a fresh or brackwater fauna has been discovered by Chao, which is supposed by Grabau[1] to prove Lower Cretaceus[1].

These observations have been plainly confirmed by the writer, especially in the region of Chungking and of Tseliutsin. But the unconformity at the base does not exist. Wherever the contact with the Coal Bearing

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1 A. W. Grabau. Stratigraphy of China Vol. II, p. 646, 1928

Sandstone could be observed, it was *strictly concordant*. This is the case even within the overturned series at Lomendong, the entrance to the gorges of Omeishan (Fig. 1).

West of Tseliutsin (Lungshan) and at Suifu even a *stratigraphical passage* in the normally lying series has been found. Thus, there is *no break between the two formations*. This result, on the other hand, confirms again the Mesozoic age of the Red Beds.

On the Japanese Atlas in 1:200.000 the following subdivisions are carried out:

a) "Lower Red Formation" (Jura-Triassic)

b) "Upper Red Formation" (Jura-Cretaceous)

c) "Lower part of Upper Red Formation" (Cretaceous)

This "Lower Red Formation" is equivalent to our Coal Bearing Sandstone. The designation of "Red" apparently derives from errors in observation. Indeed, in many places Kobayashi has mapped as a) the sandstones which clearly belong to the typical Red Beds and have nothing more to do with the Coal bearing Jurassic (Suifu, Chungking, Kialingkiang below Hochow etc.).

The subdivision of b) and c), on the other hand, is completely arbitrary. As also agreed by Mr. Y. T. Chao in discussion during mutual excursions at Tseliutsin, this subdivision has to be cancelled for the whole Red Basin.

There seems, however, to be another upper subdivision at a higher horizon; the *Brick-red Sandstone*, which forms the wide synclinal platforms all over the southeastern part of the Red Basin. It is especially characteristic at Kiatingfu, where the celebrated caves of the aboriginees are situated. It might be called *Kiating Formation*.

On the way to the Pagoda of Kiating on the left bank of the big river, cross-bedding is exposed in a striking way. While the general stratification is horizontal (Pl. II, Fig 1.), these oblique dips vary in all directions, as shown for instance by the following bearings: 30° to NNE, 25° to SSE, 28° to SE.

The general aspect of the Kiating sandstone reminds somewhat that of the Triassic Buntsandstein of Germany, which is a desert deposit.

The Brick-red Sandstone also was found at the outer rim of Omeishan, West of Omei Hsien, about 1,5 km east of the coal bearing sandstone, in a nearly vertical position (Fig. 1).

More details of the Red Beds will be presented in a later paper treating more especially the Red Basin.

The lower part of the Red Beds is the equivalent to the Tsekuei (Kweichow) Series of J. S. Lee[1] and others.

The Red Beds seem to be one of the widest spread formations of southeastern Asia, extending from Mongolia to Siam . As already discussed in a previous paper[3], there is no sufficient reason at hand to map the Red Beds south of the Yangtse as Tertiary, as for instance shown on the new Geological Atlas of Eastern Asia . The uniformity of the Red Beds also is emphasized by V. K. Ting[5]. However I do not agree to have the Yenshan-movement extended to the Post-Red dislocation. I am taking this term in the original sense as defined by W. H. Wong 1929: Yenshan A = End of Jurassic, Yenshan B = Middle Cretacic.

Pleistocene Terraces

On the trail from Kiating to Omei, two main terraces are crossed. According to the barometer readings, Kiating has an elevation at about 390 meters. An extended high terrace suddenly begins above the town of Sushi, with an elevation of 430 m, 35 m above the river. Instead of rising, it is slightly declined towards the west.

East of Omei Hsien, a younger Low Terrace is passed along the Omei River.

The hills of the Red Beds outside of the region of strong tectonical disturbance are peneplaned. The higher hills reach about 470 meters, thus

1 J. S. Lee, Geology of the Gorge District of the Yangtze....., B. G. S. China Vol. III, No. 3-4, 1924

2 According to verbal communication by Prof. Dr. W. Credner, the Red Beds of Siam have exactly the same appearance and relations as those of Kwangtung. The latter again, according to my observations, could not be distinguished lithologically from those of Szechuan.

3 Arnold Heim, Hongkong. Ann. Report G. Survey Kwangtung and Kwangsi,.....

4 Geol. Atlas of Eastern Asia, 1:2,000,000.

5 V. K. Ting, The orogenic movements in China, B. G. S. China Vol. VIII, No. 2, 1929, p. 168, 170.

are 80-100 meters above the main river. This peneplane was found all over the Red Basin of Szechuan.

The Gaps of Sedimentation.

The following gaps have been found according to the previous description:

a) Sinian Limestone on Pre-Sinian Granite. In the gorge at Hungtsŏngping, no trace of the Nantou Formation (Lower Sinian) has been discovered, although the even surface of the granite might have been caused by glacial work.

b) Possible discontinuity between the Sinian Limestone and the Kiulaotung series. No exposure of the contact yet could be studied.

c) Great parallel discontinuity between the Older Palæozoic and the Permian. As mentioned by Chao, this discontinuity of sedimentation might, as a whole, be of the type of a slightly angular unconformity.

d) Discontinuity between Triassic (7 c) and coal bearing Jurassic, the limit being absolutely sharp and concordant. This discontinuity represents the change from marine to terrestrial deposition.

e) Local unconformity of the Red Beds or the older Mesozoic on Basalt.

This latter gap is one of the most important, and the one which presents the most delicate problem.

According to Chao, the Red Beds would everywhere overly the older formations with sharp angular unconformity.

Closer observations of contacts however showed, that on the outer margin of Omeishan the Red Beds are *completely concordant* to the Coal bearing Sandstone, both being overturned together in the same way.

In the interior syncline, the same Red Beds however are overlying directly the Basalt, and as seen from long distance this seems to be also the case on the west side of Omeishan.

If there is any angular unconformity at the borders of the interior syncline at Szebaho, the angle is very small. At Liangfunggang, the Basalt dips 30° towards the SW, while the base of the Red Beds, seen from a distance

better than at the spot, dip with an angle of about 25°. At Wanyangsze (NW part), the basal Red Beds dip 18-20° towards the NE, while the Basalt seems to dip between 20 and 30°. At Kwangfusze, the contact is exposed along the gorge over several hundred meters: the Basalt dips 20° towards the NE, while the overlying Red clay shale varies between 15° and 20°. In places, the contact seems to be perfectly concordant, although the entire Triassic and Jurassic series are missing. They must have been removed by denudation. Indeed, it is inconceivable that they would not have been deposited within a distance less than 2 kilometers only from their normal development (Fig. 1).

Such differences of successions cannot be explained by steep faults, but may be caused by overthrusts on long distances. There are no observations yet at hand, which would point to such an explanation. The phenomenon needs further field examination.

Tectonical Structure

According to Y. T. Chao, "Omeishan proper is a gently dipping monocline with all the formations striking SSW and NNE and dipping generally less than 15° towards the northwest". This monocline would be cut off towards the NE by a fault

On the writer's excursion made two months later, the following observations were made.

Omeishan proper is formed of a beautiful anticline with a nucleus of Pre-Sinian Granite. This main anticline will be called *Omeishan-Anticline.*

The dip towards WNW of the great western limb gradually flattens from around 20° at the summits in going east: On the bridge between Tshulotung and Hungtsoengping the dip is 7° to WNW. The axis, with flat strata slightly pitching towards the N, is crossed one kilometer west of Hungtsoengping (Fig. 1). The temple of this name is situated already on the eastern limb, which dips 15-25° to ESE. Therefrom, it steepens, while the strike changes from NNE to NNW. At the bridge 880 meters the dip of the Sinian limestone is 35° to ENE, and this inclination is continued within the higher beds with only local changes, up to the contact with the Post Permian Granite (Fig. 1).

Although, on account of this intrusion, the Cambrian series is lacking along the gorge, through which passes the trail from Hungtsoengping to Kwangfusze, the complete series of this eastern limb of the great Omeishan Anticline is preserved and well exposed further southeast. Already from

Liushisze on the west side of the gorge, a pyramid shaped peak called Boutshangshan is visible behind the granite. On the slope of this mountain the Kiulaotung sandstone is said to be quarried, of which big plates were found in the village. Farther away, about 7 km ESE of the gorge, at Shinkaisze (summer resort), even the normal contact with the Permian limestone is preserved, the *complete series dipping regularly 40-50° towards the east.* There is no more disturbance of the younger granite.

The high crest of Omeishan thus is made of the gently dipping west limb of the great Omeishan Anticline, while the greater part of the nucleus and of the eastern limb is broken out and weathered away.

In the northern part as seen on the main trail above Kwansinding, the axis pitches 10-20° towards the north. A similar retreat of the mountain is caused by pitch towards SW, south of the top of Omeishan. The axial culmination of the Brachy-Anticline is supposed to be found at the "Granite Gorge" at Szetshingping, on the foot of the great abrupt ESE of the highest summits Tshintin and Wanfutin.

Omeishan-Syncline.

A wide and gentle syncline with a northerly pitch seems to accompany the great Omeishan Anticline on its western side, as observed with the telescope.

Also on the northeast side, is Omeishan Anticline accompanied by a gentle syncline. It has a width of 2 km in the region of the gorge of Szebaho, and is formed of red clay shales at the base, of about 150 meters, upon which follow walls of sandstone, 80-100 m. In the middle part, this sandstone is practically horizontal.

The SW limb, below the Red Beds, seems to be bent up abruptly to a nearly vertical position, as presented by the Basalt and the Permian Limestone (Fig. 1).

On the NE side of the syncline, the Basalt dips 30 to 45°.

This Basalt has been considered by Chao as belonging to the reversed series of the Frontal Range. However, within the mass of Basalt, on the N-side of the gorge, limestone is seen which seems to underly the Basalt normally, dipping about 45° towards WSW. It has the form of a wedge which thins out downwards, and is lost on the trail of the SE side of the gorge. This

limestone wedge may be the unsymmetrical uncleus of the front-range, somewhat thrusted towards the Vorland. Further observations are necessary to obtain definite information.

Omeishan Syncline becomes reduced towards the SE, and to be cut off by faults and unconformities.

The Front Range.

As already observed by Chao, the Mesozoic series which forms the Front Range, is *reversed*. The dip of the Triassic varies between 90 and 70° towards WSW. At Lomendong, the entrance to the gorge of Szebaho, the Triassic limestone is nearly vertical. Therefrom towards the Vorland the reversement is getting more pronounced, the Coal bearing Sandstone dipping 65 to 55° in its younger part. The contact with the Red Beds is 55° towards W20S, and the same position is held by the basal Red Beds. There is thus *perfect concordance*.

The reversed series can be followed towards SSE, where it is apparently cut off by a large transverse fault of an ENE strike, situated S of a line Tangösze-Pagoasze. The southern wing seems to be shifted several hundred meters towards the east. Not only the Front Range is cut off, but also Omeishan Syncline including the eastern limb of the great anticline.

The Red Bed Vorland.

Until about 2 km outside of the contact with the Jurassic, the Red Beds along Szebaho dip predominently towards WSW, seeming to remain in an overturned position. Even the Brick-red Sandstone of the upper Red Bed disvision is dipping against the mountain (80° to W).

Farther away, the dip for some distance remains 30° to 50° against Omeishan, while the mountain ranges in the back ground further north, show a general outward dip of around 30° which gradually flattens out towards Omei Hsien. We are thus outside of the overturned series, in the normal position of the Vorland.

Then follows a wide and gentle syncline. The east wing is crossed on the trail as far as *Sushi*, where dips are found of 5-15° towards WNW. At Kiatingfu, the synclinal Brick-Red Sandstone is perfectly horizontal, but gentle folding is renewed farther south (Wutungchao) and east (Tseliutsin).

General Tectonical Position

Omeishan is an autochthonous Brachy-Anticline, accompanied by a smaller Front Fold, and complicated by unconformities, faults and intrusions. It is situated like an island standing out with its old formations from a region of gently folded Red Beds.

Supposing that no erosion would have taken place, the basalt would reach over 4000 meters, and with the Mesozoic taken in consideration, the top of the anticline would be around 8.000 meters. This shows the effect of erosion since the Alpine orogenic movement.

The position of Omeishan between the great Red Basin and the high Tibetan Front Ranges reminds one of the position of the much smaller Mont Salève at Geneva (Switzerland), which also is an autochthonous brachy-anticline, leaning over towards the Vorland and being situated between this (Molasse) and the overthrusted high mountain ranges of the Alps.

REMARKS ON THE GEOLOGICAL HISTORY.

Conditions of Deposition

After the Sinian ice age which followed the first intrusion of granite (Yangtse), the country was submerged, and the large series of Sinian Limestone deposited. It seems to be a purely *chemical precipitate*, showing no more signs of a cold climate.

Then followed the invasion of sand and clay brought into the sea by rivers and currents, from Sinian to Cambrian or Silurian time.

The red colour of some of the deposits points to a warm semitropical climate, in accordance with the oolitic limestones found by Chao, which generally are warm water deposits.

Then follows the second great gap: the discontinuity below the *Permian limestone*. Further observations are necessary to determine, if this break is caused by submarine events (omission and ablution) or by subaerial denudation, or by both. Only extensive studies over large areas can help to approach the solution of such problems.

The Permian limestone with its large benthonic Foraminifera and its corals is a typical *shallow* deposit of a *warm ocean*.

Then follows the *flood of basic lava*. The wide extension of the latter, and the perfect concordance of the lava beds with the underlying limestone seem to indicate that the flow was submarine.

The *Triassic* sediments again are *marine*. Their brilliant purple shales, as well as the salt deposits of Tseliutsin point to an *arid climate*, similar to that of the Triassic time in northern Europe.

With a distinct discontinuity but in perfect concordance follows the *Jurassic sandstone* at the entrance of the gorge. The coal seams and remains of land plants leave no doubt that the marine sedimentation of the underlying marls has been converted rapidly into a continental deposit of wide extension.

This period of continental accumulation continued into Cretacic time, on account of continental subsidence.

At the beginning of the Cretacic period, one or several more or less fresh *lakes with Unio and Cyrena* extended from Kiating (Wutungchao) over Tseliutsui to Chungking and even to Kweitshou on the Yangtse (Kweichow series), a distance from W to E of over 600 kilometers.

The local occurrence of salt, at places with gas and oil, (Yenpoa, Punglaidjen-Yanszetsin) and the intensely red colour point to an arid climate similar to that of the Triassic time. Several thousand meters of continental deposits, chiefly of red clays and sandstones were accumulated in Cretacic time, under the influence of continental *subsidence*. This reminds us somewhat of the actual conditions of the great lake districts of Central and Eastern China (Hunan, Hupei).

On the northwestern and northern border of the Red Basin (Kwan Hsien) and N of Chengtu also big bodies of coarse conglomerates are found, which refer to the first phases of the older orogenic movements of the Tibetan Front Ranges. There, indeed, the Red Beds were found to be unconformable with the Coal bearing Jurassic (Kwan Hsien).

Orogenic Movements.

The cause of the lack of the Triassic and Jurassic series on both sides of Omeishan-Syncline still remains to be cleared up. Denudation must have removed them. But according to the very slight unconformity between the Basalt and the Red Beds there is no evidence for an important orogenic movement of Omeishan before the deposition of the Red Beds. The conception

of Chao cannot be maintained in its full extent. In regard to the concordance of the Jurassic and Cretacic series at the reversed marginal zone, and of a more than vertical position even of the Upper Red Beds, we must at least conclude that the greatest and *the most important part of the folding of Omeishan is younger than the Red Beds*, i.e. of latest Mesozoic or of Tertiary time. Omeishan thus is the result of the *Alpine movement*.

This result is confirmed by the proof of continuity in sedimentation from the Coal bearing Formation into the Red Beds, as found in the adjoining Red Basin at Lungshan and Suifu.

In arriving at the above conclusions, earlier movements shall not be entirely denied. They probably have occurred to a certain extent at Omeishan and may be discovered in the neighbouring regions in a more pronounced shape. The observations made at Kwan Hsien, at the border of the Tibetan Front Ranges NW of Chengtu prove, that the *high mountain ranges have been distinctly affected already in Mesozoic time*. Indeed, at Kwan Hsien, the Red Beds, dipping at an angle of 80° towards S 15° E, are unconformable with the Coal bearing Jurassic at an angle of about 75 degrees (fault?). Furthermore, within the Red Beds, after about 300 meters of chiefly red clays and sandstones, follows an extraordinary coarse Red-Bed conglomerate of over 500 meters thickness, containing the Palæozoic rocks of the Tibetan border ranges in huge pebbles.

These observations prove that the beginning of the orogenic movement at the Tibetan Front Range has occurred *before and during the accumulation of the Red Beds*. In conclusion, we must accept a *Cretacic movement*, corresponding with Wong's *Yenshan Movement B* (chiefly Meso-Cretacic).[1]

The second movement however, even on the Tibetan Border Ranges, seems to have been more important, and I think that the interesting *overthrusts* discovered last summer by Y. T. Chao at Paishuiho north of Chengtu are more likely to be related to the Alpine movement.

Until further knowledge, we must thus maintain the result already expressed in an earlier[2] paper, that *the main orogenic movement in the Yangtse*[3] *Region from Ichang to the Red Basin and as far as Omeishan is Alpine.*

1 W. H. Wong, The Mesozoic Orogenic movement of Eastern China. B.G.S. China Vol. VIII No 1, 1929

2 Arnold Heim, Zeitschr. Ges. f. Erdkunde, Berlin

3 Corresponding tectonical observations will be published in a later paper.

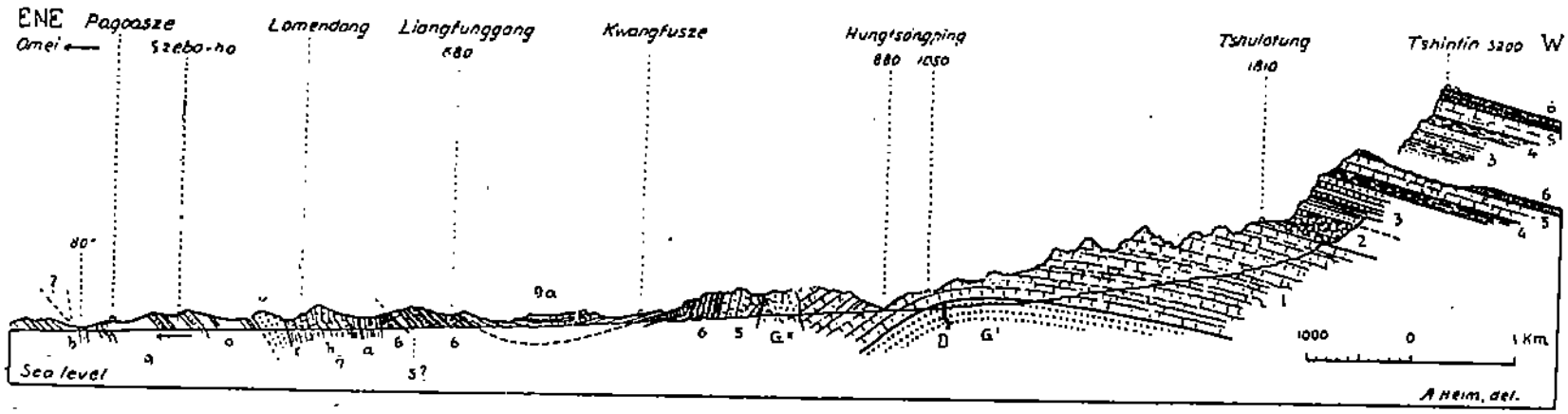

FIG. 1. TRANSVERSAL SECTION OF OMEISHAN

(same scale for vertical and horizontal distances)

On account of axial rising towards the south the highest peaks cannot be combined with the lower section.

Succession of Strata

1. Sinian limestone
2. Kiuhotung series, slaty sandstone
3. Sandstones, quartzites, shales partly red and green, Cambrian
4. Gray shale, Silurian?
5. Limestone, Permian
6. Basalt-porphyrite
7. Triassic:
   a) purple clay with limestone,
   b) gray limestone,
   c) gray marls with Pelecypods and Ammonites
8. Coal bearing sandstone, Jurassic
9. Red Beds, Cretacic: a) lower, b) upper, brick-red sandstone.

Igneous Intrusions

G' Pre-Sinian granite,
D Green basic dyke, Pre-Sinian
G'' Post Permian granite

Explanation of

Plate II

PLATE II.

Fig. 1. Kiatingfu, Brick-red sandstone of Upper Red Beds, showing horizontal stratification and platform upon which is situated the Pagoda, 60-80 meters above the Min River, seen from confluence of Minho (left) and Tungho (right) looking down the river towards the SE. Photo. A. H., 23. Sept. 1929, p. m.

Fig. 2. Temple of Kwanientin, on the top of the mountain, 1900 meters, where the main trail to Omeishan passes, seen from Tshulotung towards the North. Note the intense foliage over the rock walls. 1, Sinian limestone; 2, Kiulaotung series; 3, Cambrian. Photo. A. H., 26. Sept. 1929, a. m.

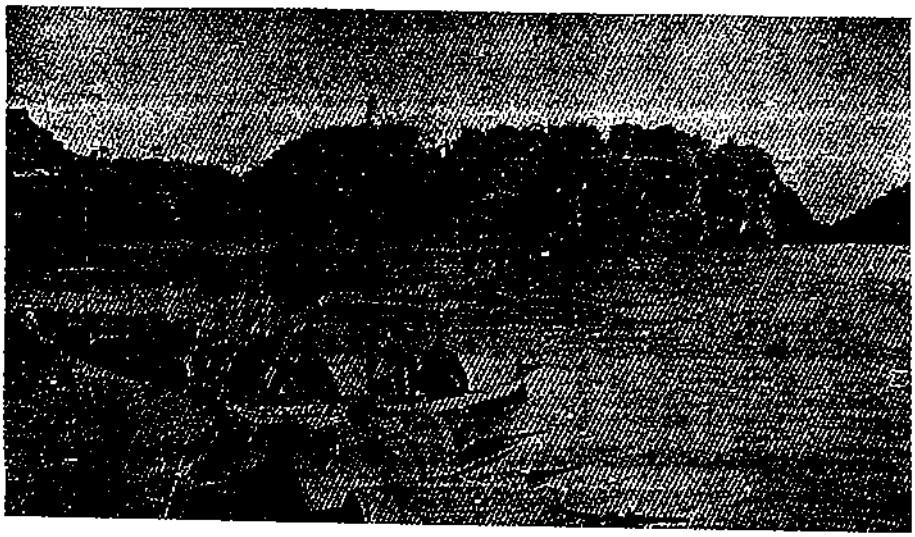

Fig. 1. Kiating

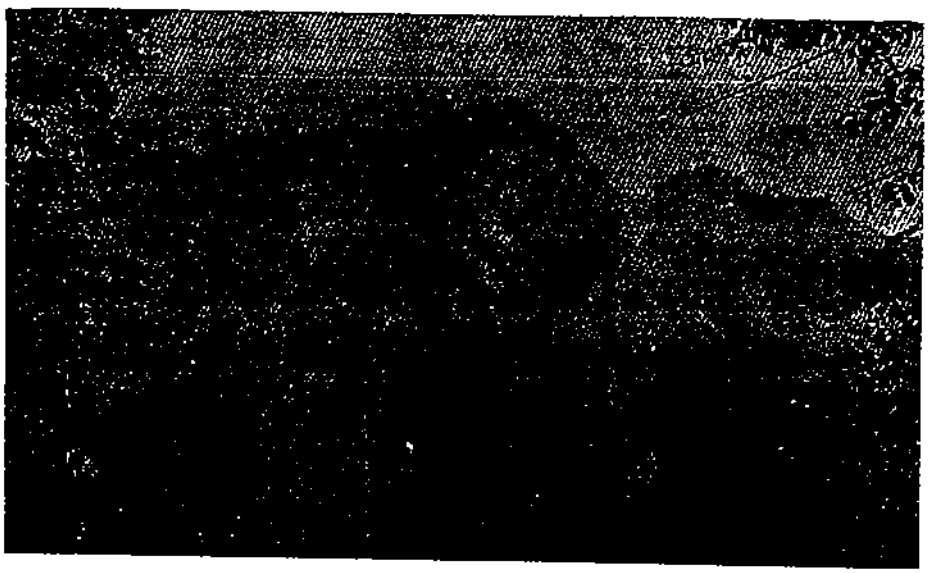

Fig. 2. Kwanientin

Explanation of

Plate III

PLATE III.

Fig. 1. Summit of Omeishan, 3200 m. with the temple Tshintin (Djindin), seen from the SW. The dark upper part of the precipice is Basalt, the white walls below are Permian limestone. Then follows the terrace of shales (lower right corner)—Silurian? In the background the Front Range F. Photo. A. H., 25. Sept. 1929, 10 a. m.

Fig. 2. Triassic, upper part of lower division 7a, Front Range above Lomendong. Purple clay shale (dark) interbedded with white to yellowish limestone, dipping 75° towards W 10° S, reversed. Photo. A. H., 26. Sept. 1929, 9 a. m.

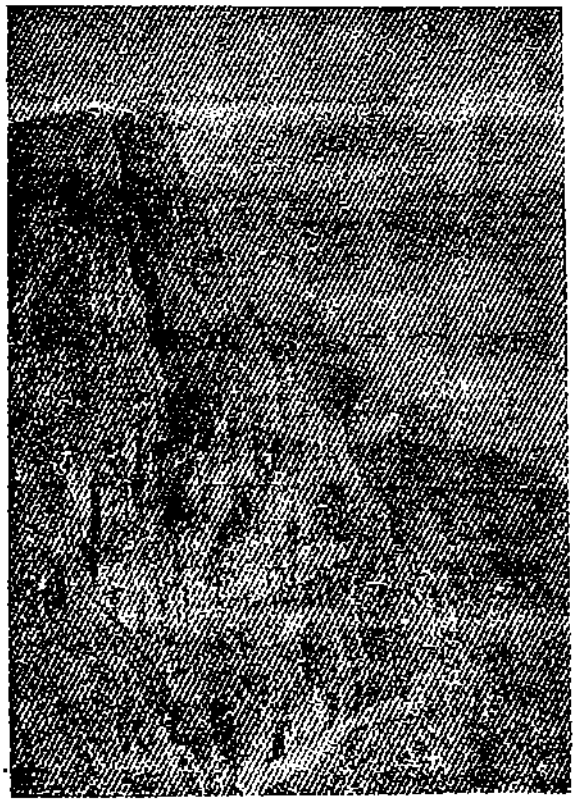

Fig. 1. Omeishan summit, Tshintin 3200.

Fig. 2. Lower Triassic, Front Range.