NOTES ON THE ARTESIAN WELLS IN NANKING

(Summary)

BY P. Y. HU, T. LIANG AND C. Y. HSIEH

Mr. Hsieh published in 1928 an article* on the geology of Chungshan and the Artesian wells in Nanking. His conclusion was that the Chung-Shan slope with its adjoining plain forms an ideal artesian basin on account of the monoclinic inclination of the strata and the porous nature of some of the intercalated beds. Two years after, the Memorial Park of late Dr. Sun Yat Sen struck at the very slope several artesian wells of good water quite suitable for drinking purposes.

In view of the fact that a clearer knowledge in regard to artesian wells condition in Nanking is of urgent need for the systematic exploration of ground water supply in that city, and that some of the previous conclusions were not entirely free from doubt, a revisit of the region, accompained by Messrs. Hu and Liang was made in 1929, under the auspieces of the Ministry of Agriculture and Mining**.

The result of this later investigation is fully described in the Chinese text, while the following is merely a summarized account of it.

1. *Stratigraphy:* The stratigraphical succession in Chung Shan and its vicinity has been fully discussed in the report* mentioned above. The result of the present investigation seems to agree in the main with what has been observed before, with only some minor changes. The succession in descending order is shown in the following table.

Name of formation	*Geological age.*
Alluvium and soil	Recent
Loess	Quaternary
Yuhuatai gravel	
Red beds	Tertiary
Buff sandstone	Cretaceous?

*Hsieh C. Y. Geology of Chungshan and its bearing on the supply of Artesian Water in Nanking. Bull. Geol. Soc. China, Vol. VII, No. 2, 1928.

**Predecessor of the present Ministry of Industries.

Linyuan shale and sandstone Tzuhsiatung quartzite Quartzitic conglomerate	Upper Jurassic
Huangma purple shale and sandstone	Triassic

It is to be noted that in the classification of 1927, the Linyuan sandstone and shale was included in the Tzuhiatung quartzite series. The present study has justified the separation of the upper part of the series to form a distinct lithological unit which in view of its water bearing character must also receive special attention.

Another change made by the present study is the correlation of the "Variegated sandstone and shale" with the Linyuan sandstone and shale series, so that in the region surveyed the buff sandstone is supposed to be the youngest member of the Chungshan formation.

For detailed lithological description of the different formations, the reader is referred to the previous report or to the Chinese text of this report.

2. *Geological structure:* The present study has added some new data in regard to the geological structure of the region.

A dip fault seems to occur at W. of Tien Pao Chen trending N. W.—S. E. as is inferred from the sudden disappearance of quartzitic conglomerate and the occurrence of Huangma shale with its numerous igneous intrusion at a place (near Tai Ping Men) too south than it should be.

Another fault trending N. W. W.—S. E. E. is found on the northern side of the Fou Chou Shan. It is indicated b the co plete disappearance of quartzitic conglomerate along the entire range.

The sudden reappearance of quartzitic conglomerate at Chi Ming Ssu justifies the occurrence of another fault trending approximately parallel to the dip direction of the strata.

The recent road building on Pei Chi Ko Meteorological Station has revealed some very excellent outcrops. The road cut shows a central core of quartzitic conglomerate having a thickness about 150 meters with its two flanks of quartzite, all dipping steeply toward east. This occurrence indicates probably an isoclinal syncline.

A boring made not far from the foot of Pei Chi Ko shows at many places the occurrence of red beds. This means that both quartzite and quartzitic conglomerate do not continue toward the plain. This discontinuation can perhaps also be explained by a fault.

As has been stated above the variegated sandstone and shale cropping out in the southern foot hills of Chungshan and with a northward dip, i.e. in a direction toward the hill is now supposed to be a part of the Linyuan sandstone and shale series. If this is the case, then the structural relation there could perhaps be explained by an overthrust as shown in Fig. 4. (accompanying Chinese text)

The striking difference in color as well as in lithological character between the eastern and the western parts of the northern slope of Chung Shan has already been noted in the previous report. This feature was explained by a difference in degree of metamorphism. Consequently the junior author was led to postulate the existence of a great mass of igneous body at the western part of Chung Shan. The extensive road building recently carried on near Tien Po Chen and vicinity has unveiled numerous exposures of igneous dikes or sills which are nothing but apophyses sent up from a larger body below, and which give another evidence to support the above explanation.

A microscopical study of igneous intrusives and their metamorphism at Chung Shan has been made by Prof. H. T. Lee of the Central University; his report is now in press by the Geological Society of China.

3. *The Aquifer:*—So far as is known the following formations may be considered as aquifers:

a) The Tzuhsiatung quartzite,—Although the quartzite itself is impervious, but water is able to circulate through the much fractured and jointed portion. The spring at Tzu Hsia Tung may be cited as an example of such occurrence.

b) The Lingyuan sandstone and shale.—Both the Well No. 1 and No. 2 of the Memorial Park have derived their water from this formation. Its importance as an aquifer is therefore fully confirmed.

c) The buff sandstone.—This is a very promising aquifer but its water bearing character has not yet been proved.

d) The Red Beds.—This formation contains abundant water supply. All the wells recently dug in the capital have struck the same formation. Their

depth varies from 100—250 ft. (See Pl. II, Logs of deep wells in Nanking). The water contains sometimes abundant amount of ferruginous matter so as to show frequently a reddish tint. Analysis made by the Public Health Board of the Nanking Municipal Government show not infrequently the existence of typhoid bacteria evidently derived from contamination. Perhaps wells dug to deeper horizon may yield water free from bacteria. All these facts indicate that in spite of their abundant water supply, the red beds can not be relied upon as a permanent and good aquifer.

e) The Yuhuatai gravel.—It may be also considered as an aquifer. Wells located outside of Ssu Pao Men, S. Nanking may tap water from this horizon.

4. *Well logs:*—A great number of logs of deep wells recently dug in the new Capital are described in the Chinese text of this report. Columnar section of the logs is given in Pl. II.

series. The latter massif extends over the whole area of Shihchiatzuliang and the southern part of Kuntoukouliang. In this whole area the Archean is directly overlain by the volcanics of the Chaoyang series without the interposition of other older formations.

South Tachingshan fault: This is a NE-SW fault on the south of the Sinian massif of Tachingshan. South-east of it is the extensive Chaoyang series from which coal is worked at Lokuochangtzu etc.

Fenghuangshan fault: This is almost parallel to the south Tachingshan fault and extends from south of Hsipingfang along the Tachingho river and cuts Fenghuangshan limestone massif at its northern foot.

The author interpreted all these faults as normal faults* (Plate VI). This region would be therefore considered as consisting of a series of fault-blocks.

ECONOMIC GEOLOGY

Gold ores: Auriferous quartz veins frequently occur in the Archean complex (see Plate I). The veins are generallv not very wide, from a rew inches to one or two feet.

Coal fields: Coal occurs in and is worked from several series of the sedimentary formation. The following is a summary of the main fields:

Carboniferous coal field: Hunglohsien (semi-bituminous);

Jurassic coal fields (Peipiao series): Peipiao (Bituminous);

Lower Cretaceous fields (Chihfeng series): Yuanpaoshan (lignitic bituminous) Shihtafen (ib.), Wuchia (ib.), Kachia (ib.), Yangliutun (ib.);

Upper Cretaceous fields: Heishankou (low rank bituminous), Lokuochangtzu etc.

Details concerning the ore deposits and coal fields are given in the Chinese text. The coal fields of Cretaceous age although not of the best quality may be of economic importance when communication becomes easier in considaretion of their pretty large reserve.

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* It seems probable that overthrusting still plays an important role in the tectonics of this region. The Peipiao - Hsinlungkou region that I studied in 1928 (See Bull. Geol. Surv. China No. 11) lies on the N. E. of Chaovanghsien (Pl. I). The Fenghuangshan limestone massif is therefore in similar tectonic position to, and in same tectonic zone as the other massif at Taohuatu and Nantienmen in my map. The Fenghuangling fault of Mr. Tan is therefore nothing but the outcrop of a thrust plane underlying all these Sinian massifs. The Tachingshan massif west of Chaoyanghsien is probably another "lambeau de charriage" limited as it is almost on all sides by the so-called north and south Tachingshan faults. Mr. Tan has in any case set a good basis, by his geological mapping, for future study which will settle the question. Note added by W. H. Wong.

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GEOLOGY AND MINERAL RESOURCES OF CHINHSI AND CHINHSIEN DISTRICTS NEAR HULUTAO, LIAONING PROVINCE.

(With 5 Plates & 12 Text Figures).

By H. S. Wang (王恒升) & T. F. Hou (侯德封).

INTRODUCTION.

The region surveyed is situated in the south-western part of the Liaoning Province. It covers a greater portion of the Chinhsi district (錦西), western part of Chinhsien (錦縣) and the whole area of Hulutao or the "Gourd Island" (葫蘆島). The latter has long been thought to be the best place for an ice-free harbour and harbour construction has once begun. The construction was, however, interrupted until last year (1930) when the authorities of the Peining Railway Administration determined to start the long stopped work.

On the request of Mr. C. Y. Kao (高紀毅), the director of the Peining Railway to investigate the geology as well as the mineral resources of Hulutao and its vicinities, we started on the 19th March, 1930, from Peiping by the Peining Railway. Only 6 days were spent on the very Island, and four days for the neighbouring districts. A greater part to the northeast of Chin-hsi district was surveyed by H. S. Wang alone during one week in April, 1931 along the Tungyü Railway (通俗鐵路).

Thanks are due to Messrs. K. C. Chang (張光正) and C. C. Shan (單志鈞) of the Peipiao Coal Mine (北票煤礦公司) for they have helped us throughout the whole work. During the last two days of our trip in 1930, we were joined by our colleagues Père Teilhard and Dr. C. C. Young (楊鍾健) with whom we had profitable discussions.

TOPOGRAPHY.

Most of the area surveyed is an advancedly dissected hilly region with open valleys (Pl. II, Fig. 1) and moderate elevations. Only in the northern and the western part, are there some high peaks and bold mountains rising at from 500 to 800 meters They are mostly composed of granitic intrusion as Tahungluoshan (大虹螺山) and Hsiaohungluoshan (小虹螺山); and occasionally characterized by the Sinian siliceous limestone and volcanic lavas of Cretaceous age.

Among the rivers in this area, Nüerhho (女兒河) is of the first magnitude to be mentioned. It meanders from west to east in the northern part and forms the sole main drainage on the north of Tahungluoshan. In its lower reaches, it joins the Hsiaolingho (小凌河), which flows from the hilly region in the north-western part of the Chinhsien district.

To the south of Tahungluoshan, there are many other small streams, flowing in a south-eastern direction. They are called by local names as Ssuerh-puho (四兒堡河), Lienshanho (連山河) and Erhtaoho (二道河), etc.

STRATIGRAPHY.

Almost all the old formations from Archaean up to early Mesozoic as Sinian, Cambrian, Ordovician, Carboniferous up to Triassic, are all represented here. Cretaceous beds have also a good development. For Tertiary we have only pliocene. The Pleistocene was locally represented by loess.

Archaean gneiss and granite:—Typical Archaean gneiss, occurs between Yingpishan (影壁山) north of Lienshan and Lungchuanssu (龍泉寺). Here the gneissic structure is well developed, with feldspars and quartz as the prominent composing minerals. Pegmatite dykes (Pl. II, Fig. 2) occasionally intrude into it.

On the southern side of Hulutao the gneissic structure becoming less conspicuous, the gneiss thus turns to a granitic appearance. However, the Archaean age is proved beyond any doubt by the fact that granitic boulders are included in the basal arkose sandstones of Sinian age (Pl. II, Fig. 3) and further the arkose sandstone fills the fissures of the granite when in contact (Fig. 1).

Sinian system:—This is the best developed system in the area studied. It lies unconformably in Hulutao upon the Archaean granite and chiefly includes arkose sandstone, quartzite (Pl. III, Fig. 3), black slate (Pl. III, Fig. 2, Fig. 4), and shales in the lower part; toward the upper siliceous limestone as well as flinty limestone intercalating with white quartzite predominate (Fig. 2). When intruded by granite, the limestones are metamorphosed into marble, for instance, the shore-cliff on the southern side of Hulutao (Pl. II, Fig. 4, Pl. III, Fig. 1). In a small embayment to the west of Tenglungshan (燈籠山) in the eastern part of the same small peninsula, there occurs a bed of siliceous limestone containing abundant *Collenia cylindrica* (Pl. IV, Fig. 1), an index fossil of Sinian age.

The rocks of this formation are usually of very hard and tough character and resistant to weathering, thus forming bold mountains and high ridges. They are of wide distribution and attain at least a thickness of 3500 meters.

The Cambrian system:—Disconformably lying upon the Sinian formation is the Cambrian system. It is divisible into three parts and the total thickness is about 550 meters.

The lower part contains chiefly red and green shales intercalating with limestone lenticules. The sequence in descending order to the south of Hungluohsien (虹螺峴) is as follows:

1. Green shale
2. Light gray limestone
3. Green shale.
4. Red shale
5. Thin-bedded limestone
6. Red shale
7. Purple shale cut by a diabase dyke
8. Red shale intercalating with limestone
9. Reddish limestone
10. Red shale intercalating with green shale
11. Brownish shale
12. Gray thin-bedded limestone
13. Red & brown shale intercalating with lenticular limestone
14. Quartzite (Sinian)

The whole thickness is about 200 meters.

In other places as at Panshihkou (板石溝), Tayaokou (大窯溝) (Fig. 3), its thickness greatly decreases due to local faults. No fossil has yet been found, but, however, on the basis of its similarity both in lithological character and stratigraphical position to the Manto shale in Shantung province, it is referred to lower Cambrian age.

In Hulutao above the Sinian system occurs an enormous shaly formation which consists chiefly of green shales and quartzite with a basal conglomerate. This formation constitutes most of the high hills and has been considered by Dr. J. G. Andersson as of Sinian age. But in the basal conglomerate, we have found among the pebbles some flint and siliceous limestone which were most probably

derived from the Sinian rocks. Further, the green shales look very like those of lower Cambrian age. It, however, has a thickness of about 2000 meters much too great for the lower Cambrian so far known in North China. It may be equivalent to the Hsiamaling formation of the Western Hills of Peking, or it may be even Jurassic. In the Geological map, we still refer it to Sinian.

In the middle division, oolitic limestone intercalating with thick bedded limestone becomes preponderant. It is about 200 meters thick and is most probably equivalent to the Changhsia limestone of middle Cambrian age.

The upper division includes chiefly, wurmkalk thin-bedded limestone and shaly limestone. The latter contains trilobite. *Ptychaspis suni* to the south of Hungluohsien. At Tayaokou (Fig. 3), in the same formation, Dr. Andersson some years ago collected the fossils from which the following species have been determined by Dr. Y. C. Sun.

TRILOBITA

1.	*Agnostus (anderssonia) fenglienensis*	Sun
2.	*Ptychaspis walcotti*	Mansuy
3.	*Ptychaspis accamus*	Walcott
4.	*Ptychaspis Chinhsiensis*	Sun

BRACHIOPODA

5.	*Eoorthis Shakuotunensis*	Sun

All of them are typical upper Cambrian fossils, and therefore prove the age of the formation bearing them. Its thickness in the vicinity of Hungluohsien is about 150 meters.

The Ordovician system:—This contains conglomerate, shale and wurmkalk at the lower part, dark gray, thick bedded limestone and brownish thin bedded limestone in the upper. The thick bedded limestone is usually of a pure character and is extensively mined for burning lime.

It occurs in four different zones: (1) from Tanantun (大奄屯) to Chuanwayao (磚瓦窯); (2) from Tayaokou to Nanfulungshan (南富隆山); (3) at the vicinity of Hsiaolanchiakou (小蘭家溝); (4) from Heiyükou (黑魚溝) to Laoshihling (落石嶺). The thickness varies in different localities. It is 300 meters at Tanantun but at Tayaokou, due to the absence of the upper part, the thickness deceases to 200 meters. Such a difference is most probably due to the Pre-carboniferous erosion which has widely prevailed in northern China.

At Heiyükou in the dark gray limestone, we collected a large simple coral looking closely to *Archeaocyathus*. The same fossil has been found in Peilintze formation of lower Ordovician age in Linyü (臨楡) basin, Hopei province.

The upper Carboniferous system:—This lies unconformably upon the Ordovician limestone usually with a layer of conglomerate at the base. It consists chiefly of sandstone, shale and conglomerate with workable coal seams in the upper part, constituting the three coal fields, namely, the Hungluohsien coal field, the Tayaokou coal field and the Heiyükou coal field. The latter is of synclinal structure, the coal series occurring in the center of the syncline (Fig. 4). At Hungluohsien, the following plant fossils have been found in the sandy shale.

1. *Neuropteris* sp.
2. *Pecopteris* sp.
3. *Sphenophyllum* sp.
4. *Annularia* sp.

Here the thickness is about 150 meters.

The Triassic system:—Disconformably above the Carboniferous coal series is a formation composed chiefly of conglomerate, grit, white and red coarse sandstones. It frequently forms a low range of ridges rising above the the coal series as at Hamashan (蛤蟆山) and Chatzeshan (渣子山), etc. No fossils have yet been found in it; it is provisionally assigned to the Triassic age from its lithological character as well as the stratigraphical position similar to those upper red sandstones occurring between Mesozoic and Palæozoic formations of other regions in N. China. Its thickness varies from 60 to 100 meters.

The Cretaceous system.

The lower Cretaceous:—This division consists of alternating beds of shales, clays, red, purple, and grayish white sandstones. Toward the upper part, greenish shale, sandstone and conglomerate becomes predominant intercalating at some place, with coaly or carbonaceous lenticules, which may be proved of economic importance as in Yihsien (義縣).

There are three zones where it outcrops; the first is the area from Fuyiutun (富有屯) to Yingshoutun (鶯首屯). The second is the low valley lying just to the north of the Tayaokou coal field. In both places, it lies disconformably upon the Triassic sandstones. The third is on the southern slope of Taitzushan (台子山), where it is in fault contact with the Sinian strata (Fig. 5).

It yields the following plant fossils at Taitzushan and Tahuangti (大荒地).

1. *Nilsonia* sp.
2. *Cladophlebis* sp.

In Yihsien (義縣), Mr. H. C. Tan has collected from the equivalent beds *Compeloma* and *Corbicula* which are considered by Prof. Grabau as of lower Cretaceous age.

The middle Cretaceous volcanic formation:—Lying unconformably upon the lower Cretaceous sandstone, is an enormous series of volcanic rocks amounting to no less than 1000 meters. In the lower part, the chief rock types are agglomerate, tuff, andesite and trachy-andesite. In the middle and upper, trachyte and rhyolite predominate, occasionally with red clay and shales as on the southern slope of the hill, south of Chentifangkou (陳地方溝). To the north of Tayaokou, it constitutes high ridges bordering the coal field

Volcanic rocks are widely distributed in North China, and are considered by some geologists as the upper part of lower Cretaceous or by other as middle Cretaceous. As it is, here, underlain by the strata of a lower Cretaceous age, the writer tentatively put it in the middle Cretaceous.

Pliocene:—This is represented by red clay. It occurs chiefly in in valleys or on the low slopes of many hills. In the western part of Hulutao, a layer of loosely consolidated conglomerate (Pl. IV, fig. 3) is taken as its base. To the north of Tanantun, it fills the clefts or fissures of the Ordovician limestone just in the same condition as at Choukoutien (周口店), Fangshan hsien (房山縣), in Hopei province. But no fossils have been found. Its thickness is about 5 meters.

Pleistocence:—Primary loess is of rare occurrence. Most of the loessic material are interbedded with gravels and sandy layers.

IGNEOUS ROCKS

Granite:—generally of a pinkish color and coarse in crystallization. Orthoclase and quartz are the essential mineral constituents. It often constitutes high cliffs as at Tahungluoshan and Hsiaohungluoshan.

Granite porphyry:—Usually of a granitic appearance but strongly porphyritic. The mineral constituents are essentially the same as those composing the granite. It intrudes as dykes both into the Cretaceous sandstones and the volcanic formation.