

## GYPSUM OF P'ING LU DISTRICT, SOUTH SHANSI

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### INTRODUCTION

In the summer of the year 1927 instructions were given Mr. C. C. Sun and myself, geologists of the Sino-Swedish Research Association in Taiyuanfu, by Dr. E. T. Nyström, Director of that Association, to proceed to South Shansi and there undertake a general survey of the geology and mineral resources. Special instructions were given to visit the P'ing Lu Gypsum deposits (平陸石膏礦) which are situated at the southern frontier of Shansi near the Yellow River, opposite Shan Chou (陝州) city in Honan.\*

About 20 li East of Ping Lu on the northern bank of the Yellow River lies a famous market-place, Mao Tsin Tu (茅津渡) situated on the highway between Shansi and Honan, consequently it occupies an important geographical position. Further East of Mao Tsin Tu at a distance of 30 li there is a large temple called San Men Miao (三門廟) near the rapids of the same name. To the North lies the high Chung T'iao Shan (中條山), Willis' Feng Huang Shan (鳳凰山)\*\* on the southern slope of which we found a very well developed red formation of presumably Cenozoic age. Chung T'iao Shan is built up of Archaean and Wu-T'ian rocks and runs in a WSW-ENE direction. Its northern slopes merge into the An Yi (安邑) Loess plain.

The red formation just mentioned is mainly composed of red, red-brown or whitish grey, calcareous marls and whitish grey, very easily weathered sandstones and conglomeratic layers occurring in the middle portion of this formation. Gypsum deposits were observed to occur frequently in these sediments, the age of which is probably early Tertiary.

The lateral extent of the area surveyed by the writer together with Mr. C. C. Sun has been estimated at more than 50 li in an E-W direction, from

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\* When investigating, in the service of the National Geological Survey, the geology and mineral resources of Honan Province, in the years 1916 and 1917, Nyström found vein-like gypsum deposits in a red formation at Shan Chou (陝州) opposite P'ing Lu (平陸). Many years later, during a visit to the Coke Works at Shih Chia Chuang (石家莊), he was shown beautiful specimens of pure Gypsum used in their manufacture of sulphate of ammonia. These were stated to originate from P'ing Lu in S. Shansi. Hence the instructions issued.

\*\* Willis, B. and Blackwelder, E. 1907. Research in China. 3 vol. and Atlas.

village San Men Ling (三門嶺) to the W. side of village Hsia Chien Tsun (下高村) along the northern bank of the Yellow River and about 17 li from that river northwards (one li roughly  $\frac{1}{2}$  km.).

In the following chapters I will give a brief description of the geology of this region and of the occurrence and exploitation of the Gypsum deposits which are found here.

### TOPOGRAPHY

As shown by the map published together with this paper the country exhibits a gently sloping surface, descending gradually southwards from the Chung T'iao Range to the bank of the Yellow River. Most of the surface is thickly covered with Loess, below which the strata dip generally towards northwest. The bed-rock, being easily eroded, is cut by numerous minor streams emerging from the adjacent Chung T'iao mountain and winding southwards through the whole region to the Yellow River. These streams, such as Lao Kou (老溝), Ch'ing Chien Ho (清澗河), Fan Chia Kou (范家溝), P'o Ti Ho (坡底河) and Ma Chia Kou (馬家溝) are more or less parallel to one another and Ch'ing Chien Ho is the largest of them all.

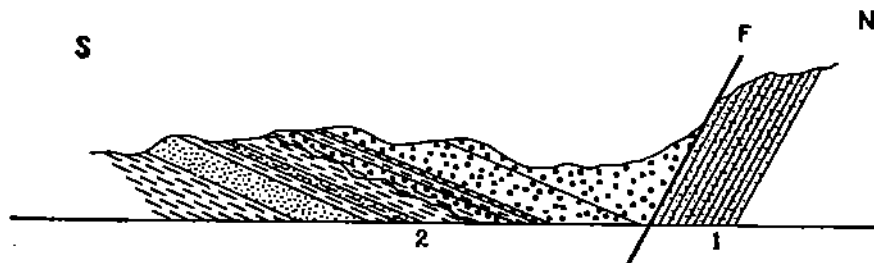


Fig. 1. Profile 3 li NW of Hsia Chien Tsun. 1, Pre-Cambrian; 2, Eocene.

At the southern frontier of the region under observation the Yellow River flows eastwards and forms the frontier between Shansi and Honan. Its course is fringed by hills and the width of the river much depends on the distribution of these rocky eminences. It is possible to navigate small boats on the river.

### STRATIGRAPHY

The geological formations encountered in the mapped area are classified as follows:

- 1) Cambro-Ordovician Limestone
- 2) Carboniferous (and Permian) Coal Series.

- 3) Early Cenozoic Red Formation.
- 4) Conglomeratic Formation (probably Mid-Tertiary)
- 5) Hipparion Clays (Upper Miocene)
- 6) Loess (Pleistocene).

1. The Cambro-Ordovician limestone is the oldest formation visible in this territory and occurs in various places along the northern bank of the Yellow River. Only the uppermost part of the limestone was observed and its thickness cannot be estimated here. As usual the upper parts of this limestone is pure and suitable for making lime and as elsewhere in North China it is covered disconformably by the Carboniferous coal-bearing series, the interval from the Silurian to the Carboniferous being unrepresented.

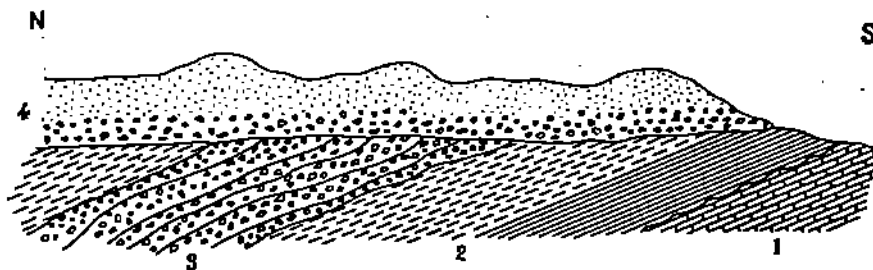


Fig. 2. Section S. W. of Tsai Hou willage. 1, Ordovician limestone; 2, Carboniferous (coal series); 3, Eocene; 4, Younger Tertiary.

2. The Carboniferous (and Permian) Coal Series immediately overlies the Ordovician limestone and forms an irregular, narrow belt (see map) from E. of San Men Miao (三門廟) to Szu Chia Ti (司家底). The strata dip north-westwards with an angle generally of about  $15^{\circ}$ . In this series the rocks commonly found are grey and black shales, dark grey sandstones and workable coal seams. Intrusives are not uncommon. The thickness of the entire series can be roughly estimated at more than 100 metres.

3. The early Cenozoic Red Formation is a thick series disconformably overlying the coal-bearing sediments. It is mainly built up of redbrown or whitish grey sandstones, yellowish grey and predominantly dark brown calcareous marls associated with gypsum beds as veins and veinlets. In spite of diligent search no fossils have been found in this formation, hence the age cannot be accurately determined. But according to the petrographic characters as well as the stratigraphical position and comparing it with a neighbouring field of known age, it is probably early Tertiary. The general dip is  $15-20^{\circ}$  in a northwestern direction. The thickness amounts to nearly 600 metres

4. The Conglomeratic Beds, lying on the whole in a horizontal position, cover unconformably all the above mentioned formations, except part of the Ordovician where it crops out along the Yellow River. The components of the conglomerate are various pebbles, of 1-4 cm in size, consisting of common dark grey biotite gneiss, white quartz, diabase, amphibolite, pinkish grey quartzite, and various igneous rocks loosely cemented by grey material. Higher up clay alternates with layers of pebbles and in its uppermost parts lie red clay and Loess beds of various thickness. The total thickness is roughly estimated to be more than 14 metres, as observed near the village Hung Kou Tsun (紅溝村).

5. The Hipparion Beds. The conglomerate merges gradually upwards into limeconcretion-bearing red clay beds (Hipparion Clay) which are generally considered to be of Upper Miocene age. No disconformity could be seen between the Conglomeratic Beds (4) and the Hipparion clay.

6. Thick Loess covers a large part of the mapped territory especially its northern area.

### STRUCTURE

The structure of this region is very simple. No folds have been observed, but two minor faults have been noted: one at P'a Tsun (柏村) 4 li N. of San Men Miao and the other at Hung T'u P'o (紅土坡), 18 li East of San Men Miao.—On examining the chronological sequence it is evident that a disconformity exists between the Cambro-Ordovician and the Carboniferous, while another is between the Carboniferous (or Permian) and the Early Tertiary. Furthermore an unconformity apparently exists between the Early and Middle Tertiary. Before the Early Tertiary period, however, no important tectonic movement seems to have affected the strata, for they were not markedly folded or dislocated. It is obvious that in this region the crustal movement took place at the close of the Early Tertiary. The direction of dip of the strata is generally north-west, sometimes to the NNE, with an angle of dip from  $5^{\circ}$  to  $25^{\circ}$ .

### THE EARLY CENOZOIC OF P'ING LU

The supposedly Eocene sediments of extreme southern Shansi are represented by a mostly red-coloured formation of very great thickness. They consist mainly of conglomerate, red-brown or whitish grey sandstones, yellowish grey and predominantly dark brown calcareous marls associated with gypsum beds, veins or veinlets.

For the convenience of description this series may be subdivided as follows :

A. The lower conglomeratic zone (fig. 4).

The thickness of this complex varies from place to place. At the mouth of Lao Kou (老溝) where it faces the Yellow River it attains a thickness of about one hundred metres while in Sung Chia Ho (宋家河) and near Szü Chia Ti (司家底) villages it attains a thickness of between 25 and 30 m. At the mouth of Lao Kou the main mass of the lower conglomerate zone is built up of irregular, rather rounded pebbles of Carboniferous sandstone, Ordovician limestone, yellowish white, whitish grey, pinkish grey and red quartzites, various coloured igneous rocks, Archaean white and grey quartz, the pebbles ranging from one to thirty cm in size and cemented with reddish material. Among these the igneous rocks and quartzite pebbles form the dominant elements. In the upper part of this zone coarse conglomerate beds are less frequent, mostly, not so thick and with pebbles of smaller size. The above mentioned conditions are very similar to the Eocene beds of Yüan Ch'u district (垣曲縣) about 200 li in a ENE direction from P'ing Lu as described by Prof. J. G. Anderson.\* He writes :

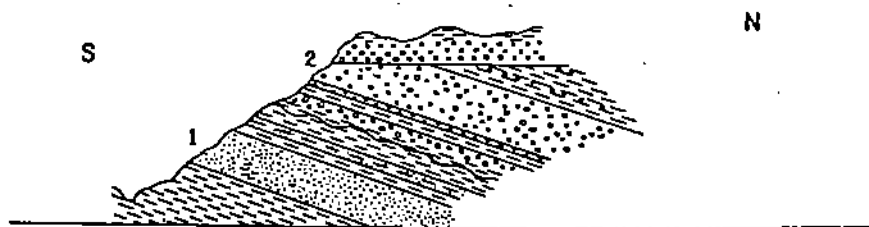


Fig. 3. Section showing the relationship between the Palaeozoic and the Eocene formations. 1, Palaeozoic; 2, Eocene.

"Conglomerates play an important role in this series, especially in the lower part, where they are more or less dominant and mostly coarse, with pebbles of fist size or even as much as a foot in diameter.

In the upperpart of the Series the conglomeratic intercalations are less frequent, mostly not so thick and with pebbles of smaller size. It is evident that in the beginning of the sedimentation cycle, hill slopes from which pebbles could

\* Andersson, J. G. 1923. Essays on the Cenozoic of N. China. Mem. Geol. Surv. of China Ser. A. N. 3

be washed down, were frequent while the streams were powerful because of the steep grade. In the course of time, as the sedimentary series grew to a thickness sufficient to fill the valleys and cover the lower hills, the role played by coarse clastics became much reduced especially as the lessened grade gave the streams less power of action."

#### B. The Gypsiferous Red Clay Zone.

Within the area in question the lower conglomerate zone is superimposed by red, reddish brown and chocolate-coloured claystone which sometimes grades into solid sandstone. They have often a certain content of very fine grained sand and sometimes thin layers of gravel occur.

At Lao Kou (老溝) I have observed the red, or red-brown claystones or marls alternating with greenish clay horizons. These distinctly indicate the stratification. The fissures of the red-brown marls are often filled with gypsum veins. In the same valley at the W. side of Ch'iao Chia Niao village (喬家島) greyish blue and dark grey, dense calcareous marl or claystone, interbedded with bluish grey argillaceous limestone, have been found. Within the marl bank the white or greenish gypsum layers, sometimes parallel, sometimes

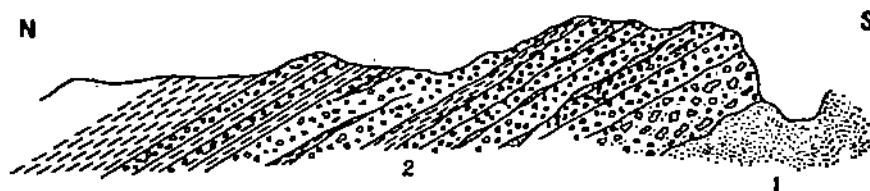


Fig. 4. Section showing the lower conglomeratic Zone of Eocene formation at the mouth of Lao Kuo. 1, Palaeozoic sandstone; 2, Eocene formation.

oblique to the rock surface are abundantly to be seen. The thickness of the outcropping gypsum is usually one to six cm. When weathered, the gypsum and the marl are mixed to form a beautiful surface. From this bank downwards we have found some gypsum veins and beds, whereas upwards the gypsum entirely disappears. Thus we may conclude that a sulphate solution having penetrated through the calcareous bank, the latter has been changed to sulphate of calcium through chemical reaction within the calcareous sediments.

#### C. The Upper Gypsiferous Clay Zone.

Immediately overlying series B, is an unstratified clay, mostly red in colour, but often intercalated with conglomerate layers, the pebbles consisting

of green and purple sandstone and white quartz sandstone (Carboniferous) and being 5 to 30 cm in size.

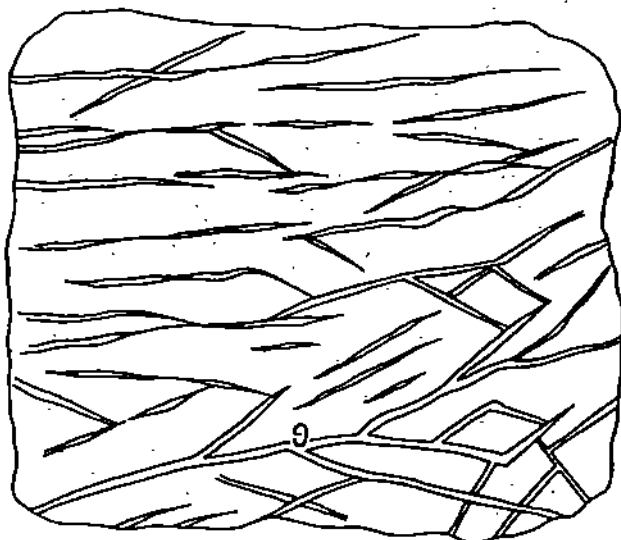


Fig. 5. Section showing the Nature of gypsum veins on outcrop. G, gypsum.

At P'a Tsun Kou (柏村溝), a northwestern tributary of Lao Kou (老溝) we find in the upper part of this zone the same red-brown clay and marl, often containing gypsum-veins, pinkish or white in colour. Interbedded with this clay is a whitish grey, easily weathered sandstone, but light-coloured clay and marl also often occur.

At P'o Ti HO (坡底河) the lithological characters of this zone are rather similar to those at Lao Kou and P'a Tsun Kou, but valuable gypsum beds have been found near P'o Ti Tsun, the detailed conditions of which will be described below. In the upper part of this zone the reddish clay and marls are not so dominant, but they intercalate with whitish grey, solid marl and, flourlike, weathering, calcareous products, merging upwards into greenish grey marl and yellowish grey clay. The red-coloured clay and marls have almost disappeared.

The whole series of the Eocene sediments is roughly estimated to be more than 500 m.

#### DISTRIBUTION OF GYPSUM

The gypsum occurs in P'ing Lu district of the supposedly Eocene series and its lateral extension is shown upon the accompanying map. The gypsiferous areas may be divided in two zones as follows :



The first zone included a temple and two villages, viz. San Men Miao (三門廟), Ch'iao Chia Niao (喬家島) and Hou P'o (侯坡). They are situated in the SW corner of the mapped area nearly on a stright line running SW-NE.

At San Men Miao, 50 li E of P'ing Lu city, the gypsum-bearing red beds are beautifully exposed in the valley San Men Kou (三門溝). Many fragments of gypsum scattered over the valley slopes attract one's attention. The gypsum veins intercalated in the red beds grow in various directions, looking like a network (see Fig. 5 and Pl. II). Its thickness, observed on outcrops, seldom exceeds three cm, but according to the natives, beds reaching about 12 cm are often found inside.

The gypsum veins are practically confined to the red or red-brown marls and sandstones in the lower part of horizon B, as described above and to the earthy limestone named by the natives Shih Kao Ken (石膏根) or "Gypsum Root" and to the greenish blue and yellowish grey calcareous shales of the upper part of the same horizon (B). The gypsum in the latter beds is more abundant than in the former ones.

In Lao Kou (老溝) near Ch'iao Chia Niao (喬家島) similar conditions have been observed.

This zone grows gradually thinner and thinner from San Men Miao towards North-East until we reach Hou P'o (侯坡) and Yoh Chia Chuang (岳家莊) where only a few inconsiderable layers of gypsum may be traced. The area within which gypsum is found is about ten li in length and 80 m in width, but in the vicinity of Hou P'o and Yoh Chia Chuang the quality of the gypsum makes mining unprofitable.

The second zone is found north of the first and embraces the following places: P'a Tsun (柏村), Miao Hou Tsun (廟後村), Liu Chia Chuang (劉家莊), Pan Kou Tsun (畔溝村) and P'o Ti Tsun (坡底村). This zone extends in a NE-SW direction roughly parallel to the first zone. Outcrops of the gypsum-bearing beds can only be found in some valleys near the above mentioned villages. In other parts they are almost covered by conglomerate or the almost ubiquitous loess.

Near P'a Tsun, 5 li north of San Men Miao a very fine and unbroken section of gypsum-bearing beds is exposed in the valley P'a Tsun Kou, a tributary of the Lao Kou. At the bottom of this valley there exists a horizon of greyish green sandstone containing abundant gypsum veins. These are either



parallel or oblique to the bedding planes. In thickness they range from one to three cm. They are pure white in colour and of fibri-form crystallization.

Overlying the greyish green sandstone is the red marl in which gypsum veins are also richly found. It seems to me that they are probably equivalent to those found in the sandstone with regard to thickness, colour and form of crystallization. Further upwards there are horizons of greyish blue, earthy limestone and yellowish green shales, the gypsum occurring here is not so abundant as in the two horizons described above.

The total thickness of the gypsum-bearing series found in this valley is roughly estimated at 50 m.

Miao Hou Tsun is a small village not far from San Men Miao in a northern direction. On the southern slope of a small hill near the former village some gypsum veins can be found in fissures of the yellowish, grey, argillaceous clay or shale and the red clay. These rocks I like to name the gypsum-bearing light grey series, it seems to be the upper part of the so-called Eocene formation. The thickness of the gypsum veins is variable, usually ranging from one to two cm. Its colour is commonly white or light pink. The pink-coloured gypsum veins are called by the natives T'ao Hua (桃花) gypsum or "peach blossom" gypsum. The crystallization may be of two kinds: one belongs to the fibrous form and the other takes the shape of hard, platy, semi-transparent crystals, the latter being usually of white or whitish grey colour. The deposits here seem scarcely to be of any economical value.

Liu Chia Chuang (劉家莊) is situated about 65 li E of P'ing Lu city or 15 li NE of San Men Miao on the W. side of Ch'ing Chien Ho (清澗河). A small area of gypsiferous formation occurs NW of Ssu Chia Chuang. The main material of this formation is composed of an alternation of predominant red or reddish brown claystones and light grey marls. The gypsum veins are rather thin, being in outcrop only one cm or a little more, but the natives say that 3-4 cm might be found at some depth. Such veins are also found in a valley SE of Kuo Tsun (郭村); conditions of occurrence being probably similar to those at Liu Chia Chuang.

Immediately S of Pan Kou (盤溝) 24 li NE of San Men Miao, some workable gypsum is met with in the east tributary of Pan Kou valley. Only two horizons of gypsum-bearing beds are well exposed in the small valley. The upper is the greyish green marl, containing light greenish gypsum layers. These may be parallel or oblique to the bedding planes. The thickness is one to ten

cm. The lower horizon is the red marl in which reddish gypsum is often found. According to information from the natives gypsum 30 cm in thickness may be dug out from this horizon. The total thickness of the two gypsiferous horizons as exposed in outcrop is about 20 m.

East of P'o Ti Tsun (坡底河) 80 li E of P'ing Lu city, some very well developed gypsum seams and veins have been found not only in the valleys Yang Shu Kou (楊樹溝) and Lao Yao Kou (老窑溝) which are the W. tributaries of P'o Ti Ho (坡底村), but also at the village Ku Chuang (古庄) on the E. slope of P'o Ti Ho and other valleys in the neighbourhood of P'o Ti Tsun.

The country rock is an alternation of red, reddish brown clay or marl and yellowish green and greenish grey marls, for details of which see below :

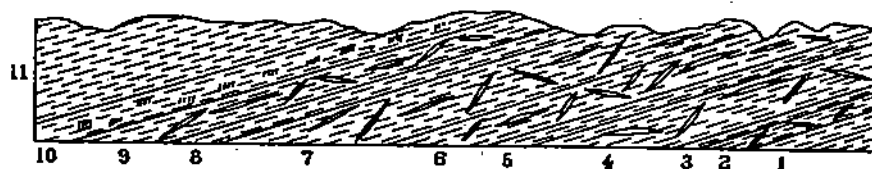


Fig. 6. Section at Lao Yao Kou, near P'o Ti Tsun showing gypsum-bearing horizons.

- 1) Red clay, often with greenish grey tinted clay ..... 5 m.
- 2) Red porous clay often tinted green with occasional gypsum veins ..... 7 m.
- 3) Greenish grey gypsiferous marl (not pure gypsum but mixture of g. & m.) ..... 3 m.
- 4) Red clay similar to No. 2. with gypsum veins 1-4 cm thick ..... 10 m.
- 5) Greenish grey marl with pure white gypsum veins 1-10 cm. .... 4½ m.
- 6) Red clay with greenish grey or yellowish grey marl layers 14 m.
- 7) Chocolate-coloured clay (small pores filled with gypsum grains) with thin layers of greenish grey marls, abundantly containing veins of pinkish gypsum of 1-5 cm thickness ..... 19 m.

- 8) Greenish grey marl with white and red layers ..... 2 m.
- 9) Red-brown, argillaceous, sandy clay containing white gypsum, 1-3 cm thick on outcrops..... 4 m.
- 10) Greenish grey and yellowish grey, solid marl mixed with gypsum and containing gypsum veins 3-8 cm in thickness 11 m.
- 11) Red-brown argillaceous clay with greenish grey marl layers and white gypsum veins..... 6 m.

It is evident from this section that the outcrops of gypsum seldom exceed 10 cm in thickness forming an irregular network on the valley slopes, but according to the experience of native miners there are four workable gypsum seams ranging from 3" (9 cm) to more than one foot (30 cm) in thickness. The four seams are listed below in descending order.

Seam	Thickness of gypsum	Colour	Crystallization	Side-rock
4th	More than one foot	pure white	fibri-form	red marl
3rd	3 or 4 inches	ditto	ditto	greyish green marl
2nd	6 or 7 inches	ditto	ditto	red marl
1st	7 or 8 inches	pink	ditto	ditto

The four seams apparently occur within an extensive area in the horizons 6,7,8,9, and 10. The so-called fourth seam is the thickest of all. The actual distances one from another have not yet been ascertained, but it is certain that they are separated by red and greenish grey marls from one another. A large quantity of gypsum is taken from these seams by the Fu P'ing (福平) Gypsum Mining Company at present time.

The P'o Ti Tsun region is by far the most important of all as regards resources of gypsum, quality and production. In fact it is the largest known deposit of gypsum and the largest producer of this mineral in Shansi province.

#### ORIGIN OF GYPSUM

It is well known that most deposits of gypsum in the world have been formed by the agencies of evaporation, percolating waters, decomposition of sulphides and volcanic action. The gypsum formed by evaporation either in lakes or ocean bays is usually regularly bedded and associated with rock salt in alternating stratification. Percolating waters may penetrate gypsiferous bed

form gypsum. Volcanic action may form gypsum in small quantities by the action of sulphuric vapours on the lime of volcanic tuffs or other rocks.

The gypsum in P'ing Lu Hsien occurs in red, reddish brown clay or marls and yellowish green or greenish grey marls, which, as far as we can judge, are of Eocene age, and of sedimentary origin. Within the gypsum-bearing area not only do the gypsum veins penetrate the country rock in various directions, but nothing has been seen of rock-salt, nor do any pre-existing gypsum-bearing beds occur. There is consequently no reason to believe that the mineral was formed by evaporation or by solution and re-deposition of already existing gypsum.

Generally the uppermost part of the gypsiferous formation seems to be composed of calcareous marls or claystones, sometimes containing thin lime-stones. These form a distinct demarkation between the gypsum-bearing and non-gypsum-bearing horizons. On the wet adhering surfaces in the sediments just mentioned and on certain light-coloured layers in the gypsum-bearing formation some traces of sulphur seem to appear. Hence we believe that sulphides, such as pyrite, might be impregnated in the primary sediments. The sulphides have through oxidation been partly changed to sulphuric acid and this, when meeting the calcareous sediments mentioned above, has converted them to calcium sulphates which would be deposited as gypsum. This suggestion is based only upon our observations in the field and its validity can only be proved by future study.

#### MINING (Incl. History of Development).

Before the 10th Year of Kuang Hsü (光緒) (1884) no one seemed to be aware of the fact that useful gypsum deposits exist near the village P'o Ti Tsun. From this year onwards the deposits were worked by natives from Honan province<sup>1</sup>, in the valley Lao Yao Kou, to the south of P'o Ti Tsun. The interest of the local population was also aroused. During the 15th year of Kuang Hsü (1889) mining was gradually developed and numerous native pits were opened in Yang Shu Kou (楊樹溝) and So Pa Kou (鎖把溝) valleys. Working was continued for some ten years. Unfortunately the natives had no knowledge of mining nor did they seem to realize the importance of registering mining rights and drawing of mining maps. In the 4th Year of The Republic Mr. T Chang

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1. It was stated in the foot note on page 1 that gypsiferous beds exist also on the Honan side of the Yellow River.

(張端) saw his chance and then the area was mapped and registered with the Industrial Bureau of Shansi. In the same year the Fu P'ing Gypsum Mining Company (福平公司) was also established by him. The native mines were not permitted to work or in other words the native rights were confiscated by the company. At the present time the company is still working but on small scale and with dubious profit.

No other company is in operation and work is concentrated only in the neighbourhood of P'o Ti Tsun. All the mining is carried on by simple, laborious, native methods. Gypsum and rock are charged in wicker-baskets fitted with four small wheels and then they are pulled out through the adits by coolies. Tools, too, are quite crude and inefficient. Five working adits are established by the Fu P'ing Company at Lao Yao Kou (老窑溝) a western tributary of P'o Ti Ho. At the eastern side of this river, near Ku Chuang village (古庄) a native mine is now in operation.

The company does not engage the workmen directly but leaves this to one or several headmen who are paid at a fixed rate according to the amount of gypsum produced. According to the information given by the miners the following different systems are practised :

1) The headman is paid by the weight of gypsum mined and receives from the Company \$20 per ten thousand catties (or \$3.30 per ton), but the miners use their own tools and oil for the lamps.

2) The headman is paid by the volume of gypsum produced and receives forty cents for a volume of gypsum 4'8" in length, 2'4" in width and the thickness equal to that of the gypsum bed (generally from 7" to 1'). Other conditions are as stated under 1).

Generally speaking the mining adits are established along the dip of strata with an inclination of about 90, being 10 to 100 metres in length measured horizontally.

#### PRODUCTION AND TRANSPORTATION

At our visit to the gypsum mines we endeavoured to obtain some statistics concerning the amount of mineral produced. There are 20 men and subsequently deposit gypsum so dissolved. Sulphuric acid resulting from decomposition of sulphides such as pyrites may act upon lime carbonate and

working in Lao Yao Kou, a western tributary to P'o Ti Ho, and one man can mine 600-700 catties (at 600 grammes) daily. The total output per day is therefore nearly 14000 catties or 8.4 ton. In Ku Chuang (古庄) there are about 4 men and the total production per day is about 2800 catties or 1.7 ton.

The gypsum is sold to several provinces such as Hopai, Shantung and Honan. The price laid down at the bank of the Yellow River is about \$40 per ten thousand catties or \$6.40 per ton. The distance from the mines to the river is 15 li. Transportation on the river is at present the only means of bringing the gypsum to the markets. But to take it down to the Huang Ho mules and donkeys must be used. Supposing that each mule or donkey can cover the distance back and forth twice a day and that the former can carry 300 and the latter 180 catties, the hiring costing respectively 60 and 36 cents per day, then per 10,000 catties the transportation will cost nearly \$10 or \$1.60 per ton from the mine to the Yellow River. This cost is paid by the company. The gypsum is then transported on boats down the river to places in Honan and Shantung going as far as Tsi Nan Fu (濟南府), the capital of the latter province. The buyers must pay tax to the amount of \$20 per 10,000 catties or \$3.20 per ton.

#### CONCLUSION (SUMMARY)

In the extreme southern part of Shansi Province, in the district of P'ing Lu (平陸縣), about 50 li East of that city, there exists a rather thick formation, presumably of Eocene age, which consists in its lower part of conglomerate and in its upper strata of semi-consolidated red marls and claystones and also sandstones. There are also layers of greenish claystone and bluish grey argillaceous limestone. The formation seems identical with the Cenozoic field in Yuan Ch'u (垣曲縣) district in SE Shansi.

In the red marl there are numerous veins and veinlets and even thicker beds of gypsum sometimes conformable with the bedding sometimes oblique to it. The thickness is mostly inconsiderable, 1 to 4 cm, but beds of up to 30 cm are stated to have been found. The gypsum often forms a very conspicuous network on the valley-slopes and exists also on the S side of the Yellow River at Shan Chou in Honan opposite P'ing Lu in the same formation.

The gypsum is at present mined in a rather primitive manner by the Fu P'ing Mining Company (福平公司) and work is concentrated mostly near village P'o Ti Tsun (坡底村). The output is round about 10 tons per day. The

mineral is transported down to the Yellow River and carried to the market in boats. Price at the bank of the river is about \$6. 40 per ton.

There is no doubt, since the gypsiferous area is quite extensive, that the reserves of that mineral are considerable and the quality is generally quite satisfactory. Indeed beautiful specimens of snow white gypsum are seen amongst the marketed product. Some profit has already been made by owners and workers, but the present rudimentary organisation lacks capital and uses very primitive methods of mining. Improvement will be necessary when demand increases, and then this hitherto little-known, but interesting item of Shansi's mineral resources will be duly appreciated.







Fig. 1. Showing the gypsum veins at P'o Ti Village (坡底村)



Fig. 2. San Men Miao (三門廟) seen from W. on the northern bank of the Yellow River.