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THE QUICKSILVER DEPOSITS OF CHINA

BY F. R. TEGENGREN.

INTRODUCTION.

Apart from some less important exceptions the occurrence of quicksilver in China is confined to Kueichow province and the adjacent parts of the neighbouring provinces Szechuan and Hunan in the *NE* and Yunnan in *SW*. Numerous deposits are scattered throughout the vast area referred to which have been worked and utilized since ancient times. Although this industry, once prosperous, has for various reasons declined very much during the last century, and although its share in the World's market is almost negligible, nevertheless it plays a considerable part in the domestic supply and is still of no little importance for the provincial economy, as it affords livelihood to tens of thousands of people. From a geological point of view the deposits offer much of interest, forming a link in the series of quicksilver deposits surrounding the Pacific Ocean, and the old mining and metallurgical methods are well worthy of recording. The aim of this article is to summarize my own observations,[§] as well as those of previous travellers in order to give the fullest possible description which can be based on the very incomplete material that as yet exists. A list of reference of the literature on the subject is given at the end of this paper.

GENERAL REMARKS ON TOPOGRAPHY AND GEOLOGY.

Topographically as well as geologically Kueichow is one of the least known provinces of China. From the description of v. Richthofen and Tiessen,^{§§} based on all the material available, it appears that the bulk of the

§) Made during a journey in the Winter of 1915 through Southeastern Szechuan, Eastern Kueichow, and Central Hunan. On this journey, which was undertaken by order of the Ministry of Agriculture & Commerce, I was accompanied by Messrs C. F. Erikson and W. P. Lo (羅文栢). To these my collaborators, who assisted me in many ways, I wish to acknowledge my obligation. I am furthermore indebted to Mr. Chang Ching-Kuang (張景光) of the Department of Mines, whom I met at Tung jen, (銅仁) and who gave me much valuable information.

§§) Richthofen: China, Vol. III Berlin 1911; Tiessen, Fünftes Capital, Die Provinz Kueitshou.

province may be characterised as an extensive high-plateau, sharply separated in North and South from the basins of Szechuan and Kwangsi respectively. Towards the *SW* it is connected with the Yunnan highland and towards *NE* it continues into Hunan, Szechuan and Hupah but lowers at last towards the great Hupeh plain. The plateau-land, at an altitude approaching 1,000 metres in the *NE* and reaching as high as 1,400 metres in the *SW* is, however, by no means a continuous plain; on the contrary it is deeply dissected by river channels, often with steep escarpments, thus forming real gorges, the bottom of which have an elevation above sea-level, ranging somewhere about 400-500 metres. As a consequence of this rugged topographical relief the means of communication are very difficult, the paths and tracks often winding and climbing abruptly up the escarpments, then passing for a while over comparatively level ground but soon plunging down again into a deep ravine. This lack of good roads is so much the more painfully felt as the rivers abound with rapids so that, in fact, with the exception of a couple of rivers in the Northern and Eastern frontier regions, there are no navigable waterways.

The geotechnical structure of the Kueichow plateau may be briefly described as a "horst" of older, rather gently folded rocks, mostly limestones and shales, ranging in age from probably pre-Cambrian to Carboniferous or Permian. The folding, with a *NEE-SSW* trend, is certainly post-Carboniferous and supposed to have taken place in Mesozoic time, whereas the great lines of dislocation—running as a rule in about the same direction—which separate the "horst" in question from the adjacent basins of Szechuan and Kuangsi are believed to be as young as Tertiary.

DISTRIBUTION OF THE DEPOSITS.

Plat. I shows the districts and localities within the main quicksilver bearing belt where this metal is being, or formerly has been mined; many regions of minor importance have certainly not been indicated, as traces of the metal are said to be found in nearly all districts, but on the other hand I believe that no places of consequence have been omitted. As far as possible I have marked the very localities of production (by dots;) where only the producing district is known I have designated it by a circle.

A mere glance at this map bears out the fact that the occurrences belong to a broad zone, at least 100 kilometres in width, extending *NE-SW* from *SE* Szechuan and *W* Hunan across whole Kueichow, and continuing into Yunnan as far as Mengtz, (蒙自) the total length being about 700 kilometres. This is, as already pointed out, the chief quicksilver bearing area of China. We here give a list of its mining districts and localities, enumerated in sequence from *NE* to *SW*.

- 1) *Deposits in SE Szechuan*:—In Yu-Yang district (酉陽) quicksilver is mined in four localities viz. Lan-Ni-Pa, (爛泥壩) Fen-Shui-Ling, (分水嶺) Lung-Men-Ch'ang (龍門廠) and Chu-Sha-Ch'i (殊砂溪).
- 2) *Deposits in NE Kueichow*:—In Wu-Ch'üan (婺川縣) and Yin-Kiang (印江縣) districts there exist several mines, the former district being more important.
- 3) *Deposits in Western Hunan and Easternmost Kueichow*:—In Feng-Huang-Hsien (鳳凰縣) the Hou-Tzü-P'ing (猴子坪) mines; in Sheng-Ch'i-Hsien (省溪縣) the Ta-Tung-La, (大洞喇) Yen-Wu-Ping, (岸屋坪) Wan-Shan-Cb'ang (萬山場) and Tien-Juan-Ping (田壩坪) mines. Of these the first mine only belongs to Hunan province, all others being situated within the borders of Kueichow.
- 4) *Deposits in Central and Southern Kueichow*:—In Kai-Chow (開州) district now known as Tzü-Kiang-Hsien (紫江縣) the famous Pai-Ma-T'ung (白馬洞) mines; in Huang-P'ing district (黃平縣) several mines are reported to exist; further in Pa-Chai district (八寨縣) important deposits; again the Nan-Mu-Ch'ang mines (楠木鎮) in Hsing-I-Fu (興義府) now known as Nan-Lung-Hsien (南龍縣) and at last the Yang-I (羊邑) deposits near the Kuangsi border stated by Duclos to have been very extensively worked in the past.
- 5) *Deposits in N Yunnan*:—Mines at Ta-Chuang (大莊) *N* of Mengtz (蒙自).

Outside of this main quicksilver belt, the metal is known to occur, sometimes associated with gold, in Western Yunnan,§ where cinnabar is washed for in the beds of creeks and streams entering the Salween, Mekong, (湄江) and Yangtze rivers, as well as in Southwestern Szechuan, especially near the Yalung (雅龍) drainage, where also placer deposits are being utilized§. The very fact that the metal is won only from placers seems to indicate that the primary deposits must be very poor.

Among the mineral collections brought together by the provincial authorities and forwarded to the Central Government Mining Department, there are specimens of cinnabar from Yung-P'ing-Hsi-Li (永平西里) at Mekong in Western Yunnan and from Wei-Ning (威寧) in Westernmost Kueichow.

The occurrence of quicksilver in Southern Hunan is reported on by von Richthofen,§§ who states that this metal is found at Peishasz, Hsin-Ning-Hsien (新寧縣) and that it was said to occur at Shuikatung N of Chen-Hsien (郴縣). Richthofen himself, however, considers these statements doubtful.

At Hsi-Kuang-Shan (錫礦山) antimony mines in Hsin-Hua, (新化) cinnabar is occasionally found in brecciated limestones.

Since most of these deposits outside of the main quicksilver belt almost certainly are of very little or no economic value, and as besides, practically nothing is known of them, I merely here note down their existence.

CHARACTER OF THE DEPOSITS.

The Chinese quicksilver deposits exhibit in all essential features a close coincidence with the occurrences of this metal in other countries. They consist of irregular veins or stockworks interweaving brecciated layers of limestone or hard shale, or the ore mineral occurs more disseminated in such layers as small crystals or aggregates of crystals.

The sediments harbouring the quicksilver ore seem to belong to various formations; at Nan-Mu-Ch'ang Leclerc has found occurrences in Devonian

§) Moore-Bennett; *Rocher* Vol. II p. 247.

§§) *China*; Vol. III p. 492.

limestone, in calcareous shales of lower-carboniferous age, in blue and dark upper carboniferous limestone and in Permian *Productus* limestone. The deposits in the North are confined, on the other hand, to the upper portion of a probably Ordovician limestone.

A conspicuous characteristic of the Northern deposits is that they occur in elevated anticlines where these old layers are exposed, whereas elsewhere no deposits are known.

Whether the occurrences are really confined to these anticlines and this horizon or not, must for the present be left undecided, as no deposits have been found in other rocks, and as no other parts of the said quicksilver bearing horizon in the North have been exposed by denudation. It may be supposed, however, that fracturing which favours the infiltration of the solutions, as well as dislocations affording vents for these solutions, are most likely to occur in the anticlinal bends. On the other hand the appearance of these deposits, in the neighbourhood of vertical fissure lines but independently of the general folding is by no means excluded; in fact it seems probable that, as Leclère does not mention any folding, the Nan-Mu-Ch'ang deposits are an example of this.

Be this as it may, anyhow it seems to be a general characteristic with regard to the territorial distribution of the deposits that they occur along several roughly parallel zones coinciding at the same time with axis of folding and with the chief lines of dislocation. Following one anticline in the North we have the deposits of Lan-Ni-Pa, Fen-Shui-Ling, Lung-Men-Ch'ang and Chu-Sha-Ch'i to the same probably also belong the Yinkiang (印江) occurrences. Connected to an anticline more East we have the deposits of Hon-Tzŭ-P'ing, Ta-Tung-la, Yen-Wu-P'ing, Wan-Shan-Ch'ang and Tien-Juan-P'ing of which probably the occurrences at Pa-Chai form a continuation. How the Central and Southern deposits may be arranged along certain lines I can, of course, not say as the necessary data are wanting.

To what igneous magmas these deposits owe their origin as well as the epoch when the mineralization has taken place must forthwith be left an open question. However some few suggestions may be made. It has already been pointed out that the period of folding is considered Mesozoic and the

fraction tertiary, and consequently the age of the ore, is connected to the latter orogenetic movements, also of tertiary age. As to the Possible igneous sources of the quicksilver solutions it may be mentioned that Leclère in many places encountered effusive rocks such as quartzporphyry and porphyrite in Southern Kueichow and that in the bed of the Tungkiang (通江) river at Tung-Jen there are abundant large pebbles of a dark gray dioritic rock, the origin of which I, however, had no opportunity to trace.

The mineral association of the deposits is that more or less common to all occurrences of this metal over the World. The quicksilver mineral is almost exclusively cinnabar, as a rarity onofrite has been found by Termier in specimens from Wan-Shan-Ch'ang, where Brelich also found native mercury associated with the antimonial cinnabar. Rocher mentions a deposit near Mengiz (蒙自) containing native mercury§. Of the monotonous association of gangue minerals of quicksilver deposits, as embodied in Becker's table§§, the following have been observed: Stibnite, Calcite, quartz, bitumen, and pyrites.

The cinnabar as usually has a tendency to form well defined crystals, and where free space has existed beautiful rhomboedra occur, often attached to druses of small, clear Rock crystals. Penetration twins of two rhomboedra are very common. The size of the crystals varies from pinhead to 2-3 centimetres in section.

The crystalline cinnabar occurs as irregular bunches and patches, short veins along joints and cracks. The colour varies from light translucent red to dark opaque red, the variation probably being due to varying proportions of lime and perhaps also bitumen. Besides also an antimonial variety with lead gray colour and submetallic luster occurs.

The onofrite found by Termier§§§ appears as patches of black colour, with a granular and lustrous fracture. The composition of this mineral (a sulphoselenide of mercury) as well as that of the cinnabar is according to Termier's analysis:

- §) La Province Chinoise du Yun-nan; p. 247. Leclère failed to trace this deposit but nevertheless considers its existence probable, as veinlets of cinnabar are known to occur in the region.
- §§) G. F. BECKER:—Quicksilver Deposits of the Pacific Slope, U. S. Geol. Survey, Monogr. XIII, 1888.
- §§§) I regret that I have access only to an abstract of Termier's paper appearing in Transactions of American Inst. of Mining Engineers.

	<i>Onofrite</i>	<i>Cinnabar</i>
Mercury	77.3%	85.75%
Sulphur	10.3%	13.70%
Selenium	8.4%	nil
Zinc (with trace of iron)	1.3%	nil
<hr/>		
Total	97.3%	99.45%

Stibnite is often found as minute acicular crystals on the quartz druses; especially abundant this mineral seems to have occurred in part of the Ta-Tung-La mine, but it was also observed at Wan-Shan-Ch'ang. Calcite, generally coarse crystalline and of a milk white colour, is abundant, and constitutes sometimes the bulk of the cement of the brecciated layers. Next comes silica, always in the form of quartz, often forming small elongated prismatic or almost acicular crystals coating the inner walls of small vughs or cavities, and as already mentioned it is in its turn coated by cinnabar or stibnite crystals. In many places the brecciated rock seems to be silicified to a great extent, what however may also partly be due to an original high percentage of silica. Bitumen as black patches, was observed by me at Wan-Shan-Ch'ang and is mentioned by Wheeler to occur at Hou-Tzu-Ping. Pyrite is not seen in the Northern deposits, but is reported at Nan-Mu-Ch'ang by Leclère.

As to the average tenor of the ore deposits it is impossible to express any definite idea. As a preliminary approximation it can be said safely that most parts of the deposits now under exploitation do not contain as high as 1% of mercury, and occasionally even far below that figure. Quite locally however richer concentrations have been struck, in which the percentage of quicksilver may reach 3-4% or even more. These richer shoots are, however, evidently confined to the immediate vicinity of the tectonic lines of fracture, have mostly already been exhausted, and although still marketable cinnabar in the form of powder can be extracted by cobbing and washing, large crystals are scarcely to be seen any more.

Although thus a general deterioration of the ore-grade has taken place, and although it is decidedly inferior to the ores produced by Spain, Italy,

Austria, Russia and California, the future prospect of the mining regions is by no means so dark. A systematic geological survey of the whole quicksilver belt would most probably lead to discoveries of new remunerative areas.

As to the genetic relations I wanted at last to point out the apparent consanguinity of the quicksilver deposits with the antimony deposits of South China, as indicated by their territorial distribution,[§] by the very similar character of the deposits, and by the occurrence of cinnabar at the antimony fields and stibnite together with the cinnabar ores.

HISTORICAL NOTES ON THE QUICKSILVER INDUSTRY.

In western countries mercury and cinnabar have been utilized since ancient times, several centuries B.C., and there is no doubt that the old Chinese recognized and appreciated this metal just as well as their contemporaries in the near East and Europe. The vermilion ink and paint has been used since times immemorial and in the gorgeous mausoleum of the First Emperor, Ch'i-Huang-Ti, (始皇帝) who died in 210 B.C., with the aid of quicksilver miniature rivers were made—the Yangtze, the Yellow River, and the Great Ocean—the metal being made to flow from one into the other by machinery.^{§§}

Tradition about the quicksilver mining in the districts visited by me does not, however, go farther back than the beginning of the Ming Dynasty (the 14th century) when probably the more important centres were productive.

As pointed out already by von Richthofen, the history of mining in Kueichow is intimately connected with the political conditions of that province, but unfortunately very few records are available to a westerner.

The province was, in olden times, populated by aboriginal tribes, chiefly Miaotzü, and bitter fighting developed between these and the immigrating Chinese, resulting in the former's retirement into remote or inaccessible

§) See another paper by the writer entitled "The Hsikuangshan Antimony Deposits."

§§) H. A. GILES:—*The Civilization of China*, London 1911, pp 30-31. The mausoleum has been described by China's greatest historian Szu Ma Chien (司馬遷) about a century after the death of the Emperor.

mountain regions. But also after the Chinese had gained a permanent footing in large parts of the province fighting occurred from time to time and cruel campaigns against the aborigines were organized. During such times of warfare the peaceful industries, and among them not the least mining, suffered severely.

In the earlier part of the Nineteenth century peace was only once disturbed, viz. 1832-1838, but from 1848 there was almost incessant fighting until 1872, when the Miaotzu were finally subdued and more lasting order restored. But the disturbances during this time did not concern the Miaotzu only. In about 1850 the Taiping rebellion broke out in Kuangsi. Whether it reached the mining regions of Kueichow, I do not know, but anyhow it must have blocked the road for the quicksilver products from the Southern mines. Again in 1858 the Mohammedan troubles in Yunnan began, developing into a desperate struggle which, spreading also to Kueichow, finally, after some 15 years duration, ended with a great massacre of the Mohammedans and a complete devastation and depopulation of innumerable towns and villages. Among the seriously affected areas were the quicksilver mining regions in Southern Kueichow, where this industry had been largely in the hands of Mohammedans.

The quicksilver mining in the South never recovered from the destruction caused by the above mentioned disturbances. When Leclère in 1899 visited Nan-Mu-Ch'ang, the village was still in ruins and no mining was carried out. As to Pai-Ma-T'ung Riault states that this village, which in the earlier part of last century had a population of 4,000 to 5,000 souls, consisted of some 40 families only, earning a scant livelihood from the mines. The attempts in 1899 of a foreign syndicate (Marteau and Durand), to resume work on a modern scale proved unsuccessful.

As can be gathered already from this failure, the insurrections, however, have not been the sole reason for the abandonment of the mines. Leclère states that at Nan-Mu-Ch'ang the workings had been extended as far underground as the natives were able to reach, and at Pai-Ma-T'ung the majority of the mines are said to have been submerged after a fissure carrying abundant water had been struck.

In the North the industry was most likely comparatively less affected by the disturbances, and Tung-Jen prefecture now became the chief centre of production. It is stated by Brelich, that in the seventies a great improvement was effected through the introduction of gun powder by Szechuanese miners; previously the ore had been broken by means of hammer and gad only and in the larger workings by the prodigal "fire-setting."

A remarkable, but sad chapter, in the mining history of Kueichow is that dealing with the "Compagnie anglo-française des Mercuries et concessions Minières de la Chine" or "Anglo-French Quicksilver and Mining Concession of China Limited." The object of this Company which started in 1899 seems to have been to develop big mining concerns in Kueichow but it evidently embarked upon enterprises without having consulted or followed the advice of competent experts, nevertheless harbouring natively optimistic expectations of brilliant success. After an Iron works erected by this Company had met with complete failure owing to the nonexistence of coking coal, the promoting of a large scale quicksilver industry was decided upon. To this end mines were purchased at Wan-Shan-Ch'ang, buildings constructed there, and operations started. However also this enterprise did not answer the expectations,[§] and in 1906 a new company with the same name, capitalised at not less than £300,000 or francs 7,500,000 took over the whole concern, continuing operations until the outbreak of the revolution in 1911, when the local garrison revolted and the staff of the Company was compelled to leave. Since that time no work has been resumed by the Company, and now also of this plant but ruins are left. The true reason for the abandonment was, however, said to be that a shaft sunk in search for new ore resources within their mining property had struck an old mine pertaining to another owner, which meant that the possibility of extending the workings towards the depth was closed.

§) The nature of these expectations may be gathered from the calculations of Mr. Chauveau, probably one of the Company's experts, which are spoken of by De Launay (*Richesses minérales de l'Asie* p. 760-761) and stigmatised by him as "singulièrement fantaisiste." According to the named expert there exist within an area of 100 hectares not less than 6 million tons of ore representing a value of 900 million francs (!).

Meantime the native industry has, as will be shown by the statistical figures given below, been carried on. The most prosperous time of the Northern centre of production seems to have been in the seventies after which time the output has evidently been gradually decreasing.

DESCRIPTION OF INDIVIDUAL MINING LOCALITIES.

It is regrettable that many important districts cannot be included in this chapter, as no information about them exists. To these unknown mines also belong those of Pa-Chai district which ranks second with regard to production and is said to be very promising. In the following a short description of the known fields is given:

The mines of SE Szechuan:—Of these very poor occurrences which have already been named there is very little to be said. Lan-Ni-Pa and Fen-Shui-Ling would in any country but China be of only mineralogical interest, as megascopically visible grains of cinnabar are rather scarce in the narrow veins of coarse crystalline calcite that are being mined. Yet these occurrences are said to be the sole means of livelihood for several tens of families.

Lung-Men-Ch'ang and Chu-Sha-Ch'i are somewhat richer; the ore occurs in the calcspar cement of a brecciated layer of the dark, probably ordovician limestone, but only small parts of the ore bearing horizon which is generally attached to a thin, nearly horizontal layer of yellow clay (parallel to the limestone strata), can be worked.

The mines, 60-70 in number, but very small are worked mostly individual miners and their families, sometimes also by groups of miners; probably they thus have been left in the undisputed possession of the natives because they have been considered too poor to bear any exactions of tribute.

About the methods there is very little to be said. The ore is broken out by means of blasting with gunpowder fabricated by the miners themselves. It is picked by hand and the ore is then crushed and washed. All ore is smelted on the spot.

At Lung-Men-Ch'ang there was stated to be 300-400 workmen. Probably including also Chu-Sha-Ch'i. The aggregate output was given as some 120 taos worth of mercury for every five days, but it had recently declined.

The workings are entered by a main adit from which a series of drives, with irregular larger excavations (stoped out where ore has been found), ramify in various directions. There were twenty working faces at the time of Mr. Wheeler's visit.

The mining property was until recently owned by the Hunan Official Mining Board, who ceased operations in April 1914, as they were unremunerative. It was then taken up by Mr. Huang, (黃先生) taoyin in Feng-Huang.

The mine is worked on a tribute system, each stope or working face being worked by a tributer who engages all the workmen on conditions as set forth in the following Chapter.

The higher grade ore is picked out, and after being crushed to about 1/4 inch. (6mm.) is panned in a wooden dish for the cinnabar content. The lower ore is also crushed and, together with the dried tailings from the panning, retorted.

Mr. Wheeler says that it is safe to surmise that the average mine grade exceeds 1%, and that the poorer ores and tailings yield from 2-4% of quicksilver. The picked ore from which the cinnabar is obtained forms but a small percentage of the total.

As to output and prices see tables in the final chapter.

The Ta-Tung-La mines (see map Plate II).—Belonging to the same broad anticline and very likely also connected to the same tectonic line, this ore deposit seems to be very similar in character to that of Hou-Tzŭ-Ping, although the last named is of less extent and importance than Ta-Tung-La (see map Plate III.) The position of the strata is also here nearly horizontal and the country is the same limestone. The extent of the ore bearing stratum, a brecciated layer of some 6-10 metres in thickness in the limestone series, is indicated by the chain of mines stretching from the mine Southwards along the West slope of the hill (cfr map) about 1,000 metres, and then Eastward along its Southern declivity for a distance of about 600 metres, thus indicating an ore bearing area of about 40-50 hectares.

Isolated from this by an alluvial plain there is another small ore bearing area in the North near the village Yun-Chang-Ping, (雲場坪) which however is very slightly mineralized and of no economical importance. The altitude of the mining area is about 725 metres above sea level.

The workings, extending along horizontal adits of up to 400 metres in length, are very large, undermining almost the entire hill: sometimes they are unusually spacious attaining a height of some 6 metres. Immense dumps containing millions of tons of rock have accumulated on the slopes below the entrances of the mines, where operations have been carried on, although intermittently, since the Ming dynasty.

The ore bearing layer occasionally carries very abundant cinnabar throughout, the tenour amounting certainly to several percent of the total brecciated mass, but often it is also much poorer. The cinnabar here has a much darker tint than that of Hou-Tzu-Ping and also much of the antimonial variety is observed. No bituminous matter has been observed here, but abundant stibnite was found in vughs by Wheler.

There are several companies and individual miners working at this field, the largest being the the Li-Heng Company (利亨公司) consisting of influential Hunanese, who several years ago (so I was told in Tung-Jen,) supported by an armed force, seized the richest mine of the place from its former possessors, some Kueichow officials.

The most conspicuous detail of the equipment is baby track railways of .47 metres gauge for transport of the ore to the mouth of the adits. The rails however are of wood (!), and the rolling stock consists of bamboo baskets (with a capacity of some 60 kilograms only) on wooden wheels.

The rich ore is picked out, crushed and carefully panned for its cinnabar content, the latter being marketed as such. The poorer ore is also treated in a similar way but then retorted and transformed into metallic quicksilver.

The Li-Heng Company is said to have 30 working faces in its mine and employs some 500 workmen. The output of this Company, said to make up about one third of the total of the place, was stated to be 40-50 catties of quicksilver and 25-26 catties of cinnabar every five days. The company has 12 to 14 furnaces working. As to tribute system, see next chapter.

The Wan-Shan-Ch'ang mines—(cfr map Plate III,) situated 30 kilometres due South of Tung-Jen, within Shen-Hsi district, at an altitude of nearly 1,000 metres above sea-level, are at present the most important quicksilver mines of the country. The numerous ore localities are found scattered within an area of about 300 hectares, on the high plateau by the limestone of the same broad anticlines as the mines of Hou-Tzŭ-Ping, Ta-Tung-La, and Ai-Wu-Ping in the *N* and Tien-Yao-Ping in the *S*. Evidently the deposits are-connected to big lines of dislocation which have given rise to the steep escarpments and deep gorges on the East part of the mapped area (cfr also panorama on Plate IV also two photo on Plate V).

At least 2 well defined ore bearing horizons can be discerned, viz. the chief brecciated layer cropping out along the precipices of the canyon, the other ore bearing layer being found some 100-150 metres above the former, on the slopes of hillocks rising above the mean plateau level.

The former is the chief source of production, being, in the immediate vicinity of the canyons, occasionally very abundantly mineralized, the cinnabar often penetrating in innumerable veinlets a limestone layer of several, up to 5-6 metres, in thickness. The upper horizon has a much larger extent, but is, on the other hand, so poor that it was only recently taken up in connection with the rise in quicksilver prices, due to the World war, and the partial exhaustion of some mines belonging to the lower horizon. The picked ore of this lower horizon was stated by the Anglo-French Company to assay maximum 4.4%, minimum 1.7%, average of assays being 2.78% of mercury.

The mining of this place according to local tradition dates back to the beginning of the Ming Dynasty (14th century); since that time it has been carried on intermittently. The palmy days of the field, probably in the seventies of the last century, but afterwards partial depletion of the rich deposits near to the canyon has taken place and the production has decreased accordingly. That gunpowder was introduced some decades ago and the failure of European enterprise has already been narrated.

There are numerous native enterprises in the field, one of the biggest operating the Hsi-Lang-Tzŭ (黑龍子) mine owned by Chinese gentry, em-

playing some 500 workmen of which about 100 miners, about 200 ore-carriers, the rest being engaged in the cobbing, crushing, washing and smelting. The total number of workmen in all mines may be estimated at something like 5,000.

That certainly millions of tons of rock have been mined is testified by the immense dumps of waste rock in the big canyon (see photo on plate V,) extending from the orifices of the mines hundreds of metres down into the valley below.

For treatment of ore and output, reference is made to the next chapters.

The Pai-Ma-Tung mines§ are situated in the Kai-Chou or Tzŭ-Kiang district *N* of Kuei-Yang-Fu and about 20 kilometres *SE* of the district city.

Very little is known about the mode of occurrence and extent of the ore deposit; it is only stated that the cinnabar was found dispersed in limestone, and that ore seemed to be rather poor. Richthofen was told that the ore was spread over an area of 10 li (5 kilometres) in section.

Only two of the numerous mines were working at the time of Riault's visit, most of them being inundated since many years. As the workings were unsupported he considered a future collapse inevitable. The number of workmen was some tens only against about 2,000 in the middle of last century, when this was the premier quicksilver mine in China producing according to v. Richthofen some 20-30 piculs a day corresponding to some 400 tons per annum.

The output had decreased accordingly, only 8 furnaces were in operation, 5 at the bigger and 3 at the smaller mine, using local coal as fuel and producing altogether 10 charges (of 60 catties each) per month, hence the annual output was calculated at about 3,000 kilograms as the smelting is interrupted for some 4 months. §§

§) Description according to Riault, who evidently had very little professional knowledge as is indicated for instance by the following passage: "Le mercure s'y trouve sous forme d'oxyde rouge... .."

§§) Probably, however, Riault has erroneously stated 60 catties of mercury instead of ore, as it seems very improbable that so large an amount of mercury could be obtained from one smelting.

The construction and operation of the furnaces is described on page 24.

The output was all carried by land to Chungking. The price, as also stated in the table III, was said to be Tls 70 per catty at the mines and the cost of transport was given as 5 centimes per catty.

Now all the work is said to have ceased.

The Nan-Mo-Chang mines, §—about 60 kilometres NW of Hsing-Yi-Fu (興義府 今改南龍縣) now changed as Nan-Lung-Hsien.

The deposits consist of innumerable veins of cinnabar dispersed over a very large area extending from the village with this name towards Northeast as far as Mu-I-Szü (募役司,) a distance of about 25 Kilometres. The veins seem to be found in several different horizons varying in age from lower Carboniferous to Permian, partly in limestone, and partly in shaly layers. At one place a band of limestone, impregnated with pyrites, had been mined out to a thickness of 1.5-2 metres. The waste heaps at the smelteries consisted of a gray calcareous shale with only a few scattered patches of cinnabar, but abundantly fossiliferous. Apart from undeterminable Encrinites and Brachiopodes it contained some remains of *Orthis* which were recognised as lower Carboniferous.

Of great importance for the quicksilver industry was a seam of bituminous coal occurring in a shaly layer intercalated in the Permian limestone, at an altitude of about 1,400 metres and 40 metres below the entrances of the cinnabar mines. The seam, attaining about 1.5 metre in thickness, carries coal of a bituminous character, but of a very low grade on account of the high percentage of sulphur and ash. A partial analysis gives the composition as follows:

Moisture	.8%
Volatile matter	9.5%
Ash	35.0%

The coal was being mined at the time of Leclère's visit.

§) Description according to Leclère, who visited the mines in 1898, when they were lying entirely abandoned.