

# GEOLOGICAL RECONNAISSANCE OF WESTERN KUEICHOU.<sup>(1)</sup>

By S. S. YOH.

With 9 text-figures

## ITINERARY.

The reconnaissance work started from Kuei Yang, capital of the Kueichou<sup>(2)</sup> province on 8th Nov. 1927, going south-westward till Yung Ning district near the Pei Pan Kiang (北盤江) river, thence turning north-westward to Lan Tai and Sui Cheng. From Sui Cheng, the journey went north-eastward to reach Pi Chieh on 8th January 1928. Observations were made along all the way from Kuei Yang to Pi Chieh, a distance of a little over one thousand li. The following are the principal stations.

Stations	Distance	Geological interest
Kuei Yang 貴陽		Ching Shan Yao Permian.
Ching Chen 清鎮	50 li	Ching Shan Yao Coal field.
An Shun 安順	85 ..	Shih Li Tou Pu fresh water shells. Chiao Tzu Shan coal field, Gastrioceras beds.
Chen Ning 鎮寧	60 ..	Ti Shui Yen coal field Littonia and Gastrioceras beds.
Kuan Ling 關嶺	120 ..	Hua Chiang Canyon, Marine Triassic ammonite.
Fa Lang 法郎	25 ..	Ammonite beds.
Yung Ning 永寧	50 ..	Ammonite beds.
Lang Tai 郎岱	90 ..	Liang Shui Chung coal field.
Tzu Chung 茨冲	210 ..	Mao Kou Schwagerina limestone beds.
Shui Cheng 水城	55 ..	Silver and iron deposits.
Pi Chieh 畢節	270 ..	

The region traversed is a high plateau from where take origin the numerous upper tributaries of the Pei Pan Kiang river running southward into the Si Kiang or West River, and the two; north and south sources of the Wu Kiang river going

---

(1) The original report was in Chinese, the English text composed by the editorial staff.  
(2) Kueichou is sometimes written Kweichow.

northeastward to the Yangtzu river in Szechuan. This western part of the Kueichou province, thinly populated and inhabited by Miaotzu tribe. It was therefore not possible to make as detailed studies as he would like to do had he been better equipped and preteched in his travelling. But even the fragmentary observations he could make may be interesting to be recorded from this previously little known region.

### STRATIGRAPHY

Among the geological formations most commonly met with in Western Kueichou we may especially notice the Permian clayey limestone beds containing the typical *Littonia* fauna. These beds are unmistakably underlaid by coal bearing series and overlaid by a compact and thin bedded limestone. But other formations are also present.

1. *Yangwu formation* (Middle Devonian)—Yangwu is a locality 90 li S. of Anshun and on the border of Tzu Yun (紫雲) district. The locality is well known for the fossil brachiopod *Stringocephalus burtini* a typical form of Givetian. Fossils were bought from the local people and the author was not able to visit the place himself.

2. *Wangchiapa limestone* (Upper Carboniferous)—This most richly fossiliferous limestone occurs at Wang Chia Pa 30 li NW of Sincheng. The fossiliferous beds are 10 meters thick, containing especially brachiopoda in the lower part and cephalopoda in the upper part. Among the cephalopoda there are nine species of Nautiloids, one species of Ammonite, and two species of Orthoceras. Among the brachiopoda, Mr. Y. T. Chao recongnized the following species:

- Productus yohi* (sp. nov.)
- Echinoconchus elegans* M'Coy.
- Echinoconchus punctatus* Martin
- Buxtonia kueichouensis* Chao (sp. nov.)
- Marginifera* sp.
- Chonetes cf. pygmaea* Loczy
- Spirifer* (*Choriatites*) *kueichowensis* Chao
- Spirifer* (*Anelasma*) *rectangula* Kutorga
- Spirifer orientalis* Chao (sp. nov.)
- (*sp. cameratus* Tchernyschew)
- Squamularia asiatica* Chao (sp. nov.)

(*Reticularia lineata* Waagen)

*Martinia* 2 sp.

*Spiriferina* 1 sp.

*Spiriferello* 1 sp.

*Camarophoria* 3 sp.

*Dielasma* 2 sp.

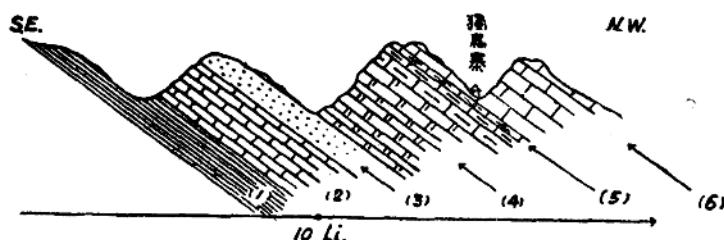


Fig. 1. Geological section showing the position of the fossiliferous horizon in the Wang Chia Pa limestone.

- (1) Variegated fragile paper shales.
- (2) Thin-bedded grey limestone.
- (3) Cross-bedded coarse sandstone.
- (4) Light greyish compact limestone.
- (5) Fossiliferous horizon (Loc. No. 1314) - Massive light grey limestone. (10 M thick?).
- (6) Unfossiliferous massive limestone.

According to Mr. Chao's opinion, this limestone can not be older than upper Carboniferous and is probably equivalent to the Waitaoshan limestone observed by Dr. V. K. Ting in Wei Ning (威寧) district situated further west.

The Wangchiapa limestone overlies, a thin coal series and a thick quartzite and slate formation. The coal series must be different from the Permian series commonly observed in Kueichou province.

3. *Maokou Schwagerina* limestone (Lower Permian) - *Schwagerina* limestone is well developed in Lang Tai and Shui Cheng district. On the two banks of the Mao Kou river 45 li SW of Lang Tai district where several hills rise up to over thousand feet, there is an anticlinal folding with one limb west of the river and the other lying at Tan Tieh Kuan 25 li NE of the river. The *Schwagerina* limestone consist of an upper part of compact black limestone very rich in fossils and a lower part of light grey thin bedded limestone. The latter is underlaid by an unfossiliferous shale. Among the fusulinidae fossils, *Neoschwagerina* and *Doliolina* are most easily recognized. Simple corals are also observed. Two li north from Tan Tieh Kuan, occurs the Middle Permian coal series containing abundant *Lyttonia*,

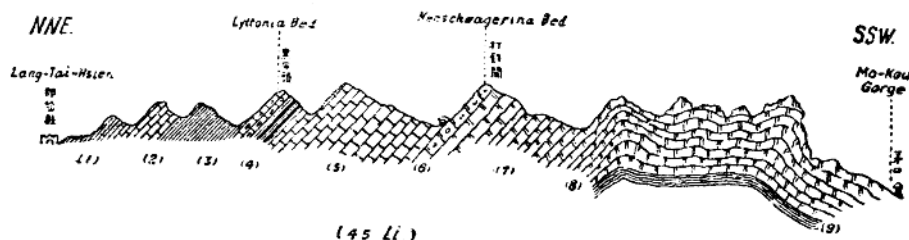


Fig. 2. Ideal section from Lang Tai Hsien to Moukou gorge. Stratigraphical Sequence.

- (1) Hard whitish quartzite.
  - (2) Dense grey limestone dipping NNE with an angle varying from 15-25.
  - (3) Brown hard shale with yellowish soft shale at the top.
  - (4) Coal series—Bituminous coal seams & sand-stone intercalated with carbonaceous shales—with *Lyttonia* bed at the top.
  - (5) Massive ls.
  - (6) *Neoschwagerina* bed (actual thickness unknown) Specimens crowded with *Neoschwagerina* were obtained from bed in situ, near a village below Ta-tieh-kwan.
  - (7) Grey massive ls.
  - (8) Dark grey massive ls. underlaid by thin-bedded ls.
  - (9) Brown and buff dislocated shales.
- (1)-(4) Chiao-tze-shan coal series Mid-Permian. (5)-(9) Mao-kou limestone Lower Permian.

the strata dip to NNE, conformable with the Schwagerina limestone above described. The latter limestone occurs at Mao Kou (茅口) and Tan Tieh Kwan (打鐵關) in the Langtai district and also Wan Fu Chang (萬佛廠) and Pou Wa (跑瓦) in the Shui Cheng district. The fossils as determined by Mr. K. H. Hsu of this Geological Survey are listed below:

Tan Tieh Kuan (Locality No. 1312 fl)

*Neoschwagerina craticulifera* Schwager

*Neoschwagerina globosa* Yabe?

*Neoschwagerina parva* Deprat

*Doliolina schellwieni* Deprat

*Doliolina lepida* Schwager

*Fusulinella inflata* Colani

*Schwagerina pseudoverbecki* Deprat

*Sumatrina annae* Volz

Wan Fu Chang (Locality No. 1313)

*Neoschwagerina craticulifera* Schwager

*Neoschwagerina globosa* Yabe

*Schwagerina douvillei* Deprat

*Verbeekina verbecki* Geinitz.

Pou Wa (Locality No. 1316)

*Schwagerina* sp.*Fusulinella inflata* Colani4. *Chiaotzushan coal series*—This series consist of three different parts:

A. The lower part is the coal bearing series *stricto sensu*. It contains six workable coal seams intercalated with yellow shale and sandy shale.

B. Overlying the coal bearing shales is the *Lyttonia* bed made up of impure clayey limestone with much weathered surface. It is very clearly stratified and cut by many vertical joints so that it can be easily recognized in the field without fossil evidence. It is only about ten meters thick at Chiao Tzu Shan 60 li north of An Shun district. The principals fossils are:

*Lyttonia nobilis**Oldhamina* sp.*Squamularia* sp.

C. Above the *Lyttonia* bed and after about fifteen meters of transition, comes a thin bedded light gray limestone which yielded at the top of the Chiao Tzu Shan hill (轿子山) *Gastrioceras liui* Grabau formerly known from the Permian of south Anhui. The same bed is found also at Tien Shui Yen (滴水岩) 10 li SE of the Chen Ning district where *Gastrioceras* fossils are more numerous and better preserved with also beautiful specimens of other fossil shells, but the rock there changes to a green shale.

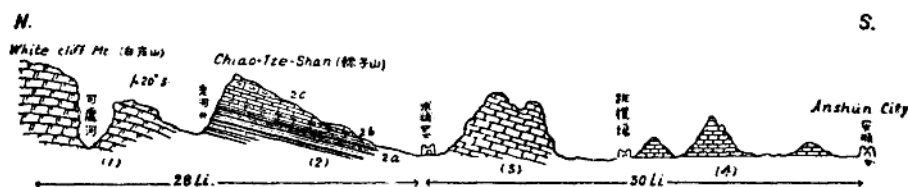


Fig. 3. General geol. section from White Cliff Mt. to Anshun city showing the unconformable relation between the An-shun Lacustrine beds & the Permian Chiao-tze-shan coal series and its overlying thin-bedded ls.

- (1) Mokou limestone (*Schwagerina*?)
- (2) Chiaotzushan coal series 2a: coal-bearing beds; 2b: *Lyttonia* Bed, 2c: *Gastrioceras* bed.
- (3) Thin-bedded limestone series.
- (4) Anshun lacustrine beds.

The Chiatzushan series is widely distributed in the western Kueichou province. Rich fossiliferous localities are Ching Shan Yao of Ching Chen district, Tien Shui Yen of Chen Ning district and Hei Shih Tou of Lang Tai district. Large coal fields exist also in Ta Ting (大定) and Chieh Hsi (or Kiensi) (黔西) districts east of Pi Chieh on the way to Kuei Yang. In fact it is beyond doubt that most if not all of the coal fields of western Kueichou province are very certainly of Permian, and it is evidently a great error of the Japanese geologists who colored this geological map of South China in giving all the coal fields of western Kueichou to Trias or Jurassic age.

Overlying the *Gastrioceras* bed is a compact dark gray limestone, very clearly bedded. But the bedding plane is often irregularly undulated like ripple marks. The relief of the undulatory surface is from one or two feet to over ten feet. This character is easily recognisable over wide area. This is probably the uppermost part of the Permian (possibly including the base of Trias?), and is equivalent of the so called "Thin bedded limestone" of the Yangtzu valley.

All the above mentioned Permian strata are widely distributed and very characteristic of western Kueichou.

5. *Sin Pu Mesozoic formation* (Trias-Jurassic)—The south-western part of Kueichou province is drained by the Pei Pan Kiang which often cut deep canyons forming very picturesque sceneries the upper course near Lang Tai is called Mao Kou Ho (茅口河) while a little lower down near Yun Ning it is called Hsiao Pan Kiang (small Pan river). It is again named Hua Kiang (flowery river) still further down near Kuan Ling district the old name of which is Mu Yu Sze (募役司).

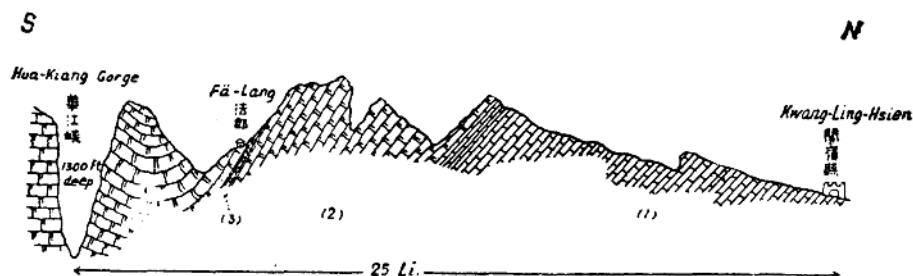


Fig. 4. General geological section showing the occurrence of the Upper Triassic *Trachyceras* bed along the Hua-kiang Gorge, near Kwang-ling Hsien.

- (1) Thin-bedded grey limestone (L. Triassic?).
- (2) Dark grey dense limestone (heavily bedded) thick.
- (3) *Trachyceras* bed—Soft yellowish and blackish shales 5 ft thick (exposed part) (Fossil Loc. No. 1308).

In each of the valleys Hua Kiang, Hsiao Pan Kiang, and Mao Kou Ho, geological sections have been made by the author and are included in the present note. A perusal of these sections, it is clear that there is much to be revised in the geological map of South China published by the Japanese Geological Society of Tokyo. What was attributed to the Lower Palaeozoic from Cambrian to Silurian in the Japanese map is now proved to be Triassic to Jurassic. What was called Carbo-Permian is now more exactly determined to be the Schwagerina limestone of Lower Permian age. The following is a short description of the Mesozoic strata we have observed:

The Mesozoic strata are well developed along Hua Kiang and Shiao Pan Kiang. The section (Fig. 5) is especially complete at Sin Pu village 30 li south of Yung Ning, and may be taken as standard section of the Mesozoic formation in South West China three successive parts may be distinguished.

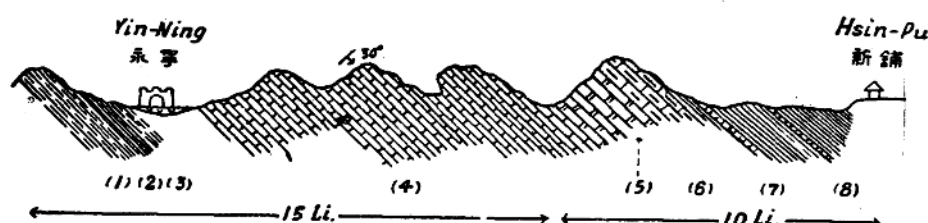


Fig. 5. Geological section from Yin-ning city to Hsin-Pu (25 li) showing the succession of the early Mesozoic beds. Geological sequence.

- (1) Unfossiliferous yellow shales.
  - (2) Gastrioceras bed—Black pyritiferous shale (Loc. 1309).
  - (3) Very hard blackish sh.
  - (4) Unfossiliferous thin-bedded limestone (thick).
  - (5) Heavy-bedded blackish tough limestone.
  - (6) Heavy-bedded dark dense limestone—Trachyceras Bed very fossiliferous (Loc. No. 1310 f1).
  - (7) Buff soft calcareous shales.
  - (8) Buff fragile calcareous shales.
- 7-8—very fossiliferous (Loc. No. 1310 f2).

The upper part consists of black hard limestone containing many beautiful specimen *Ammonites* which are under study by Dr. Y. C. Sun of this Geological Survey (Locality No. 1310 f1). The middle part gradually becomes more clayey and still richer in *Ammonites* (loc. No. 1310 f 2). The lower part is a marly shale which contains brachiopoda (loc. No. 1310 f 3) but no *Ammonites*. The whole series including all the three parts which are continuous one to the other is only fifteen meters thick. Below this is the upper most Permian limestone apparently

without interruption. It is however directly overlying the Permian *Gastrioceras* bed at Lung Sheng Miao (Temple of Dragon god) outside the city of Yung Ning.

The section of Hua Kiang is very similar that described from Sin Pu, but there several species of echinoderm have been found (loc. No. 1308). The exact age of these Mesozoic formations remain to be determined by the palaeontological studies. This is the first collection of marine Mesozoic fossils from Kueichou province.

6. *Fresh water gastropoda bed of An Shun* (Cretaceous?)—This is a light gray fine grained limestone 2-3 meters found at the top of a hill 3 li south of Tou Pu (頭舖) village which is situated at 10 li east of An Shun. The hill is 120 feet high and the occurrence of the fossil gastropoda is well known to the local people who did not fail to call may attention on. It was however difficult to obtain complete specimens. The fossiliferous limestone is underlaid by alternating white and green sandy shales, all in horizontal position with only local slight inclination. The formation is very well developed in the surroundings of An Shun is a area wide (east-west) of 100 li (from Lon Ti Siao to Yen Ti Siao) and long (north-south) of 50-60 li from Tiao Ten Chang to 20 li south of An Shun. The topography consisting of isolated cones is well characteristic. At Tiao Ten Chang, this series directly overlies Permian limestones with marked unconformity. The exact age of the series depends on the determination of the fossil gastropod. While it is temporarily taken for Cretaceous, there is wide possibility of its being of quite different age, for instance Tertiary.

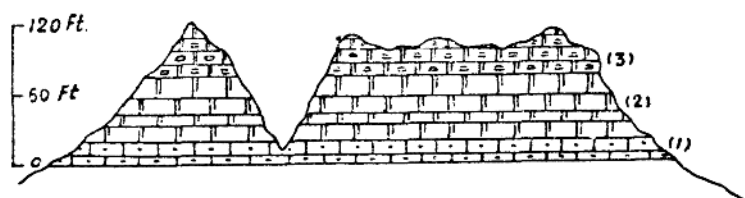


Fig. 6. Section of Lo-shi-shan in the vicinity of An-shun, showing the occurrence of the fresh-water gastropod bed of Late Mesozoic age (?).

- (1) Light green sandy shales.
- (2) Whitish sandy limestone.
- (3) Grey dense limestone gastropod bed (Loc. No. 1305)—6.5 ft.

#### MINERAL DEPOSITS.

The Western Kueichou was well known for its riches of mineral resources. The principal minerals are copper of Wei Ning, lead of Shui Cheng, realgar of Lang Tai, antimony of An Nan.



Within the area traversed by the author, the coal is the chief mineral riches while all the metallic are deposits visited by the author seems to be rather unimportant.

### COAL.

Permian coal occurs widely in Western Kueichou. The coal bearing strata of Middle Permian age always underlies the *Littonia* bed. The principal fields are described more details in the accompanying Chinese text. The following table is only a summary of the main fields:

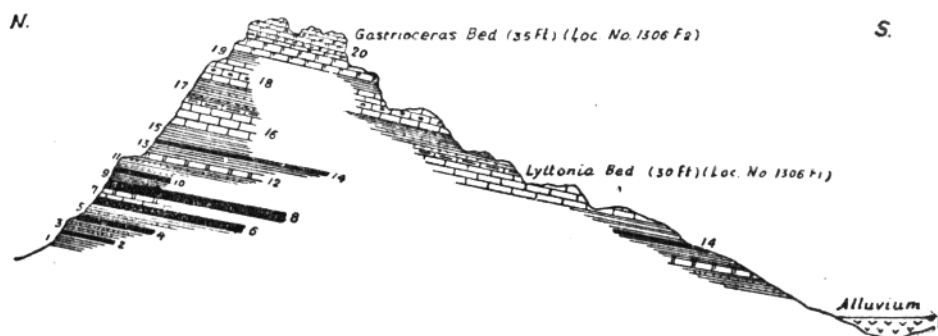


Fig. 7. Detailed section of Chiao-tzu-shan, N. of Anshun, showing the succession of the M Permian coal-bearing series.

- (1) Brown yellowish sh. (base not exposed).
- (2) 1st. coal seam (unworkable).
- (3) Buff sandy sh.
- (4) 2nd coal seam (productive)
- (5) Brown sandy sh.
- (6) 3rd coal seam (productive)
- (7) Argillaceous limestone.
- (8) 4th coal seam (productive) 4 ft.
- (9) Brown asenaceous sh.
- (10) 5th coal seam (productive).
- (11) Brown sandy sh.
- (12) Thin beds of limestone (yielding fragmentary fossils)
- (13) Buff paper sh.
- (14) 6th coal seam (unworkable)
- (15) Black carbonaceous sh. & purplish fragile sh.
- (16) Weathered impure shaly ls. with *Lyttonia* bed at the top 30 ft.
- (17) Yellow sandy sh.
- (18) Dark limestone with pyritiferous concretions.
- (19) Deep yellow hard sh.
- (20) Massive ls. at the lower, thin-bedded at the top *Gastrioceras* bed, 35 ft.

Coal Field	District	No. of coal seams	Thickness	Extension	Coal
Ching Shan Yao	Ching Chen	3	1-2 ft	15 li	Bituminous
Chiao Tzu Shan	An Shun	6	2-4 "	100	"
Tieh Shui Yen	Chen Ning	3	2-5 "	—	"
Hei Na Kung	Lang Tai	12	2-20 "	25	Bituminous
Hsia Siao	Yung Ning	3	—	30	"

Ta Ting probably very extensive.

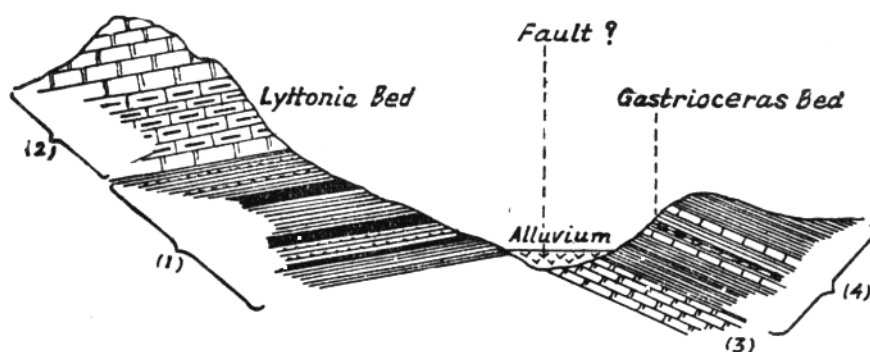


Fig. 8. Section of the Permian coal series at Ti-sui-yen in the vicinity of Cheng-ning Hsien.

- (1) Coal seam with intercalated grey shales 10 m.
- (2) Argillaceous impure limestone with *Lyttonia* bed 9 m.
- (3) Argillaceous impure ls.
- (4) Purplish fragile shales with calcareous intercalations & *Gastrioceras* bed at middle. 8 m.

The coal fields in the Ta Ting district is probably the most important in the area visited. The native mining industry produces annually over 60,000 tons of a good bituminous coal in large lumps. Next in importance is the Chiao Tzu Shan field. It is very extensive although the annual output is only less than 2,000 tons. The coal is a high rank bituminous easily produced in large lumps.

## SILVER

Silver ores are known from Kien-si (Chieh Hsi) and Shui Cheng districts.

The best known deposit is that of Wan Fu Chang 25 li south of Shui Cheng. Argentiferous galena occurs in massive form in fissure veins in association with calcite. The latter mineral is often well crystalized but becomes more and more reddish colored as it approaches the metallic ore. The country rock is the Permian limestone which becomes crystalline near the metalliferous veins. The ore

contains in average 2-3 per thousand silver and sometimes 5 per thousand according to the experience of the native miners. The veins occur within an area of not more than twenty square li in two prominent hills each over 200 feet high.

The Wan Fu Chang Silver Mines was very prosperous in the Chien Lung period (17-18th Century) when, according to the local tradition, there were several tens of thousand miners working at over hundred places. The ore was smelted with the coal of Hsia Kou situated not far away. It is said that at that time the smoke from smelting plant polluted so much the air that birds could not fly over. Four main mines can be still observed at present, called respectively Yen Tzu Tung, Hao Lung Tung, Fu Lu Tung, and Ta Hsia Hsien. Yen Tzu Tung is the largest. It is 50 feet high, 30 feet large, and over 100 feet long. Hua Lung Tung was crumbled down once killing over 200 people at work. This once prosperous mining center was badly destroyed by the Miao Tzu rebellion, till now the silver mining and smelting have never been revived.

Other silver deposits in Shui Cheng are Pai Ma Tung and Kuan Yin Shan which the author could not find time to visit.

Generally speaking, Western Kueichou should be considered the region most hopeful for silver deposits are so scarce in other province. It is certainly worth while of more systematic prospection.

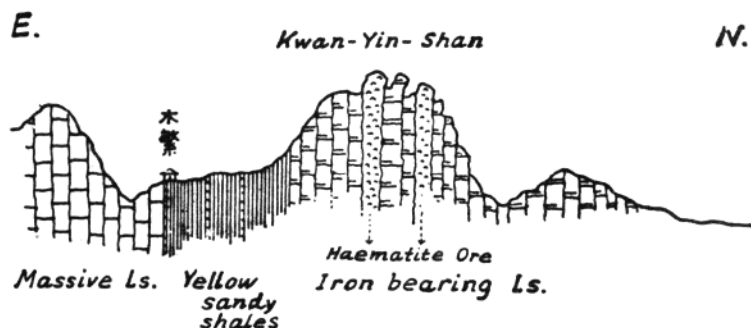


Fig. 9. Section of Kuan Yin Shan iron ore deposit.

## IRON

Of the several iron ore deposits visited, the relatively more important one seems to be that of Kuan Yin Shan 50 li east of Shui Cheng. Two main veins of quite pure hematite ore occur in a dark gray limestone containing white calcite veins. The hematite veins being more resistant to erosion, form parallel ridges of the hills extending over two li. One of the veins is 20 feet thick at its main part,

the other is thinner. The ore is now worked in small scale by a dozen miners in open quarry and smelted at Hua Yu Tsin near Shui Cheng city with charcoal. The pig iron is sold to Lang Tai and An Shun

#### REALGAR AND ORPIMENT

Lang Tai produces the best realgar and orpiment of Kueichou province. It is mined at Sin Chang 40 west of Lang Tai. The arsenic sulphides occur in association with calcite in a dark gray limestone. There are several varieties of the arsenic minerals. The mineral-transparent and of orange yellow color is called Hsiung Tsin (雄精) and corresponds to realgar while that light yellow and not transparent is more abundant although the two are generally associated. The production has decreased since the last twenty years. The annual output is now only some thing like over three thousand catties. The price at Shanghai has fallen from 17-18 taels to only 2 taels for one catty.

#### ASBESTUS

Asbestos is produced at Kuei Chih Ho in Shui Cheng district in large sheets of 3-4 feet diameter, yellow white, very flexible. The locality being too remote from the main road has not been visited.

# GEOLOGICAL RECONNAISSANCE OF SOUTHERN KUEICHOU.

By S. S. YOH.

With 2 text-figures

## ITINERARY.

The Southern Kueichou province was traversed by the author by instruction of the Geological Survey of China from 9th March to 3rd April 1928 along a total distance of 600 li. The district along the road are the following.

Kuei Yang 貴陽	Distance
Lung Li 龍里	70 li
Kuei Ting 貴定	70 „
Tu Yun 都勻	132 „
Tu Shan 獨山	120 „

The road goes first from Kuei Yang eastward to Kuei Ting, thence it turns in average SSE ward till the frontier of Kuangsi province.

## TOPOGRAPHY

While the North and West Kueichou is very mountainous and rugged, the south Kueichou has a much gentler relief although also quite hilly. The hills often rise not more than 600 feet such as Nang Chai (南寨) of Tu Yun and Yun Ting Kuan (雲頂關) of Lung Li. Deep gorges canyons are not common, the topography is therefore in a more mature shape.

## STRATIGRAPHY.

The essential difference in the Southern Kueichou stratigraphy from the North and West parts is that the *Lyttania bed* and its overlying limestone gradually dies out on the south while the flinty limestone becomes better developed. The following is a description of the principal series.

1. *Chiennan series*—This is a name to cover two main formations widely represented in South Kueichou.

A. *Mangshan quartzite* (Silurian? or Devonian)—Mang Shan is a prominent hill 560 feet high in Tu Yun district. It is made up by a quartzite formation. The lower part of the quartzite is red colored by iron oxide, but the iron content gradually decreased upward until the quartzite becomes pure white in the top part of the formation. The rock is fine and uniform grained compact and hard. The

bedding is very clear with N-S strike, dip to E at  $55^\circ$ . The exposed part of the formation has a thickness of 700 feet but the lower part is not exposed. On the east of the hill, some traces like compound corals have been observed on the top of the quartzite formation. Above this horizon immediately comes a gray limestone 40-50 feet thick containing fossil Ostracods in its upper part.

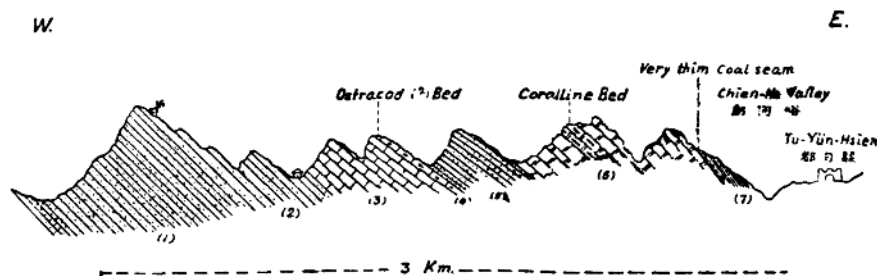


Fig. General geological section of Mang Shan near Tu Yun Hsien.

- (1) Reddish quartzite.
  - (2) White quartzite.
  - (3) Grey platy ls.
  - (4) Dark greyish massive limestone with Ostracod bed at the top.
  - (5) Various well-bedded quartzites.
  - (6) Dark flinty limestone with typical Coralline bed.
  - (7) Brown hard shales with very thin coal seam at the base.
- (1) - (5) - Mang Shan quartzite series.  
 (6) - (7) - Hsia Ssu flinty limestone series.

Above the Ostracod bed is again a quartzite about 100 feet thick with alternating red white layers. These formations constitute long parallel ridges on the east of Mang Shan.

The Mang Shan quartzite formation extends on the west bank of Chien Ho (劍河) river over several tens li in N-S direction. Another area where this formation is observed is at Yen Chai (沿寨) 30 li S.E. of the city of Tu Shan. The quartzite is there cut by a small stream to give a 100-200 feet deep canyon. Other outcrops are found scattered between Tu Yun and Kuei Ting, and between Tu Yun and Tu Shan.

The geological age of the Mang Shan quartzite was believed to be Carboniferous, but according to the researches carried out in other provinces especially in Hunan it may be much earlier, Silurian or more probably Devonian.

B. *Hsia Ssu flint limestone* (Lower Carboniferous)—This formation occurs over wide area from Tu Yun to Nan Chai (南寨) on the border of Kuangsi province. It is characterized by its reddish color, high hardness and containing abundant

black flinty concretions. The total thickness has not been measured, it is at least twice as much as that of the Mang Shan quartzite.

The flinty limestone can be again divided into two main parts. The lower part is better developed in the surroundings of Tu Yun while the upper part more so in Hsin Ssu and Tu shan.

East of Mang Shan near Tu Yun, the hard flinty limestone directly and conformably overlies the Mang Shan quartzite. The limestone contains fossil corals such as *Michelinia*, *Fistulipora*, *Lonsdaleia*, *Amplexus* etc. *Fusulinidae* and *Productadae* are occasionally found. At another locality 50 li N. of Hsia Ssu, the limestone of very similar character has yielded *Michelinia*, *Fistulipora*, *Syringopora* (*ramulosa?*) and *Chaetetes*. A little distance 4-5 li north of the mentioned place, occurs a limestone containing brachiopoda fossils among which is *Kansuella yunnanensis* Loczy. This horizon seems to be higher than the coral bed and flint become more scarce. The geological age of the Hsiassu limestone is no doubt equivalent to the Chihhsia stage in lower Yangtzu according to the fossils above mentioned.

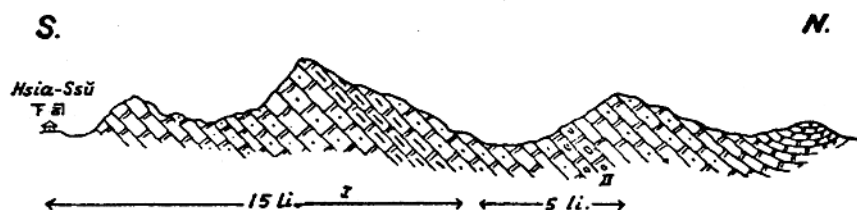


Fig. 2. Section showing the succession of the Hsia-ssu flinty limestone.

- (1) Coralline bed with *Syringopora*, *Michelinia*, *Fistulipora*, *Chaetetes* etc. (30 ft in thickness).
- (2) Limestone bed characterized by *Kansuella yunnanensis* (10 ft in thickness).

2. *Hsuanchiaping coal series* (Middle Permian)—Coal is being produced at Siao Tung (蕭洞) and Hsuan Chia Ping 5-6 li north of Kuei Ting. There are only two coal seams in the lower part of a dark colored limestone. The latter is very compact and hard and yielded at its upper part several specimens of *Oldhamia* but *Lyttonia* was not found. Notwithstanding this apparent difference the formation still belongs to Middle Permian. The rock character also is however different from the contemporaneous formation is north and western Kueichou. The coal seams also become gradually thinner southward and the sulphur content higher. Permian coal no more exists in the Tu Yun district and further south. Wood become the main fuel, and very few people there burn coal.

3. *Poumuchung thin bedded limestone* (Permo-Triassic)—The author had already occasion to report on the existence of a thin bedded compact limestone of pretty good thickness above the *Gastrioceras* bed in Western Kueichou. This limestone was believed to be of Uppermost Permian or Permo-Triassic age.

The limestone contains petroleum at Pou Mu Chung between Kuei Yang and Lung Li. The upper part of the oil bearing limestone contain marine fossils which are not yet determined. But from the stratigraphic evidence its age can not be otherwise than later Permian or early Triassic. The same thin bedded limestone occurs over more than 100 li extending from Tu Yun Kuan (圖雲關) 10 li south of Kuei Yang to Ma Sang Chung (馬桑冲) of Kuei Ting district passing by Lung Li. It gradually disappears south from Kuei Ting.

#### MINERAL RESOURCES.

Among the mineral deposits reported below, only the antimony deposit of Yen Chai of Tu Shan district and the Pou Mu Chung oil field east of Kuei Yang have examined by the author himself; the conditions of the other deposits are reported from local informations.

1. *Coal fields*:—Permian coal is produced by native industry from several localities of Lung Li and Kuei Ting districts in very small amount. Coal of Lower Carboniferous age in Tu Yun and Tu shan district is of bad quality and in thin seams. It is not worked.

2. *Pou Mu Chung oil field*:—Described in a separate paper.

3. *Iron ore deposits of Tu Yun*:—Four deposits are known from S, SE. and W. of the city of Tu Yun.

4. *Lead ore deposits of Tu Yun*:—Two localities are known on the N. and S. of the city.

5. *Silver ore deposit of Tu Yun*:—Some silver ore occurs 20 li west of the city of doubtful quality.

6. *Antimony deposit of Yen Chai*:—Antimony ore occurs at Ta Chia (大甲) near Yen Chai (沿寨) 30 li SE. of the city of Tu Shan district. From the city to the locality is developed a white quartzite formation cut a 200 feet deep gorge by a small river. The communication to the city is therefore difficult. The metallic ore occurs in the hills 250 feet high, 3 li long and heavily covered by trees. Stibnite often occurs in prismatic aggregates in association with calcite in numer-



ous irregular veins. The larger veins are over 10 meters long, 1-2 meters broad and 7-8 meters deep. Before 1924, the antimony deposits were worked by Tou Fu Lien company with \$5,000 capital. About 80,000 catties of ore were produced and the more was smelted in crude antimony sold to Cantonese merchants at the price of \$8.00 per picul of crude antimony. That company was however soon disorganized. There remain still several thousands of catties ore at the mines.