

Topography and Geology of Fu-chien Province

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I. Topography

The Fu-chien Province is located on the southeastern coast of China and comprises a few mountain ranges that trend from northeast to southwest. The general topography shows a step structure which is high in the west and low in the east where the land faces the sea. The coast shows a ria shoreline. In summary, the province belongs to what Li Ssu-kuang called the "folded mountainland", and closely resembles in topography the southern region of Che-chiang Province.

The longest river of this province is the Min Chiang which flows in the northern central part of the province, and traverses, nearly at right angles, the mountain ranges which trend from northeast to southwest. Hence, its tributaries run from northeast to southwest or from southwest to northeast, parallel to the mountain ranges.

II. Mountain System

The Hsien-hsia-ling Mountains which form the provincial boundary between Fu-chien and Chiang-hsi and run from northeast to southwest are called the Wu-i Mountains in the southern region, and the Feng-ling Mountains in the Che-chiang borderland. The eastern part is called the Yen-tung-shan Mountains.

Hsien-hsia Ling, the main peak of the Hsien-hsia-ling Mountains, rises on the boundary of three provinces, Chiang-hsi, Che-chiang and Fu-chien. In the south in the neighborhood of Chiao-ling, a branch range trends in a north-south direction. In the area between Pu-cheng and Chung-an there are many peaks such as Hsin Ling, Tou-chu Ling, Yang-yuan Ling, Ku-chu Ling, Shuang-ting Ling and Wu-chia Ling, but their heights are only 500 to 900 m above sea level. Wu-i Shan is located southwest of Chuang-an Hsien, and its southern extension is called the Wu-i Mountains which branch out into two parallel ranges, one stretching from Tung-an-kuan northeast of Shao-wu Hsien and the other stretching from Chou-ssu-ling southwest of Shao-wu Hsien, with the river Fu-tun-chi in between. The southeastern end of the mountains reaches Nan-ping and Shun-chang.

The Wu-i Mountains in the neighborhood of Kuang-tse have several peaks,

namely, Niu Ling, E Shan and Hsiang-ya Feng in the west, Chiu-lung Feng in the south, Shang-kao Shan in the east, Ching-yun Feng and Chin-ling Shan in the north, and Ku-y Ling in the northeast. The height of the last peak is more than 1,000 m above the level of Kuang-tse Hsien.

On the west and south borders of Shao-wu Hsien there are peaks called Chiao-feng Shan, Pai-hu Shan, Yun-chin Shan and Kao-po Ling, and at Tai-ning is found the Ta-shan Feng. A branch range rises north of Ning-hua Hsien and extends northeast, and near the border of Chien-ning Hsien it further branches into two ranges, one trending east-northeast and the other trending southeast, with a peak called Pi-chia Shan. Northwest of Kuei-hua it branches again into three directions; one branch continues to trend southeastward and reaches west of Nan-ping, passing through the northern part of Kuei-hua. The Wu-i Mountains diverge into two systems south of Ning-hua. One of the systems, which raises the peak Ching-chun Shan northwest of Chang-ting, runs between Chang-ting and Lien-cheng and diverges again a southeast range south of Lien-chang; the southern extension of this range is called the Po-ping-ling Mountains which form a watershed of the Chiu Chiang, Chiu-lung Chi and Min Chiang. The other range diverges in the south of Lien-cheng, runs east-northeast, and branches again in the northeast of Nin-yang; one branch runs north-northeast and ends on the south bank of the Min Chiang north of Yu-chi, and the other crosses the Tsai-yun-shan Mountains south of Ta-tien and reaches the coast of Chang-lo by way of Yung-chun and Te-hua prefectures. In the southwestern corner of the province the Wu-i Mountains diverge into two ranges, one extends to Wu-ping and the other to Chang-nan.

Moreover, there are the Tung-kung-chiu-feng Mountains on the north bank of the Min Chiang, which runs from east of Ching-yuan of Che-chiang Province to the south, and diverges at Tung-kung Shan which is located north of Ping-nan; one branch reaches the Min Chiang and stands opposite the Tai-yun Mountains beyond the river, while the other branch further diverges at the Shuang-chi Shan, both parts running southeast, and one ends in the east of Fu-chou and the other ends on the coast southeast of Ning-te.

III. Drainage System

The Hsien-hsia-ling and Wu-i Mountains, which bound Fu-chien and Chiang-hsi provinces, form watersheds for the two provinces. There are few large rivers in Fu-chien except for the Min Chiang. The drainage area of the Min Chiang is comparatively wide and constitutes two-thirds or more of the whole areal extension of the province.

The watershed between the Min Chiang and other rivers is the mountain range which diverges from the Chang-chun Shan, southwest of Ning-hua, and reaches Chang-lo, passing south of Lien-cheng and north of Ning-yang and running between Te-hua and Yung-chun. In the area south of this watershed are found

three small river systems, namely, the Chiu Chiang, the Chiu-lung Chiang and the Lan Chi. The watersheds of these rivers are the Po-ping-ling Mountains and the southern Tsai-yun-shan Mountains.

A. MIN CHIANG

The uppermost drainage of the Min Chiang consists of the following three streams: The Chien Chi, which originates in Chien-ning-fu and flows down to Nan-ping after gathering the Nan-pu Chi, the Chung Chi and the Tung Chi; the Shao-wu Chi, which joins the Fu-tun Chi and the Chin Chi at Shuan-chang and reaches Nan-ping and the Sha Chi that rises in Chang-chiang-fu and reaches Nan-ping after gathering many small tributaries.

The main stream joins the above-mentioned three rivers and flows eastward, then it gathers the Yu Chi and the Ku-tien Chi and turns toward southeast. At the Min-hou-cheng delta, it diverges into two distributaries, the Nan-tai Chiang on the north and the Tao Chiang on the south, and after gathering these rivers it separates again until it pours into the sea.

The volume of the river water differs by season, extremely decreasing in winter and increasing in summer when the current becomes so swift that the navigation is very difficult. However, the water in the lower reaches below Nan-ping is abundant in all seasons and the current is gentle. The total length from the mouth of the river to the upper reaches of the Chien Chi is said to be 568 km.

1. *Chien Chi*

The upper drainage of the Chien Chi is composed of three headwaters. The stream on the west is called the Chung Chi and takes in the water from the Wu-i Shan in Chung-chi Hsien, and flows southeastward meandering through Chien-yang and Chien-ou, then it joins the Tung Chi; the central stream is called the Pu Chi which takes in the water from the Hsien-hsia-ling and runs southward from Pu-cheng and then joins the Chung Chi at about 2.6 km east of Nung-lo-chieh; the one on the east is called the Tung Chi which accepts the water from the west slope of the Chiu-feng Mountains and runs northward to Cheng-ho, turns south and joins the Chung Chi at Chien-ou.

2. *Shao-wu Chi*

The Shao-wu Chi has two tributaries. The Fu-tun Chi on the north gathers the Hsi Chi and the Pei Chi of Shao-wu-fu, and flows southeastward until it reaches Shun-chang; the other consists of the Ning Chi and the Chih-hu Chi that originate in Ting-chou-fu and join in the southwest of Chiang-lo, and flows eastward to join the above-mentioned Fu-tun Chi at Shun-chang.

3. *Sha Chi*

The Sha Chi gathers the waters in the south of Ning-hua, and flows eastward and then to the southeast at Ching-liu. It joins the Wen-chuan Chi which comes from the southwest, and flows eastward until it joins the Yen-shui Chi in the west of Yung-an where it turns to the northeast. Then, after joining the Fang Chi at Kung-chuan, the Ta-chi Chi at Shui-lou, the streams north and east of Kuei-hua

several miles west of Sha-kou, and the Hsi-hsia-shui south of Sha-kou, it flows northeastward and enters Sha Hsien.

B. CHIU-LUNG CHIANG

The Chiu-lung Chiang is also called the Lu Chiang and comprises the north and south tributaries which join at Chiang-tung-chiao east of Lung-chi.

The north tributary rises in Lung-yen-chou, and joins such streams as the Chiu-peng and the Lei Chi (Fei Chi) in the north and the Chih-wang Chi in the south. It passes Chang-ping and reaches Hua-kou where it joins the Chi-nan Chi from the north, and turning to the south, it reaches Chiang-tung-chiao. The west tributary has three headwaters; the Kao-shan Chi which comes from Ping-ho on the southwest, and Leng-shui Chi which flows in the central part, and the Yung Chi and the Ho Chi from the northwest. These three streams join in the west of Nan-ching, and after passing through Chiang-chou it joins the north tributary at Chiang-tung-chia.

C. CHIU CHIANG

The Chiu Chiang belongs to the upper reaches of the Han Chiang, and originates in the Chiang-chu Shan north of Chang-ting. After passing through Lung-men, and the Chang-ting castle, water of the river comes so abundant that it is navigable by big boats of several thousand pounds (in Chinese weight). Farther south, the river joins many streams such as the Hsi Chi, Huang-feng Chi, Cho-tien Ho, Yang-chueh Chi, Hsiao-lan Ho and Lien-cheng Ho, and enters Kuang-tung Province.

IV. Sea Coast

As already mentioned, the coast of Fu-chien Province shows the ria-type subsiding topography and abounds in sinuations, so there are many ports. Among the numerous bays, San-sha Bay, Fu-chou Bay and Hsia-men (Amoy) Bay are especially noticeable as they are large enough for the anchorage of big ships. Other and minor bays are Sha-cheng Chiang (Kang), Fu-ning Bay, Hsing-hua Bay, Ping-hai Bay, Mei-chou Bay and Chuan-chou Bay. There are also numerous islets along the coast, attaining 599 in number. The principal ones are the Hsi-tan Island and the Chin-men Islands (Amoy and Quemoy), the former covers an area of 290 km² and the latter about 124 km².

Each bay has a plain on its west stretching almost northeast. The relationship between the bays and the plains is as follows:

- | | |
|----------------------------|-------------------|
| 1. San-sha Bay | Fu-an Plain |
| 2. Mouth of the Tai Chiang | Lien-chiang Plain |
| 3. Fu-chou Bay | Fu-chou Plain |
| 4. Hsing-hua Bay | Hsing-hua Plain |

- | | |
|-------------------------------|-------------------|
| 5. Chuan-chou Bay | Chin-chiang Plain |
| 6. (Montane basin) | Yung-chun Plain |
| 7. Wei-tou-ou | An-hai Plain |
| 8. Ku-an Channel | Tung-an Plain |
| 9. Chang-chou Channel | Chang-chou Plain |
| 10. Mouth of the Chang Chiang | Yun-hsiao Plain |

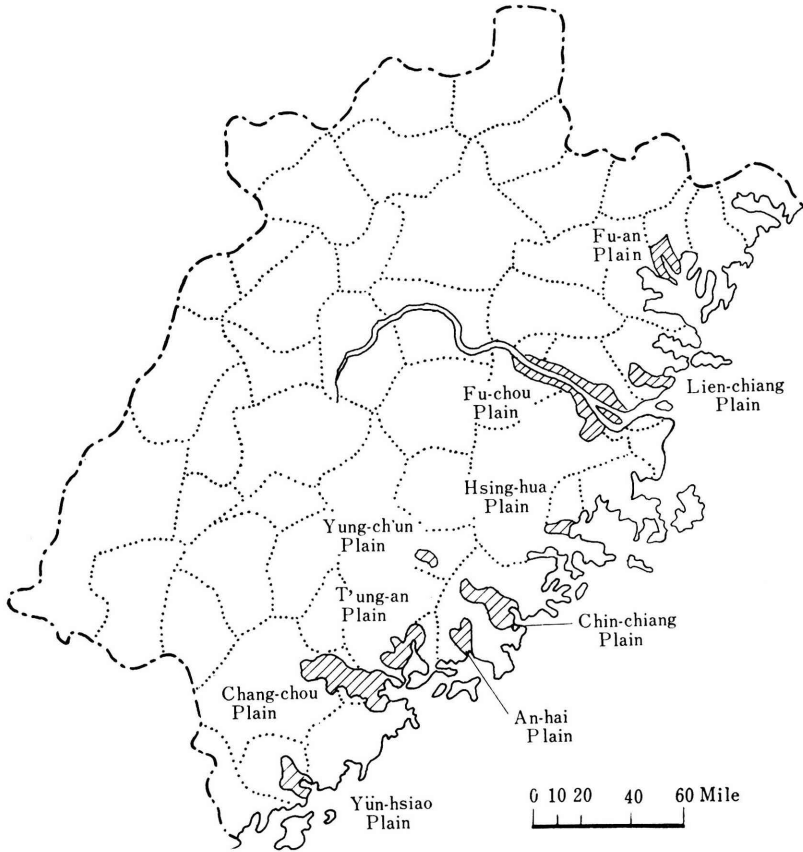


Fig. 1. Distribution of coastal plains of Fu-chien province.

V. Geology

As the geology of the province has not been surveyed to a satisfactory extent, it is impossible to describe it in detail. However, the existing reports present some very interesting facts. I could refer to only a few reports but they are reliable enough to be used as the basis of a geologic study of the province.

In the north and east coastal regions, no strata corresponding to the Lower

Paleozoic, i.e., Cambrian to Devonian, have been discovered as yet, while in the southwestern part of the province, namely, the prefectures of Shang-hang, Lien-cheng, Chang-ting, Ning-hua, Ching-liu, Kuei-hua, Yung-an and Sha-hsien, the existence of the whole Paleozoic formations, though intermittently, was reported by S. W. WANG. No fossils have been found in the Cambrian to Devonian formations, so the formations were lithologically correlated chiefly with the groups in Che-chiang Province. T. F. HOU, Y. L. WANG and C. C. CHANG maintain that the formations which were correlated with the Cambrian to Devonian by S. W.

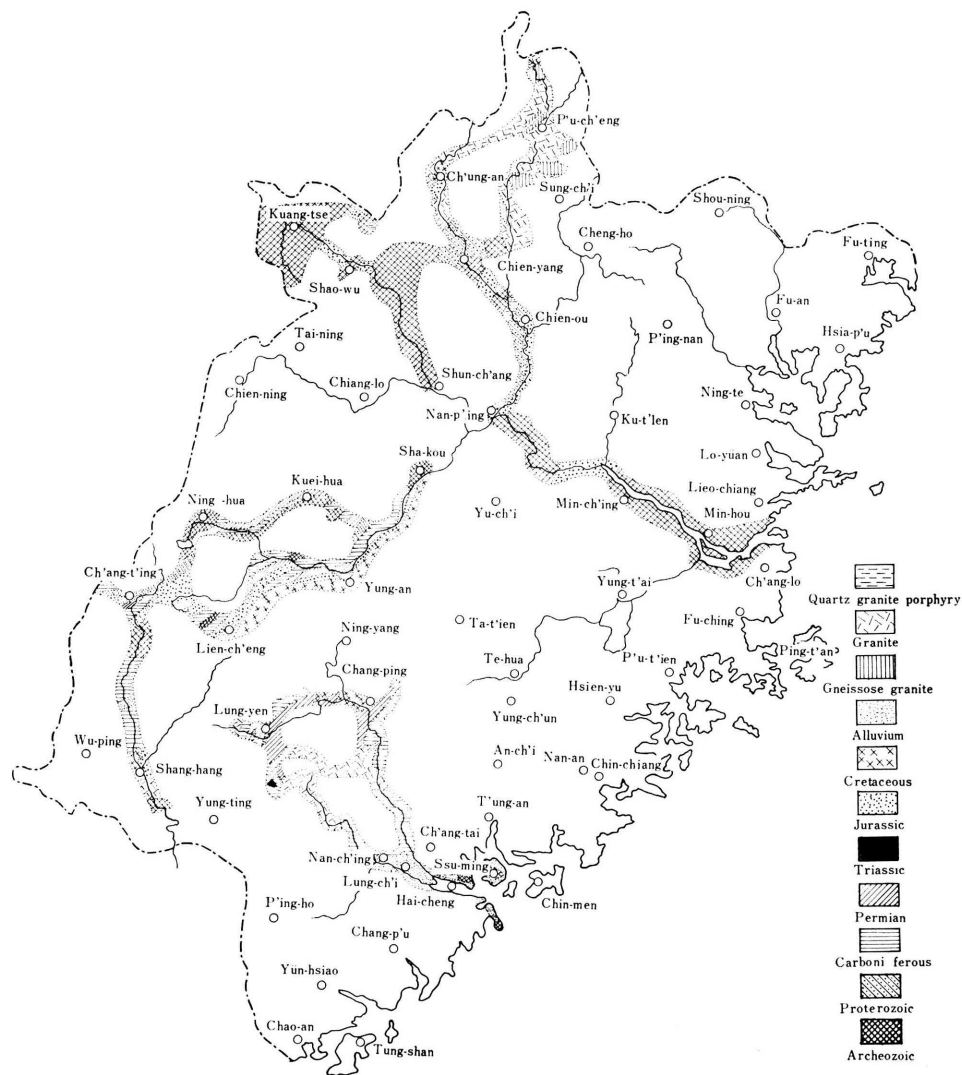


Fig. 2. Geological map of Fu-chien province.

WANG should be Carboniferous in age. Unfortunately, I have no data to judge these two opinions, so I introduce here both theories and discuss the age of the formations in the section on geologic history.

A. ARCHEAN GNEISS

The distribution of the Archean gneiss is comparatively wide, stretching over the Shan-kuan-ling Mountains on the border between Chiang-hsi and Fu-chien provinces, as well as in the area between Chien-yang and Chien-ou and in the prefectures of Chang-ting, Ning-hua and Sha-hsien.

In the Shan-kuan-ling Mountains, it is called the Shan-kuan series and is composed chiefly of granitic gneiss, pegmatitic gneiss and mica gneiss, markedly intercalated with igneous intrusive bodies. The gneiss exposed in the southwestern area, that is, Lien-chang, Chang-ting and Ning-hua, is called the Hu-mang-tung gneiss. The rock character of this gneiss is the same as that of the Shan-kuan gneiss, although the former is not intruded by igneous rocks.

B. PROTEROZOIC CRYSTALLINE SCHIST

The Proterozoic crystalline schist is correlated with the Lin-chuan series which is exposed in Lin-chuan Hsien of Chiang-hsi Province. It is composed chiefly of schist, often associated with gneiss and phyllite. In the area covering Nan-ping and Tsai-tou, a white marble, with a light greenish yellow or pink tint, is well developed, alternating with quartzite and crystalline schist. It is occasionally associated with small igneous intrusives. In the southwestern region, which includes Ning-hua (or Lung-ti), Yung-an (or Pu-tou), Sha-wu-tang and Chang-ting (or Shang-tu-li), a chlorite schist, corresponding to the Proterozoic crystalline schist, is exposed. It is called the Lung-ti schist.

C. CAMBRIAN (CARBONIFEROUS?) FORMATION

This formation is not distributed in the northern and eastern parts of the province, and is found only in the southwestern region. The type locality is Nan-tien-pu, 13.2 km east of Chang-ting, where the formation is called the Nan-tien-pu formation. The lower part of the formation is composed chiefly of volcanic tuff or breccia, and the upper part is a complex of dark sandstone, pale green shale, and fine-grained sandstone. The distribution is limited only in Nan-tien-pu of Chang-ting, and its western area including Niu-wei on the east flank of the Ta-ling-ai—Ku-mang-tung geanticline. Since no fossils have been found in this formation, the geologic age is not determined as yet, but S. W. WANG lithologically correlated it with the Tao-shui-wu formation of Che-chiang Province.

D. "ORDOVICIAN" (CARBONIFEROUS?) FORMATION

This formation also is not found in the north and east regions of the province. Its occurrence is reported in the southwest region, but it was confirmed not by fossils but by lithology which S. W. WANG correlated with the Yin-chu-pu series

and the Yen-wa-shan series of Che-chiang Province. WANG named the former the Chi-kou formation and the latter the Lo-feng-chi phyllite.

1. *Chi-kou Formation*

The lower part of this formation is composed of black shale and black earth, intercalated with coal seams; the middle part consists of impure platy limestone, and the upper part consists of laminated sandstone, phyllite, etc., but the outcrops are very few. The coal seams in the lower part are correlated with the coal in the Yin-chu-pu series of Che-chiang Province and their age is thought to be Lower "Ordovician."

The area of distribution is comparatively limited, and the formation is exposed between Lo-feng-chi and Ta-ling-wei of Yung-an, and at San-chien-nao of Chang-tien.

2. *Lo-feng-chi Phyllite*

The Lo-feng-chi phyllite is exposed in the area 2 km northwest of Yung-an and An-hsi, in the Yu-hua-hsia gorge and Lai-fang, at Chung-ting, and at Tsao-hsieh-ling and Tsui-feng, northeast of Ching-lin. The formation is composed entirely of phyllite, and the lowermost part is grayish green while the upper part is generally purplish. No fossils have been found in this formation, but from the lithology and from the fact that the formation overlies the Chi-kou formation, it is correlated with the Yen-wa-shan formation of Che-chiang Province. The geologic age of the formation was assigned by WANG to Middle Ordovician.

E. "GOTLANDIAN" (CARBONIFEROUS?) FORMATION

The formation was named the Yang-ku-luan shale by S. W. WANG and was tentatively assigned to the Gotlandian age. The formation consists of yellowish green sandstone that is slightly schistose, resembling the Feng-chu shale of Che-chiang Province. The formation is distributed in the area between Tzu-chin-shan and Shui-kou in the drainage basin of the Chiu Chiang and in the prefectures of Ching-liu and Kuei-hua.

F. "DEVONIAN" (CARBONIFEROUS) FORMATION

By the lithologic character this formation is divided into two parts; the lower part is chiefly sandstone and the upper part is siliceous sandstone. S. W. WANG named the lower part the Niu-wei sandstone and the upper part the An-sha siliceous sandstone. While the distribution of the former is very narrow, the latter is widely distributed.

1. *Niu-wei Sandstone*

This formation is well developed on the east and west flanks of the Hu-mang-tung geanticline and consists chiefly of sandstone. It is divided into upper and lower parts. The lower part is hard, compact, somewhat siliceous, grayish green, and at the bottom intercalated with a bed of purple sandstone. The upper part consists of micaceous sandy shale or sandstone, and the color is grayish green which becomes reddish when weathered. This formation is correlated with the

Chien-li-kang sandstone of Che-chiang Province and is supposed to be Lower Devonian in age.

2. *An-sha Siliceous Sandstone*

As already mentioned, the distribution of this sandstone is fairly wide, spreading from Mei-li-sha-kou of Sha Hsien to south of Ching-lin and north of Yung-an, and reaching both flanks of the Hu-mang-tung geanticline. It also occurs in the area between Tzu-chin-shan and Shui-kou of the Chiu Chiang basin. The rocks constituting the formation are chiefly siliceous sandstone and siliceous conglomerate, the former predominates in the upper part and the latter becomes predominant in the lower part.

Since no fossils have been found the exact geologic age cannot be determined, but S. W. WANG opines that it probably corresponds to the upper Chien-li-kang sandstone and is Upper Devonian in age.

G. CARBONIFEROUS FORMATION (according to T. F. HOU, Y. L. WANG and C. C. CHANG)

The beds belonging to the Carboniferous formation are widely distributed in the southern part of the province, but are more restricted in the north. The beds are known as the Nan-ching quartzite group and are often metamorphosed by intrusion of granites. From the lithology the beds can be divided into three parts.

The lower part consists chiefly of thick white and pink quartzite, intercalated with thin shale, and is distributed in the area north of Fu-nan along the Pei Chi and in the area upstream of Nan-hsi along the Hsi Chi.

The middle part consists of shale, schist, clay slate and quartzite; it is well developed near Sha-kuan along the Pei Chi, and at Shui-wei and Hsi-shan between Yung-fu and Lung-yen.

The upper part is an alternation of gray and black sandy shale, coaly shale and siliceous sandstone, and crops out at Hsi-ling of Shui-wei, Lung-yen, and in Pi-chien Shan of Lung-men.

According to T. F. HOU, Y. L. WANG and C. C. CHANG, this formation belongs to the Carboniferous period and includes S. W. WANG's Chi-kou formation, the Lo-fang-chi phyllite, the Yang-ku-luan shale, the Nin-wei sandstone and the An-sha quartzite. The Carboniferous Tzu-shan coal series is not exposed in the province.

H. PERMIAN FORMATION

The Permian formation is comparatively well developed in the southeastern region of the province. It is divided into the Hsi-hsia flinty limestone, the *Gigantopteris* coal series, the Tsao-yuan limestone and the Nu-lou limestone. The Fei-lai-feng limestone of Nan-ping is correlated with the Hsi-hsia flinty limestone.

1. *Hsi-hsia Flinty Limestone*

Outcrops of the Hsi-hsia flinty limestone are generally sporadic, seldom continuous, and the thickness varies from several meters to 100 m. Lithologically the

limestone is pure, fragile and laminated. The lower part is gray and the upper part is black. The limestone contains flint concretions. The localities of the limestone are as follows: Tieh-shih-yang of Lung-yen, Lung-yen-tung, north of Shih-chung, south of Tsao-yang of Chang-ping Hsien, Tsao-yen of Yung-an Hsien and west of Lien-cheng.

2. *Gigantopteris* Coal Series

All coal measures in southern China, such as Lo-ping, Hsuan-ching, Lung-tan, Lai-pa-kou and Lao-hu coal series, are correlated with the *Gigantopteris* coal series. Although they may somewhat differ in the mode of deposition, they usually contain fossils of *Gigantopteris*. The distribution of the coal series is wider in the southeast, and the known localities are the Lung-yen region, the eastern and southern Chang-ping Hsien and the Hua-an region. At Lung-yen this series consists of shale and sandstone and is intercalated with coal seams, the thickness of which varies by places but usually between 0.5 and 1.6 m. Locally the coal seams thin out entirely.

3. *Tsui-ping-shan* Shale

This is a series of shale and sandstone, overlying the *Gigantopteris* coal series. The type locality is Tsui-ping Shan east of Lung-yen. The lower part consists of greenish gray or yellowish brown shale, intercalated with sandstone; the upper part is rich in thinly-bedded sandstone and poorer in shale.

Generally the fossils are found in the lower part. The fossil fauna is locally marine and locally fresh-water. Plant fossils are also found though on rare occasions, which suggests that this series is a shallow water deposit.

I. TRIASSIC? FORMATION

The Yang-ping shale is thought to be Triassic in age, but because of the poorly preserved fossils contained therein it is difficult to determine the exact geologic age. The shale crops out at Yang-ping west of Shih-chung of Lung-yen Hsien and on the west coast of Sung-hsu. The shale is yellowish brown, reddish brown, red or greenish gray, and is intercalated with thin sandstone. The shale is sometimes calcareous. Most of the fossils are marine bivalves, but fragments of fossil plants are occasionally found.

J. JURASSIC FORMATION

The Jurassic formation is widely distributed in the north and southwest regions of the province. In the north it is divided into three groups which are called the Li-pi-chiao, Chung-jen and Jung-shan formations.

1. *Li-pi-chiao* Formation

This formation is developed comparatively widely in eastern Chiang-hsi Province. It consists of shale and sandstone; the former is thin muddy black or gray shale intercalated with coal seams, and the latter is gray or grayish white fine-grained sandstone. According to S. W. WANG, the Tung-tzu-yen coal series exposed west of Yung-an and Lien-chang is correlated with this formation, and

consists mainly of brown coarse-grained sandstone intercalated with black shale which contains a coal seam more than 1 m thick.

2. *Chung-jen Formation*

This formation corresponds to the upper part of the Jurassic coal-bearing formation and consists of sandstone and shale, rarely intercalated with conglomerate. Occasionally quartzite intercalated with metamorphosed shale is observed to be developed very well. There are several coal seams, whose thickness ranges from 16 cm to 3.53 m. Coal is locally metamorphosed into graphite. The formation is distributed in Shao-wu, Chien-ou, Nan-ping and Min-ching. In the vicinity of Kuei-tou between Lien-cheng and Chang-ting is found the Kuei-tou sandstone which is correlated with this formation by S. W. WANG.

3. *Jung-shan Formation*

This formation overlies the Jurassic coal-bearing formation and does not contain coal seams. It consists of white or grayish white coarse-grained sandstone alternating with reddish brown or greenish gray muddy shale. However, very few beds corresponding to this formation are found in the province. As the Yen-fang tuffaceous sandstone, named by S. W. WANG, is supposed to be Upper Jurassic in age, it may be correlated with the Jung-shan formation.

K. CRETACEOUS FORMATION

The Cretaceous formation corresponds to the Wu-i formation in the north and to the Kuan-chai red sandstone in the southeastern part of the province, as well as to the Nan-cheng formation of Chiang-hsi Province. It is widely distributed in the Chung-an—Chih-shih-chieh region, the Chang-tai region south of Shao-wu, Kuan-shai of Lien-cheng, and also at Shang-kan, Cheng-peng-yen and Chih-mien-shan of Yung-an. The formation consists chiefly of red sandstone, locally intercalated with conglomerate and shale.

L. TERTIARY FORMATION

S. W. WANG studied a red soil and an orange-yellow soil in the southwestern part of the province, and correlated them with the red soil of North China which is believed to have been formed in the Tertiary period. The soils are more than 20 m thick and are fine-textured and very plastic.

M. QUATERNARY FORMATION

The Quaternary formation includes clay, soil, sand and gravel, as well as lacustrine and fluvial silts of recent deposition. They are unconsolidated, and the thickness is usually several to ten meters, very rarely exceeding 50 m.

N. IGNEOUS ROCKS

The distribution of igneous rocks in the province seems to be very extensive, but due to the incompleteness of the geological survey it is very difficult to know even

an outline of the distribution. On the whole, the presence of granite, quartz porphyry and olivine basalt has been confirmed.

1. *Granite*

There are two kinds of granites. One is salmon pink, fine equigranular in texture, and partly grades into granite porphyry. Its distribution is quite wide, and the greater portion of granite in the province belongs to this kind. The other kind is hornblende granite of narrower and later intrusion than the former. The two kinds of granites are distributed in the following areas; Pu-cheng, Chien-ou and Chung-jen in the north, Chang-chou, Yung-fu, Chin-shan and Hsiao-chi west of Lung-yen in the southeast, Chang-fang-tan and Che-tan south of Shang-kou in the southwest.

2. *Quartz Porphyry*

The quartz porphyry is seen to have intruded in many places in southern Fu-chien Province. In the area between Amoy and Chung-fang it intrudes the granite and the Mesozoic shale, and forms a great intrusive body extending NE-SW along the coast. The rock also intrudes the Nan-ching quartzite between Nan-ching and Lung-shan, and intrudes the granite at Yung-chi, Pa-yao and Ching-yang. The intrusion of this rock can be seen also at Chien-ou and Kuang-tse in the north. The time of intrusion seems to be somewhat later than that of the granites and nearly contemporaneous with that of the Cretaceous igneous rocks.

3. *Olivine Basalt*

The olivine basalt occurs as dikes or sheets in the southern region. The constituent minerals are plagioclase, augite, hornblende and mica, accompanied by olivine and magnetite. There are no traces of intrusion of this rock into granites or into rocks older than Early Mesozoic.

VI. Useful Minerals

As mentioned already, Fu-chien Province belongs to the southeastern coastal folded region, and is markedly intruded by the Yen-shan granite and other igneous rocks. Nevertheless, occurrence of useful minerals is very poor in comparison with other provinces. As the known metallic ore deposits there are iron ore, silver-lead-zinc ore, molybdenum ore and cobalt ore. Nonmetallic ore deposit is represented by coal.

A. IRON ORE DEPOSITS

There are two kinds of iron ore deposits in the province, magnetite and placer. In the mode of occurrence, the magnetite ore deposits are grouped into the following four types:

1. Occurring in the Proterozoic gneiss and schist.
2. Occurring in the Paleozoic limestone, sandstone and shale.
3. Occurring in the Mesozoic sandstone and shale.

4. Occurring in granite.

Deposits of type 1. are found at Hui-tou-shan in Fu-ching prefecture, and at Lao-fu-shan and Hou-men-shan in Pu-tien prefecture. The type 2. deposits are known at Chen-ti in An-chi prefecture, Lo-yang in Hua-an prefecture, Tsao-tsin in Chang-ping prefecture, and Ta-pao-lin in Lung-yen prefecture. Deposits of type 3. are found at Pan-tien in An-chi prefecture, and the type 4. deposits at Tan-lin of Lung-chi prefecture.

Placer iron deposits and the so-called Fu-chien iron sand are found at Sung-yuan-tsun of Chien-ou prefecture, Hsu-tsun of Pu-tien prefecture, and Huang-ken of Kuei-chou prefecture.

B. SILVER-LEAD-ZINC ORE DEPOSITS

Most of the silver-lead-zinc ore deposits are of epithermal or mesothermal origin. They are distributed in the following prefectures; Min-hou, Chien-chiang, Ku-tien, Ping-nan, Fu-an, Shou-ning, Hsien-yu, Yung-chun, An-chi, Te-hua, Ta-tien, Ning-hua, Lien-cheng, Lung-yen, Ping-ho, Lung-chi, Fo-cheng, Sung-chi and Cheng-ho. They usually occur as veins penetrating quartz porphyry, and are found also in sandy metamorphic rocks, shale and limestone, though on rare occasions.

C. MOLYBDENUM ORE DEPOSITS

In the molybdenum-yielding area between Ta-kou and Chiao-keng of Yung-tai prefecture, the igneous complex consisting of tuff, agglomerate, porphyrite and rhyolite is widely distributed. In the area between Pu-pi-tsun and Chiao-keng, an intrusive body of the Yen-shan granite is found. The granite is accompanied by veins of pegmatite and quartz which contain molybdenum. In the vicinity of Pu-pi-tsun are found important molybdenum localities, namely, Li-pi-keng, Chiao-keng, Ssu-chien-keng and Ku-ling-keng, all being located not far from the granite.

1. *Li-pi-keng*

This locality is about 1.3 km northwest of Pu-pi-tsun. Details of the ore deposits are unknown, but judging from the waste scattered around an old pit, the molybdenum is fine-grained or is composed of radially aggregated crystals. A coarse-grained granite is exposed in the neighborhood, suggesting that the granite is the country rock of the ore veins. Pyrite is found as an accessory mineral.

2. *Chiao-keng*

This is located at about 6.6 km north of Pu-pi-tsun. There are no outcrops of the ore deposits, but judging from the waste of the previous year's mining the greater portion of the ore occurs in pegmatite and part of it occurs in quartz veins.

3. *Ssu-chien-keng*

This is at about 1.3 km southeast of Chiao-keng-tsun. The area is composed of fine-grained granite intruding the igneous complex. There are some outcrops of pegmatite which, however, does not contain much molybdenum.

4. *Ku-ling-keng*

The locality is about 6.6 km north of Pu-pi-tsun. The country rock is fine-grained granite containing much muscovite. Molybdenum in this area is not worthwhile mining.

In addition to the above four localities, occurrence of molybdenum deposits is known at Tsao-keng, Su-keng and Tao-keng, where the country rocks are pegmatite and quartz veins.

Geologic Correlation of Fu-chien Province

Era	Period	East region	Southwest region	
Cenozoic	Recent	Alluvium		
	Quaternary	Sand and gravel		
	Tertiary	Red soil, sand and gravel Liu-huei-sha basalt	Red soil formation	
Mesozoic	Cretaceous	Tou-tou igneous rocks Pei-sha red sandstone and shale	Kuan-chai red sandstone	
	Jurassic	Jung-shan formation	Yen-fang formation	
		Chung-jen formation	Kuei-tou sandstone formation	
		Li-pi-chiao formation	Tung-tzu-yen coal series	
Triassic	Yang-ping shale			
Paleozoic	Permian	Tsui-ping-shan shale	Hu-kou coal series	
		<i>Gigantopteris</i> coal series	Tsao-yuan limestone	
		Hsi-hsia flinty limestone		
	Carboniferous	Nan-chin quartzite		
	Devonian	\	An-sha siliceous sandstone	
			Hui-wei sandstone	
	Gotlandian		Yang-ku-luan shale	
Ordovician	\	Lo-feng-chi phyllite		
		Chi-kou formation		
Cambrian		Nan-kou-pu formation		
Proterozoic		Lin-chuan System	Lung-ti schist	
Archeozoic		San-kuan System	Hu-mang-tung gneiss	

D. COBALT ORE DEPOSITS

Cobalt ore deposits are found in the neighborhood of the Weng-yao Shan and Ta-chi-pien in Fu-an prefecture. The country rock is usually quartz porphyry(?), but due to advanced weathering the rock is decomposed and the cobalt ore occurs as large lumps, 2 to 3 inches in diameter, scattered in the soil. In the Li-chia valley of Ching-lin prefecture and in the Chiang-fang region, cobalt-manganese ore is found and its country rock is rhyolite, unlike the former type.

VII. Geologic History

In the north and southeast regions of the province, the Cambrian to Devonian rocks are entirely absent. In the west region, however, S. W. WANG identified strata of all stages of the Paleozoic era. On the other hand, T. F. HOU, Y. L. WANG and C. C. CHANG correlated S. W. WANG's Nan-tien-pu formation, Chi-kou formation, Lo-feng-chi phyllite, Yang-ku-luan shale, Niu-wei sandstone and An-sha siliceous sandstone with the Nan-ching quartzite and assigned them to the Carboniferous age. Should the correlation be correct, it is inferred that no deposition of the beds ranging in age from Cambrian to Devonian took place in this region, or that such beds were deposited but were eroded away completely. At any rate, the geologic history of the Cambrian to Devonian period remains unknown due to the absence of corresponding strata. However, it is evident that intrusion of igneous rocks took place after the deposition of the San-kuan series and again after the Lin-chuan series which underlies the Nan-ching series. An exact age of intrusion cannot be determined. The igneous intrusion was supposed to have been followed by diastrophism called the Caledonian folding, but no beds corresponding to the movement are found in the province, making any inference impossible. With the presence of the Nan-ching quartzite, it is evident that terrestrial deposition took place beginning with the early part of the Lower Carboniferous period. Moreover, the Middle Permian transgression resulted in the deposition of the Hsi-hsia flinty limestone. It was succeeded by the regression which accounts for the terrestrial *Gigantopteris* coal series and the neritic Tsui-ping-shan shale. During the Triassic period no conspicuous changes may have occurred; for instance, the Triassic beds at Yang-ping-tsun contain bivalve fossils, and those at Shih-chung contain similar fossils and also fragments of plant fossils. After the deposition of the Triassic Yang-ping shale, there occurred the so-called Yen-shan movements which extended from Jurassic to Late Cretaceous, resulting in the NE-SW folds. In the Middle and Late Tertiary, faulting took place and caused the gentle tilting of the land. Then, the period of diluvial and alluvial deposition began.