THE IRON DEPOSITS OF SOUTHERN ANHUI*

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CONTENTS

I. INTRODUCTION.

It is well known that iron deposits of the contact metamorphic type are widely distributed along the lower Yangtze valley, about which the monograph of Dr. Tegengren[1] has given us detailed informations. Of particular interest is the iron deposits of southern Anhui; they are represented by a great number of types and are distributed in a region which tectonically and metallogenetically is characteristic enough to form a single unit by itself.

* This is a preliminary note; complete report will be published as memoir by the Geological Survey of China.

The geographic distribution of the iron deposits of southern Anhui and a part of S. W. Kiangsu is shown in fig. 1. It can readily be seen that the iron districts form almost a continuous belt bordering the great Yangtze River and approximately parallel to it. This iron belt could be extended much further toward southwest to include the deposits of central Hupeh or toward north or northeast to include the deposits in Honan, Shantung and Northern Kiangsu.

Although the majority of opinion seems to favor a contact metamorphic origin for most of the deposits along the Lower Yangtze, recent study, especially supplemented by detailed microscopic examination, shows however that this is by no means true. It was Mr. L. F. Yih,[2] who first laid emphasize on the hydrothermal origin but his classification of the iron deposits into too many types is in fact not necessary.

In the spring of 1931, while sent by the Ministry of Industry and the Geological Survey of China to investigate the possibility of obtaining iron ore supply from S. Anhui for the establishment of a new blast furnace at Pukow, Mr. C. C. Sun and the writer had occassion to re-examine practically all the iron deposits of the said province. Detailed geological maps and sections of different fields were prepared and a great number of minerals and rocks collected for microscopic study. With these new data at hand, the writer is thus able to arrive at certain conclusions which will be discussed in the following pages.

The writer wishes to acknowledge his best thanks to Mr. C. C. Sun for his assistance in the field work; to Messrs. H. S. Wang and S. W. Wang, the writer is indebted for their assistance and criticism in laboratory investigations.

II. THE ECONOMIC ASPECTS OF THE DEPOSITS.

The iron deposits of southern Anhui are all located S. of the Yangtze River; their distance from the river port varies from a few kilometers to 20 km. or more. Already, a number of modern mines with modern equipments have been opened up at Tawashan, Nanshan and Lopushan in Tangt'u and Ch'anglungshan in Fanch'ang.

The total iron ore reserve of S. Anhui has been estimated by Dr. Tegengren at 15,375,000 tons. His estimate was based upon very conservative assumptions, especially in regard to the vertical extension toward the depth. Present investigation has shown that some of the deposits like Tawashan, Nanshan and Ch'anglungshan, a much deeper extension can in fact be assumed. With this new idea, the reserves of some of the deposits were re-estimated which are given as follows:

	Total Reserve
Tawashan	3,188,800 tons (net reserve of pure ore)
Nanshan	2,984,000 „ („ „ „ „ „)
Ch'anglungshan	4,645,600 „
T'ungkuanshan	5,000,000 „
Chikuanshan	4,000,000 „

The ore is composed of hematite and magnetite with some limonite. The iron content varies from 53%—65%; the best kind is found at Nanshan, where 60% iron being the average. The ore of Tawashan is fairly rich in iron, but it is too high in phosphorus which varies from 0.6—1.4%. Both the ores of Hsiaokushan and Chungshan are high in silica and phosphorus. This is due, as will be explained later, to the presence of abundant chalcedony with inclusions of minute crystals of apatite. The same kind of mineral association is found in the ore of Fenghuangshan near Nanking.

At present only four companies, the Paohsing, Fuliming and Ihua in Tangt'u, and Yüfan in Fanch'ang, are in operation. Their output for the recent three years is listed as follows:

Name of Company	Location	Production		
		1928	1929	1930
Paohsing Co. (since 1917)	Tawashan & Tungshan	62,433	149,607	124,983
Fuliming Co. (actual Mining since 1930).	Nanshan	———	———	80,000
Ihua Company.	Lopushan Huangmeishan etc.	———	———	———
Yüfan Company. (since 1918)	Ch'anglungshan	112,390	120,000	120,000

Up to 1930, a total of about 800,000 tons including the production from the exhausted open cut at Pinghsienkang, has been turned out by the Paohsing Co. The Ihua Company is at present not working, but formerly it had produced

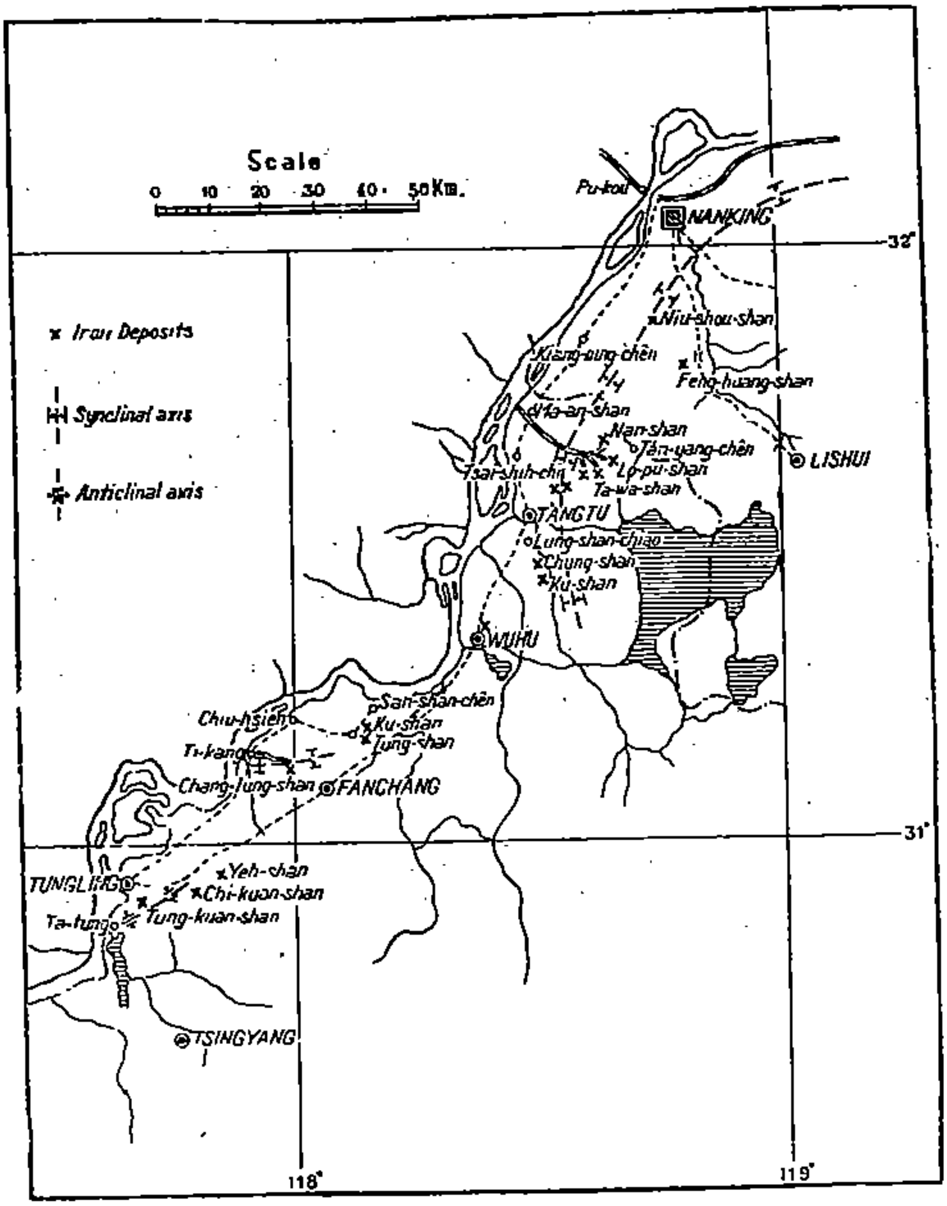

Fig. 1. Sketch showing geographic distribution of Iron Deposits in Southern Anhui & South-western Kiangsu. Compiled by C. Y. Hsieh. (1931).

not less than 260,000 tons from the deposit at Huangmeishan and several others. The Yüfan Co. has produced since 1918 a total of 3,500,000 tons. Thus we can see that a grand total of 4,560,000 tons of iron ore has already been supplied from the iron deposits of S. Anhui.

III. THE TANGT'U IRON DISTRICT.

This district comprises the iron deposits lying both in north and south of the Tangt'u city. The northern field is at present more important and includes the deposits of Tawashan, Nanshan, Lopushan and many others. In the southern field, the deposits of Hsiaokushan and Chungshan are evidently the most important, but until now they have not yet been actually mined.

(1) *General geology:* The northern field is a mountainous region characterised by maturely dissected hills with Huangshan, 260 m. above sea level, as the highest peak. The geological formation consists essentially of volcanic tuff, agglomerate and rhyolite of probably Cretaceous age. Into these is intruded numerous dikes, apophyses or irregular bodies of dioritic porphyry, which, as will be discussed later, forms the mother rock of the iron deposits.

On the western bank of the Yangtze river in the vicinity of the town Tsaishichên, there occurs a series of escarpments near Maanshan and Tsaishihchi which on the whole forms a narrow range trending approximately in the north-south direction. This range lies about 15 km. west of the ore bearing district. The range is composed of purple shale, sandstone, conglomerate and quartzite, formerly believed to be of Siluro-Devonian age, but now by comparing with the fairly well studied section at Chungshan near Nanking, a Triassic to Jurassic age has been tentatively assigned and to which the name Tsaishih formation is herewith proposed. This correlation is further supported by structural considerations to be discussed later.

Broadly speaking, the northern field including the escarpment along the Yangtze River, forms structurally an elongated syncline with a slight pitching toward the southwest. The escarpment just mentioned forms the western limb, whereas the southern border of the region, a well shaped range called under various names as Weipingshan, Lungwangshan or Changshan, constitutes the eastern or southeastern limb of the syncline. In this southern range, sedimentary rocks probably equivalent to part of the Tsaishih formation are found.

As the volcanic series has been extensively altered, and in some cases badly jointed and fractured, it shows only on rarest occassions its original bedding and succession. However, a few of such outcrops have been noticed; near Tamakuts'un on the western limb, the volcanic series (here of tuff and rhyolite) shows a dip toward east, while near Lungchiashan and Niangniang-miao along the railway track, a beautiful exposure of volcanic series dipping flattly toward S. W. is distinctly shown.

The synclinal structure above described has a wide extension; toward north it seems to be connected with the syncline between Chungshan and Chinglungshan near Nanking, whereas toward south the same structure appears to continue as far as to Wuhu. I propose here to call this important structure, the Ningwu syncline; i. e. a syncline connecting between Nanking and Wuhu.

The southern fields is characterized by numerous isolated hills scattered in the alluvial plain. Some of the hills as T'iaoyushan, Hsiaokushan, Chung-shan etc. are iron bearing. These hills are made up largely of purple shale, conglomerate, sandstone etc. of the Tsaishih formation which is intruded at several places by dioritic dikes or apophyses. The strata trend as a whole from north to south, dipping toward east at 30°—60°.

(2) *Ore deposits:*—A number of iron deposits has been discovered in Tangt'u districts; only the following will be described in the present paper.

(a) *The Tawashan iron deposit:*—This deposit is now being worked by the Paohsing Mining Company. It is mined by open cut where three levels have been opened up. The top of Tawashan is about 140 m. above the adjoining valley.

The entire hill is formed by dioritic porphyry which has been extremely altered and appears now in most cases as a soft and plastic clay in which reticulated veinlets of limonite are abundantly penetrated. The ore deposit occurs either in veins or reticulated veinlets or in irregular bodies of replace-ment origin.

The principal vein is found on the top of the hill, striking from northeast to southwest. The length of the vein, so far as can be traced on the surface is about 300 m., while its thickness, varying greatly from place to place, is on the average about 50 meters. As can be seen from a number of exposures, the vein maintains generally a steep dip, so that great extension toward the depth may

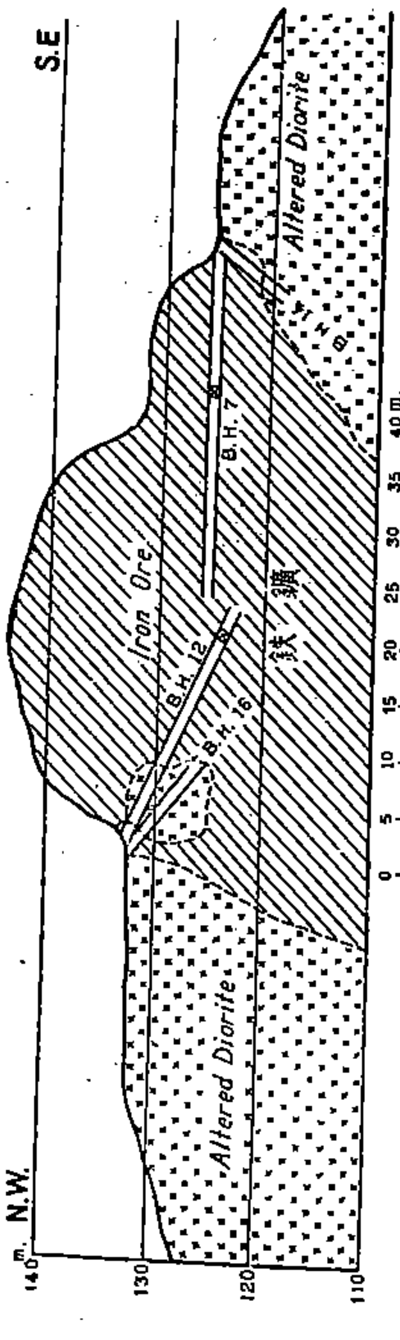

Fig. 2. Section across the Tawashan iron vein (central portion) (Modified after F. R. Tegengren).

be expected (Fig. 2). The ore is principally hematite with very little gangue matter.

Two minor veins, one occuring to the north and the other to the south of the principal vein are found. The northern minor vein strikes approximately in the same direction as the principal one, while the southern vein has a different direction in its strike. They are composed also mainly of hematite.

Besides the ones mentioned above, there occurs a great number of small veins, some of them are quite regular in shape. The ore is mainly magnetite with abundant gangues of apatite and a peculiar serpentine, provisionally idenitfied as jenkinsite, the latter being an alteration product of actinolite. Intimate association of apatite and magnetite resembling graphic intergrowth is frequently observed. Veinlets or pockets of radiately arranged prismatic jenkinsite are abundantly present either in the ore body itself or cutting across it. Fig. 3 shows a sketch of the vein and its associated gangue mineral.

b) *The Nanshan iron deposit*:— Tananshan and Hsiaonanshan are two adjoining hills located about 2 km. north of Tawashan. The highest point on Tananshan has an elevation of 100 m. above the sea level. The claim is owned by the Fuliming Mining Co., which began mining operation since 1929 and has already turned out quite an appreciable quantity of ore.

The principal vein, 350 m. long and about 40 m. thick striking approximately in east-west direction is found on the southern slope of Tananshan not far from the summit. The vein thins out gradually toward east and from there, a small separated ore body begins to appear at 20 m. north of the principal one. On the top of Hsiaonanshan, about 100 m. south of the principal vein, there occurs another vein, about 100 m. long and 40 m. wide; its strike changes from northeast to southwest.

The outcrop can be seen at several of the open cuts, one of which shows a volcanic agglomerate replaced by iron ore but the former still maintains dis-

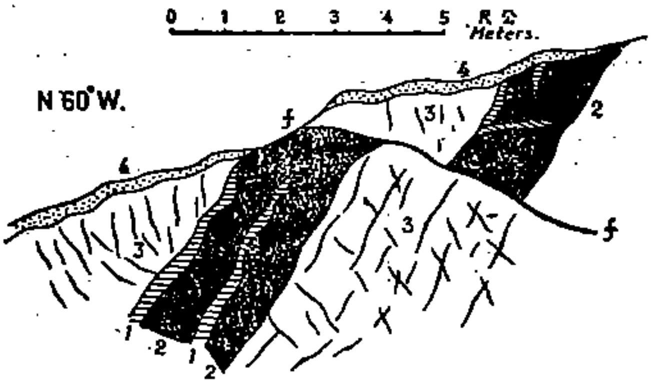

Fig. 3. Section of a high temperature vein at Tawashan with (1) Veinlets of Jenkinsite (altered from Actinolite), (2) Magnatite-apatite-jenkinsite ore, (3) Altered diorite with network of limonite, (4) Soil.

tinct stratification dipping at 45° toward S. 10° W. On the southern slope of Hsiaonanshan, volcanic tuff is seen to dip 50° to S. 15° E. Outcrops of diorite are found only at a few places, as in the vicinity of Hsiaotitangt'sun and on the road between Tangt'u and Chaishan. These outcrops are already three or four hundred meters away from the iron vein.

The above observations are enough to show that the iron vein of Nanshan occurs actually in the volcanic series, and was formed by replacement of either the volcanic tuff or agglomerate. In all respects the ore body seems to form a regular bed dipping toward south at about 40° (Fig. 4). Should this be the case, the possible extension of the ore body in depth would be quite considerable. This important assumption can only be confirmed by future drilling.

The ore consists mostly of hematite of good quality; it averages 60% in iron, being very low in phosphorus. Microscopic examination of the ore specimens shows frequently the existence of a small amount of magnetite together with casts of a formerly prismatic mineral, which has now been entirely altered to an aggregate of quartz.

c) *The Lopushan iron deposit:*—Lopushan lies between Tawashan and Nanshan. The claim is owned by the Ihua Company, the latter has worked the deposit in 1922-1923 with a production of about ten thousand tons of ore. At the time of investigation, the working has been entirely stopped.

The geology of Lopushan consists of a circular body of diorite intruded in the volcanic series. Numerous veins or veinlets of iron ore are found both in the diorite and in the volcanic tuff. According to their occurrence and mineral association, the iron deposits of Lopushan can be divided into four types as follows :—

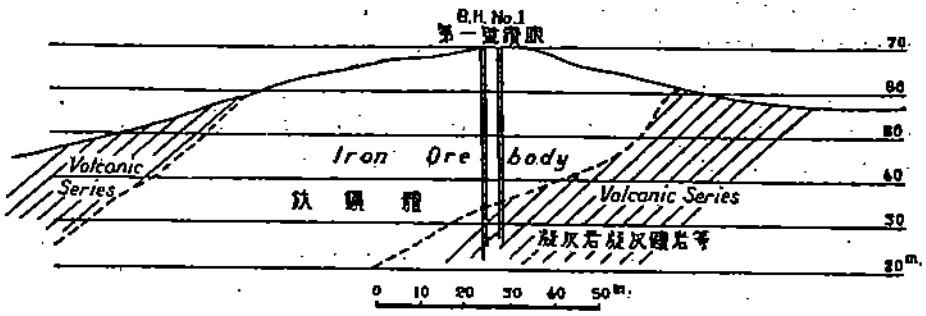

Fig. 4. Section of the Nanshan main ore body. (Modified after Tegengren).

(1) Fine aggregates of magnetite, apatite and jenkinsite (Pl. I, Fig. 1) forming irregular replacement bodies in an exceedingly altered diorite.

(2) Altered diorite extensively replaced and filled in by hematite, forming a brecciated rock, clearly of dissolution origin.

(3) Hematite veins of regular shape, 4 m. or more in width, occurring either in altered diorite or cutting across the magnetite aggregates. The vein is faulted and displaced at the southern end of the Lopushan open cut.

(4) Reticulated veinlets of hematite and limonite irregularly scattered in the altered diorite.

From the fact that hematite veins cut across the fine aggregates of magnetite and jenkinsite, it follows clearly that the latter type of deposit must have been formed before the former one. This conclusion agrees perfectly well with what has been observed at Tawashan.

d) *The iron deposits of Chungshan, Hsiaokushan etc*: — These deposits are located south of the Tangt'u city, therefore they belong to the southern field of the Tangt'u iron district. Economically speaking, the deposits of Hsiaokushan and Chungshan are the most important, while the other hills represent merely local concentration of no great value.

The geology of Chungshan consists of purple shale and breccia of the Tsaishih formation, into which is intruded several bodies of dioritic porphyry. The distribution of iron ore is irregular and scattered. Roughly speaking there occurs two principal ore bodies on the northern slope of the hill, all having a length of about 120 m. and a width of 50-60 m. On the western slope several minor ore bodies are found.

The ore is composed exclusively of hematite with apparently little gangue mineral. Microscopic study of crushed ore by immersion method reveals, besides quartz grains, a great number of small, rod-like apatite crystals similar to those found at Hsiaokushan to be described later.

Takushan and Hsiaokushan (marked Kushan in fig. 1) are two connected hills about 30 m. above the adjacent plain. The eastern hill is called Hsiaokushan and is composed almost entirely of iron ore, which is rather siliceous and of low grade. Close study reveals frequently the inclusions of pebbles or boulders of diorite or purple shale, the latter often showing a brecciated structure.

The ore is a mixture of massive hematite and well crystallized specularite, the latter forming sometimes drusy fillings or veinlets. Drusy fillings of well crystallized quartz are also frequently observed. Intimately mixed with the ore is abundant chalcedony and some quartz. Chalcedony shows the usual fibrous or cryptocrystalline forms often exhibiting spherulitic extinction. A great number of small rod-like crystals of apatite is abundantly present as inclusions in the chalcedony (Pl. I, Fig. 4). In some specimens, thin veinlets of barite are occasionally found; as they cut across both hematite and specularite, they represent beyond doubt the latest mineral formed in this region.

(3) *Chemical composition of the ores*: A great number of chemical analyses of the Tangt'u iron ores is available, a few of which is reproduced here for comparison. The following table shows clearly that the iron ore of Nanshan is the best which contains on the average 60% in iron and is low both in phosphorus and silica. The Tawashan ore is exceptionally high in phosphorus which can easily be explained by the presence of apatite. Both the iron ores of Chungshan and Hsiaokushan are very siliceous and fairly high in phosphorus; these are evidently due to the gangue mineral, chalcedony, and its inclusions of rod-like crystals of apatite.

	Fe%	Mn%	SiO_2%	P%	S%	Cu%
Tawashan	55.28	——	9.51	0.68	0.29	——
,,	64.09	——	6.33	0.545	0.04	——
Nanshan (c)	61.96	0.16	5.26	0.15	0.14	0.018
,, (E)	62.18	0.18	4.80	0.195	0.014	0.04
,, (W)	61.46	0.13	3.95	0.294	0.224	0.018
Lopushan (higher grade)	62.13	——	6.60	0.318	——	——
Lopushan (low grade ore)	45.70	——	24.40	1.454	——	——
Chungshan	59.76	0.180	8.24	0.150	0.229	——
Hsiaokushan	50.48	——	20.45	0 214	0.058	——

(4) *Hydrothermal alteration of the country rock:* One of most conspicuous features of the iron deposits of Tangt'u is the extensive alteration of the country rocks which have now been changed into a kind of soft, porous, and sometimes plastic mass. Both the volcanics and the intrusives have suffered the same alteration and some times both of them have been so changed that a sure discrimination between the two is practically impossible. Generally speaking, the alteration is more intense in the vicinity of the iron veins, and it becomes less so in regions away from them. Thus at Tamaokuts'un and at Niangniangmiao, volcanic tuff and rhyolite are found which are fairly fresh and exhibit still distinct stratification.

The altered rock is usually white or yellowish in colour, but owing to the presence of various amount of iron, a varigated colour of purple, red or brown is often resulted. It is usually very porous and light.

Under the microscope the altered rock shows different compositions among which the following types may be distinguished.

a) White to yellowish coloured clayey rock which is soft and light. This type, when seen under the microscope, is composed of a great mass of hydrous aluminum silicates such as kaolinite or halloysite, intimately mixed with a fine aggregates of quartz and occassionally fibers or scales of sericite.

b) Yellowish to brownish coloured arenaceous rock, more compact and heavy as compared with the previous one. This type contains abundant quartz which is crystallised into microfelsitic textures. Scattered here and there is found drusy fillings or veinlets of fibrous kaolinite (Pl. I, Fig. 3).

c) Purple to yellowish coloured rock with a density and consistency intermediate between the above two. This rock, when studied under the microscope, shows frequently scales or lath-shaped crystals of alunite dispersed here and there among a silicified and sometimes also kaolinized ground mass.

d) The diorite porphyry at Lalishan is also extensely altered whereby every phenocryst of the original feldspar has been changed now into a fine aggregate of kaolinite crystals (Pl. I, Fig. 2).

Thus four types of alterations, namely silicification, sericitisation, alunitisation and kaolinitisation, may be observed among the altered rocks of the Tangt'u district. Especially important is the process of silicification; the microfelsitic aggregate of quartz constitutes the most prominent feature in practically every thin sections of the altered rocks studied.

Although the crystallisation of the different altered minerals occurred in a definite order, microscopic study shows, however, no important time interval between them. Our conclusion is therefore that these four processes of alteration have been produced by the same agent and perhaps under the same conditions.

Both silicification and sericitisation can be produced under widely variant conditions, although the latter process, i. e., the formation of sericite, is accepted in most cases, as of hydrothermal origin of the intermediate zone.

The origin of alunite can most probably be explained by the action of the sulphurous solution emanated from some igneous body below. The absence of pyrite in the country rocks, excludes the possibility of being formed by descending solutions.

According to recent study, kaolinite may be formed under various conditions of weathering or hydrothermal action. The latter explanation seems to be more suitable in our present case.

From the foregoing review. we may safely conclude that rock alteration in the Tangt'u iron bearing district is essentially due to the action of the hydrothermal solution emanated from some igneous source. The next question to solve is whether the solution was originated from solfataric exhalation immediately following the eruption of the volcanic series or by the after effect of the dioritic intrusion. According to the latter hydrothesis the rock alteration is essentially a by-product of iron deposition.

From the fact that both the volcanics and the intrusives have been affected by the same kind of alteration and that the extent of alteration seems to be more or less influenced by the relative distances from the iron veins, the writer is inclined to believe the second explanation as the most plausible one.

In conclusion, we may say that the alteration of the country rocks in Tangt'u is essentially the result of hydrothermal action following the dioritic intrusion. It was the same action that formed the iron deposits. In view of the presence of sericite, alunite and kaolinite, a mesothermal to epithermal state of the solution may probably be suggested.

In this connection it is to be noted that similar occurrences of pyrophyllite, alunite, kaolinite, sericite etc. are widely distributed in China, and are known under the collective name of agalmatolite. The occurrence at Pingyang and Ts'ingtien in Southern Chekiang has been recently described by L. F. Yih,[3] by whom a similar explanation of hydrothermal origin produced after monzonitic or granitic intrusion has been suggested. Other occurrences in Fukien, (known as Shoushanshih), Chekiang, (Ch'anghuashih), Jehol (Linghsishih), and Kwangtung (Kuanglüshih) as described by H. T. Lee[4] and A. Lacroix[5] are most likely of the same origin. The alunite deposit at Luchiang in central Anhui studied by C. Li * falls evidently under the same category. Thus we can see how important a rôle the hydrothermal action has played in the alteration of the Mesozoic igneous rocks in the whole of eastern China.

*unpublished information

(5) *Type and genesis:* That the iron deposits of Tangt'u is in genetic relation with the diorite and was formed as an igneous after-effect of the intrusion is too obviously shown by their mode of occurrence, the associated minerals as well as the geological and structural history of Central China as a whole.

However, the whole history of the iron deposition is a complicated one. Both field and laboratory studies have shown very well that there occurred at least three stages of mineralisations as follows:

(1) *The first stage of mineralisation:*—This is represented by the deposition of apatite, magnetite, and actinolite (now almost entirely altered to jenkinsite) with perhaps a little amount of hematite. These three minerals are closely intergrown and showing sometimes graphic structure. They were formed under high temperature and perhaps partly under pneumatolytic conditions as is evidenced by the presence of abundant apatite. The solution from which these minerals were crystallized was evidently emanated directly from the residual part of the dioritic magma.

The crystallisation period of actinolite was perhaps much lengthened, as part of the actinolite veinlets have intruded into the already formed magnetite veins.

(2) *The second stage of mineralisation:*—Not long after the formation of the previously mentioned magnetite-apatite-actinolite intergrowth, there emanated from the same magmatic source, a solution from which large bodies of hematite were formed. Almost simultaneously with the deposition of hematite, the already formed veins as well as the country rocks were subjected to a far reaching alteration by which actinolite was almost completely changed into jenkinsite, while the country rocks (including both the volcanic series and the intrusives) were largely silicified, sericitised, and partly alunitised or kaolinitised. From the nature and extent of the alteration, we can conclude that the mineralising solution was at first very rich in iron and silica and subsequently became alkaline and locally also sulphurous. The entire sequence of deposition and alteration has taken place under a condition of moderate temperature and intermediate depth, as the minerals sericite, alunite and perhaps also kaolinite are characteristic products of that zone.

The mineralising solution of the second generation has not only filled up the cracks in the country rock or to replace the same to form a new system of veins or veinlets, but it has also replaced to some extent the first formed magnetite. Microscopic examination of polished surfaces of the iron ores has revealed frequently residual masses or patches of magnetite in an otherwise almost homogenous hematite. That hematite veins are of a younger generation than magnetite is further evidenced by the occurrence at Lopushan, of a hematite vein of moderate width which has cut through a body of fine intergrowth of apatite, actinolite and magnetite.

(3) *The third stage of mineralisation:* This stage of mineralisation is not so marked in the northern field of Tangt'u, but it is of importance in the southern field. At Hsiaonanshan and Hsüshan, small veinlets of specularite are frequently found to penetrate into the hematite body. This represents perhaps the only indication of a third stage of mineralisation in the northern field.

At Takushan Hsiaokushan and partly Chungshan of the S. field, specularite constitutes a prominent part of the iron body. It forms frequently veinlets or drusy filling in the compact mass of hematite. Intimately associated with specularite is abundant chalcedony with inclusions of rod-like apatite Veinlets of barite are occassionally seen to cut across specularite, so the former is distinctly of a still younger age.

The last stage in the formation of iron ore at Tangt'u is atmospheric weathering which has resulted in the production of a considerable amount of limonite and yellow ochre.

IV. THE FANCH'ANG IRON DISTRICT.

A number of iron deposits is known in the Fanch'ang district, among which the Ch'anglungshan iron deposit of hydrothermal origin is the most important. Contact metamorphic iron deposits are found at Takoshan, northeast of T'aoch'ung and a group of minor deposits near Sanshanchên about 15 km. north of the Fanch'ang city.

1) *General Geology:*—The formation of Ch'anglungshan and its vicinity consists of a thick sequence of sedimentary rocks ranging in age from Siluro-

Devonian to Permo-Triassic. A classification of the formations according to lithologic characters may be given as follows:

Formations	Lithologic characters.
Permo-Triassic	Thin bedded limestone.
Permian	Black shale, sandstone etc. containing several seams of poor anthracite.
Permian or Carboniferous	Limestone, thick bedded and massive, chert bearing at certain horizons.
Siluro-Devonian	Quartzite and shale in the upper part and phyllite and shale in the lower part.

Dioritic rock often extremely weathered, occurs at about 6 km. to the north of Ch'anglungshan. It occupies a belt of low land and undulating hills lying between the southern bank of the Yangtze, and the northern foot hills of Ch'anglungshan. Similar to Tangt'u, this dioritic rock has furnished again the source of mineralising solutions from which the iron deposits were separated.

The major geological structure is an east-west syncline, together with several minor foldings and a great number of faults. A prominent strike fault occurs on the southern slope of Chaishan, and another one perhaps occurs further north. The strata of the southern slope up to the summit of Changlungshan has been overturned; the overturning becomes more and more intense so that on the summit of Changlungshan, a small thrust fault is developed. As will be noted later, the formation of iron deposit was partly facilitated by this faulted zone.

2) *Ore Deposit:* The iron deposit at Ch'anglungshan forms a regular vein trending from east to west and dipping at 70°—80° towards south. It occurs in the lowest part of the chert bearing limestone, not far from the contact of its underlying quartzite. The vein has been formed by replacement of a certain horizon in the limestone formation; which lies above a yellow and dolomitic limestone and below a rather thin bedded, chertless and argillaceous limestone. As the strata here have been overturned by folding, so the actual sequence is just the reverse as what has been described.

The vein measures 500 m. from east to west. The thickness of the vein varies greatly: formerly when working was concentrated into the upper part of the vein, a maximum thickness of 50 m. or more has been encountered; now at a level about 80 m. from the top, only 15 m. to 20 m., or still less, are found. Thus the vein is gradually thinning out toward the depth.

At Hsiaoshant'ou, the middle open cut of the vein there shows an average thickness of 6 meters on the third level. Here the hanging wall of the vein is a garnet rock about 50-60 m. thick in which the garnet is often crystallised in fine trapezohedral forms. Drusy filling or veinlets of calcite, quartz, adularia are frequently found. The ore is chiefly specularite, with a little amount of hematite and limonite. The foot wall of the vein is a rather thick bedded limestone with numerous intercalations of calcarious shales. It is pure and fresh and shows practically no alteration. At the eastern end of Hsiaoshant'ou cut, there occurs between the iron vein and its underlying limestone, a vein composed of a peculiar pyroxene which is provisionally identified as babingtonite. This vein is about 3 meters in thickness which gradually thins out towards the west.

Two dikes of extremely weathered diabasic rocks are found; they cut across both the iron vein and the garnet rock, so that their formation has evidently no genetic relation with the iron deposition.

West of Hsiaoshant'ou is the Tashant'ou open cut where mining work has extended down to a sublevel between the 4th and the 5th one. Here the vein is about 20 m. thick dipping 80° towards south. The hanging wall, about 25 m. thick, is a marble with abundant dessiminations of specularite and other minerals. Above the limestone is the garnet rock about 50 m. thick, in which some specularite are also found. Still further toward south, a yellow, dolomitic limestone, only 5 meters thick, is seen and below that there comes the great sequence of quartzite and shale of Siluro-Devonian age (Fig. 5).

The foot wall of the vein is a thick bedded limestone with several intercalations of thin shales, showing practically no alteration. This limestone is evidently equivalent to the one found at Hsiaoshant'ou. Veinlets, pockets or dessiminations of babingtonite are abundantly present both in the garnet rock and in the marble.

The ore consists chiefly of specularite occurring either in fine acicular crystals or in thin micaceous scales. A little amount of hematite is also found. The gangue is mainly calcite and quartz, with a small amount of adularia forming cavity-fillings in the ore.

In many sections of the Tashant'ou iron vein, a clayey shale, often extremely contorted, occurs between the dolomitic limestone and the quartzite and shale series. This indicates that some movement, probably in the nature of a thrust fault, has taken place along this belt. As has already been ex-

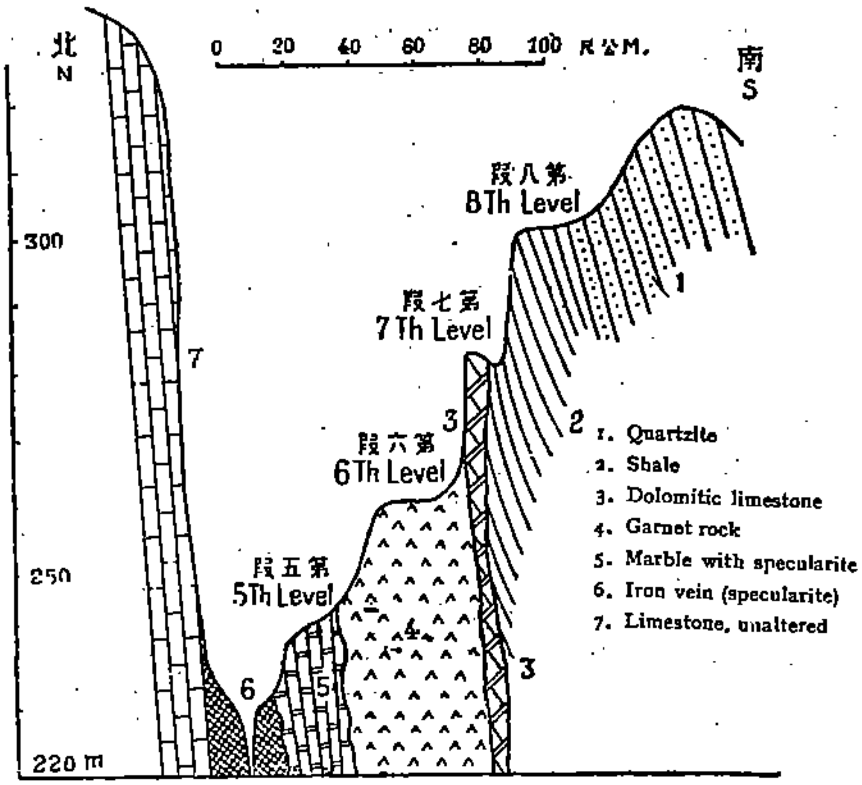

Fig. 5 Section across the Tashant'ou open cut, Ch'anglungshan, Fanch'ang district.

plained, the strata of Ch'anglungshan have been affected by a remarkable overturned folding; it is perhaps because of this overturning, which has caused slipping between the beds, that an overthrust along the bedding planes was resulted. As the overthrust plane is mainly parallel to the beds and the displacement is probably not so great, disturbance in stratigraphic succession is not to be seen. On the other hand, it is perhaps this fractured zone that has furnished the mineralising solutions with an easy path to pass through and facilitates the subsequent deposition.

Several minor ore deposits are found both in the north and south of the Ch'anglungshan iron vein. Some of them as the deposits of Takoshan, are of typical contact metamorphic origin, while others are merely local and superficial concentrations of no great importance. The deposits of Takushan are characterized by a thick garnet zone in which small amount of iron ore is found.

Fifteen km. north of Fanch'ang city and 5 km. south of Sanshanchên, is a group of minor deposits. The ore is chiefly hematite which occurs usually at the contact between a limestone and a dioritic rock. A thick zone of garnet rock is well developed. All these evidences point to contact metamorphic origin.

3) *The contact metamorphism:* The presence of a thick garnet zone at Ch'anglungshan iron deposit indicates clearly that contact metamorphic effect has been developed and that some hidden igneous rock must be there. As has been mentioned, no igneous rock, except an extremely weathered diorite is found in the vicinity, so the hidden igneous rock must be related or similar to this diorite.

Both the formation of marble and of the mineral, babingtonite, are evidently to be accounted for by contact metamorphism. As babingtonite contains a great amount of iron and also some manganese, it follows that introduction of material from magmatic source has taken place. On the other hand, the garnet zone has been formed probably in the main by recrystallisation of the impurities in the original limestone. The more or less regular distribution of the garnet belt and its conformable relation with the bedding planes all point to some kind of selective replacement, and consequently it is to be explained by the recrystallisation of the original impurities.

4) *Types and genesis:* That the iron vein of Ch'anglungshan was of later development than the garnet zone, and consequently it belongs not to the contact metamorphic type, but is of hydrothermal origin, is well shown by the following facts:

a) Minor iron veins are seen to cut across the garnet rock.

b) Drusy fillings consisting of quartz, specularite and adularia are found in the garnet zone, indicating not only the later development of the iron ore, but also a hydrothermal origin of probably shallow depth, as is further evidenced by the mineral adularia.

c) The foot wall of the iron vein is practically not altered. This signifies the lower temperature, and consequently the less corrosive effect of the mineralising solution.

d) The specularite vein of Ch'anglungshan can perhaps be compared with the third stage of mineralisation at Tangt'u, being of a later origin and perhaps shallow depth and lower temperature. This is, however, merely a suggestion, as more evidences are needed.

V. The T'ungling iron district.*

1) *General geology:* Between the city T'ungling and Tat'ung and its adjoining river flat, there occurs a vast alluvial plain in which is scattered here and there rolling hills of low elevation. Lying south east of this plain is the T'ungling mountainous area, with T'ungkuanshan, 440 m. above the adjoining valley, as the highest peak.

T'ungkuanshan proper is composed of sandstone of probably Devonian age. It is flanked both on the northeast and on the west by younger strata such as the Yangsing limestone of lower Permian and the coal series of Midde Permian age. All of them maintain a conformable contact.

The strata dip at various angles towards east in the eastern portion and towards west in the western portion. It follows then that T'ungkuanshan and its vicinity forms an anticlinal structure with a pitching toward north east.

Diorite intrusion occurring in the form of dikes or intrusive sills is found at Hsüpan, on the north-western limb of the anticline.

2) *Ore Deposit:* The T'ungkuanshan iron deposit is of typical contact metamorphic origin and is found almost exclusively in or near the contact between a diorite and a quartzite or between a diorite and a limestone.

*Based upon data furnished by Mr. C. C. Sun of the Geological Survey.

A number of ore bodies has been located; they are distributed chiefly on the north-western slope of T'ungkuanshan. Starting from southwest to north-east, the following hills, Shihtzeshan, Paoshan, Laoshan, Hsiaot'ungkuanshan, Laomiaochishan, Sungshushan, Changshan etc. are all ore bearing.

The ore consists chiefly of magnetite with some hematite and limonite; a small amount of chalcopyrite which has now been largely altered into malachite is found at Laoshan and Pishan. The common gangue minerals are garnet and quartz; the former is, however, absent at Laomiaochishan, Sungshushan and Changshan, where quartzite forms the chief country rock.

So far as can be ascertained from surface exposure or by theoretical deducation, the iron bodies of T'ungkuanshan occur in most cases in tabular shapes of varying dimensions. Their extension towards the depth must exceed what was previously assumed by Dr. Tegengren by whom only a depth of ten meters was given. On basis of this new assumption and more accurate survey of the surface exposure, the reserve of the T'ungkuanshan iron deposit has been re-estimated to be about 5,000,000 tons.

The iron ore is characterised by high content of silica and fairly abundant impurities of copper and sulphur. The average tenor of iron is only 55%. It is therefore an iron ore of inferior quality as compared with those of Tang-t'u or Fanch'ang.

A smaller ore body but of similar nature as the previous one, is found at Chikuanshan, about 8 km. east of T'ungkuanshan. The ore is hematite with a little limonite and pyrite, together with gangue minerals such as garnet and quartz.

VI. MINERALS FROM THE IRON BEARING DISTRICTS.

The iron fields of southern Anhui offer special opportunity for mineralogical collection, as fairly well crystallised minerals, such as apatite, garnet, adularia etc. are quite common. The present collection is, however, far from being exhausive, and further addition to the list is certainly to be expected when more careful collecting is made. In the following description of the minerals, the crystallographic measurements have been kindly furnished by Mr. S. W. Wang of the Geological Survey.

Adularia: This mineral is found as drusy fillings in garnet rock at Hsiaoshant'ou of Fanch'ang iron district. It occurs together with quartz and micaceous specularite forming a kind of comb structure. From the fact that quartz crystals occur close to the wall of the cavity and adularia only next to it, the conclusion is that the latter has been formed a little later than quartz. Some adularia has also been found in the laminated specularite occuring as fillings in the open cavities of the solid ore. As is well known, adularia is a vein mineral of low temperature origin, and its occurrence here in the cavities of the specular iron ore indicates probably that at least the last phase of the Ch'anglungshan mineralisation belongs to the epithermal category.

The form of the mineral is well preserved; it occurs in distinct euhedral crystals with perfect development of c (001) x ($\bar{1}01$) and m (110). The orthodome ($\bar{1}01$) is only represented by a very indistinct face. The measurement of interfacial angles by S. W. Wang gives the following result:

m (110) ∧ m (1$\bar{1}$0) = 61°8'
c (001) ∧ m (110) = 67°12'
m ($\bar{1}$10) ∧ x ($\bar{1}$01) = 69°20'
m (110) ∧ m ($\bar{1}\bar{1}$0) = 118°30'

The mineral is white and dull, coated on the surface with red iron oxide. Hardness is about 5–6, and specific gravity is 2.55. Microscopic study of the crushed fragments by the immersion method gives the following optical properties:

Biaxial negative
Nm = 1.522±,
Optical angle is very small,
Extinction angle Z ∧ twinning lamellæ = 12°–19°.

Alunite: In the thin sections of the altered volcanic rocks, an acicular to prismatic mineral approaching the character of alunite is found. The mineral is characterised by low refringence and moderate birefringence, uniaxial positive and negative elongation. It is closely associated with the extensive silicification so frequently observed among the altered volcanic rocks of Tang-t'u district. In some specimens alunite is found together with sericite.

From the mode of occurrence and the associated minerals just described, it is concluded that here the alunite has been formed probably under mesothermal conditions, though by some authors, this mineral is attributed also to the epithermal group.

Apatite:—Apatite is abundantly present in the iron deposits of Tawashan in Tangt'u district. In the minor ore body or small vein of first generation, large crystals of apatite together with jenkinsite are closely associated with magnetite to form a kind of graphic intergrowth. In the extensive replacement deposit on top of Tawashan and especially at the eastern end of the deposit, a great number of well preserved apatite crystals has been collected. Here the matrix rock has been extensively altered into a kind of red clay which is very soft and friable, so the apatite crystals can be easily picked out. The largest crystals obtained attains a diameter of no less than 6 cm. or more and a length of about 10 cm. Small, but excellently shaped crystals, only a few mm. long are also abundant.

The apatite crystals from Tawashan occur in simple hexagonal prisms and pyramids of x (1011) and m (1010). The faces show usually some distortion, so that they are not similarly disposed. Measurement of interfacial angle gives the following results:

$$m\ (10\bar{1}0) \wedge x\ (10\bar{1}1) - 49°42'$$
$$m\ (10\bar{1}0) \wedge m'\ (01\bar{1}0) - 59°39'$$
$$x\ (10\bar{1}1) \wedge x'\ (01\bar{1}1) - 37°42'$$
$$m\ (10\bar{1}0) \wedge x'\ (01\bar{1}1) - 71°27'$$

The larger crystals have a brownish white color, whereas smaller ones show a greenish tint. It is dull to translucent with a subresinous luster.

Microscopic examination of crushed iron ores from Hsiaokushan and Chungshan reveals a great quantity of minute rod-like crystals of apatite forming inclusions either in chalcedony or in quartz.

Babingtonite:—This rather rarely found mineral belonging to the group of Triclinic Pyroxene occurs in the iron deposit of Ch'anglungshan in Fanch'ang district. It occurs as fibrous, radiating aggregates forming veinlets, pockets, disseminations or other irregular forms in the marble as well as in the garnet rock. The crystalline form is not well shown which makes it impossible to give a morphological description.

The mineral has a hardness between 4 & 5, a specific gravity about 3.40 (approximate determination of impure samples). It breaks into fine fibers.

Under the microscope the thin section shows a remarkable pleochroism which gives the following colours:

X – deep green
Y – light green
Z – brownish yellow.

It is biaxial positive with optic angle around 70° (2V). The optical plane is parallel to the direction of prismatic cleavage. On basal sections, two directions of imperfact cleavage, intersecting at nearly 90°, is well shown. Extinction angle from c amounts to 30° or more. The extinction direction is positive.

The refractive indices as determined by the immersion method gives the following result:

np – 1.7273 ± parallel to prismatic cleavage
nm – 1.7309 ± perpendicular to prismatic cleavage
ng – is not observed.

When tested with sodium carbonate bead, the mineral shows a faint indication of manganese.

Barite: Both Tegengren and Yih have mentioned the presence of barite veinlets at the Chungshan iron deposit, but the present investigation has failed to find any in the region just named. Instead, barite veinlets cutting across the specularite are seen in the Hsiaokushan deposit as well as at Kuangyinshan, the latter occurrence having been also noticed by both Tegengren and Yih. At Kuanyinshan, the barite veinlet occurs in limestone; it forms tabular mineral of fairly large sizes, but no good crystals could be obtained.

According to Yih, barite is abundantly present in the ferruginous quartzitic sandstone near Wuhu. Microscopic study of the rock shows that iron infiltration has followed largely the boundaries between quartz grains and barite, so that iron deposition was distinctly later than the formation of barite. As will be explained later, aside from this single occurrence mentioned by Yih, most of the other barites have evidently no genetic relation with the iron deposits, as they were formed subsequent to the introduction of iron veins.

Calcite: Fairly good crystals of calcite are abundant at Ch'anglungshan in Fanch'ang district occurring in most cases as drusy or cavity fillings in the limestone as well as in the garnet rock. The minerals are crystallized most frequently in two types: a) a short prism combined with rhombohedral faces, b) a longer prism and rhombohedrons.

Measurement of interfacial angles gives the following results:

$$m\ (01\bar{1}0) \wedge e\ (01\bar{1}2) - 63^\circ 42'$$

$$e\ (01\bar{1}2) \wedge e''\ (\bar{1}102) - 45^\circ 8'$$

These calcites sho wfrequently a brown to yellowish colour, probably due to iron or other impurities.

Nearly transparent rhombohedrons of calcite are abundant in the Ta-shant'ou open cut, on the fifth level in section south. They occur as veinlets or drusy crystals in limestone.

Chalcedony: As has been stated above, chalcedony forming the matrix of the iron ore is abundantly present in the deposits at Hsiaokushan and Chung-shan. It shows under the microscope cryptocrystalline aggregates or fibrous forms with extremely low birefringence. In both places the chalcedony includes a large number of minute prisms of apatites which are especially abundant at Hsiaokushan.

Chalcopyrite:—A little Chalcopyrite is found in the T'ungkuanshan iron deposits. It has been largely altered into malachite.

Chrysotile: In one specimen collected from Ch'anglungshan in Fanch'ang district, specularite veinlets are inter-laminated with a yellow fibrous mineral, which, when seen under the microscope, proved to be a chrysotile. It has a medium refractive index near to 1.540; it is biaxial positive and with a positive elongation. It is believed that the chrysotile has probably been formed by alteration of babingtonite, which is so frequently present and so intimately associated with the specularite in the Ch'anglungshan iron deposit.

Garnet: Garnets are widely distributed in both the Fanch'ang and the T'ungling iron districts. At Ch'anglungshan, the mineral forms a prominent zone amounting to 50 m. or more in thickness. At T'ungkuanshan, the same kind of occurrence is found. Garnet is however, absent in the Tangt'u iron deposits.

The garnets of Ch'anglungshan and Takoshan are commonly crystallised in trapezohedral forms (211). Under the microscope, the thin section shows marked optical anomaly as can be seen in the illustration (Pl. II, Fig. 1).

The garnets of T'ungkuanshan are commonly crystallized in combination of dodecahedron (110) and trapezohedron (211). Some garnets as collected from Paoshan show also distinct optical anomaly, but other specimens show complete extinction under the crossed nicols.

Jenkinsite; This mineral is abundantly present in the iron deposits of Tangt'u; it is especially abundant at Tawashan forming frequently large, radiating and prismatic crystals.

The mineral is very soft, between 1-2 in the scale of hardness. Specific gravity is about 2.40. Under the microscope the mineral is yellowish green in colour, slightly pleochroic which varies from yellowish green (Z) to light green (X & Y). It is biaxial negative, with apparently a very small optical angle. The extinction is parallel and positive in direction.

Study of crushed fragments by the immersion method gives the following approximate values of refractive indices:

$$X = 1.5763 \pm$$
$$Y = 1.5937 \pm$$
$$Z = 1.5987 \pm$$
$$Z\text{-}X = 0.0224$$

From the fact that actinolite occurs as residual inclusions in the interior part of jenkinsite, it can be safely concluded that the latter mineral must have been formed from the former as a result of hydrothermal alteration.

Kaolinite:—As has been described above, kaolinisation constitutes one of the common type of alteration in the intrusive as well as the extrusive rocks of Tangt'u district. The mineral occurs usually in cryptocrystalline and fibrous forms. It can easily be recognized by its extremely weak birefringence, and a refringence near to 1.56.

Magnetite:—Fairly well formed but usually small crystals of magnetite are abundant at Tawashan, Hsiaowashan, and Lopushan. The crystal forms are simple octahedrons; they are usually aggregated together, so that separate and well preserved crystals are not common.

Pyrite: Crystals of pyritohedron (210) showing pseudomorphism of hematite after pyrite is found at Ch'anglungshan, Fanch'ang district. The mineral occurs as drusy fillings together with quartz and specularite. Besides, fine dessiminations of pyrite are found in a quartzose rock at Nanshan in Tangt'u district.

Quartz: Drusy fillings of fairly well crystallised quartz are common at Hsiaokushan in S. Tangt'u and Ch'anglungshan in Fanch'ang district. These are of the usual rhombohedral-trapezohedral forms.

Sericite: This is another alteration mineral so commonly found among the igneous rocks of Tangt'u district. By all authorities, sericite is believed to represent hydrothermal alteration at the intermediate depth.

Specularite: While most of the specularite occurring in prismatic, acicular, or foliated forms, a few fairly good crystals are seen among the ore of Hsiaokushan. They are hexagonal and flattly depressed crystals and are formed by combination of prisms $(11\bar{2}0)$, pyramids $(10\bar{1}1)$ & base (0001).

VII. Summary & Conclusion.

The present paper is a brief discussion of the geological structure and mode of occurrence of the iron deposits in S. Anhui. Three iron bearing districts, namely, Tangt'u, Fanch'ang and T'ungling are described.

All the iron deposits are in genetic relation with a dioritic intrusion which occurs mostly in dikes or apophyses and rarely in lacolithic forms of small extent. The youngest rock intruded by the diorite is a Cretaceous volcanic series, so the age of intrusion may be roughly assigned to the end of Mesozoic or the beginning of Tertiary.

No definite conclusion can yet be reached as to the relation between the intrusion and the principal period of folding. At least two periods of orogenic movement must have occured, one before and the other after the formation of the Cretaceous volcanic series. These foldings are most probably the equivalents of the Yenshanian movement. As the diorite shows no evidence of strain whatsoever, a post—Yenshanian age for the intrusion can most probably be assigned.

Broadly speaking, the iron deposits of S. Anhui may be divided into two types: (1) Contact metamorphic deposits and (2) hydrothermal deposits. The former type is represented by the deposits of T'ungkuanshan in T'ungling district and the minor deposits at Takoshan in Fanch'ang district. All the other deposits belong to the second type i. e. the hydrothermal deposits.

The contact metamorphic deposits were formed by replacement of either limestone (more common) or sandstone by the residual magma emanated immediately after the intrusion of the diorite. The ore bodies are generally located at the contact between the igneous and the sedimentaries, though occurrences entirely included in the sedimentaries and a little far away from the igneous are also found. The deposits are generally marked by a thick zone of garnet in which iron ores are intimately associated. Magnetite forms the principal ore with some hematite and a little chalcopyrite; the latter mineral, though never abundant, is characteristic enough for that kind of deposits, as it is practically absent in the type of hydrothermal origin.

Among the iron deposits of hydrothermal origin, variations both in mineral association and in mode of occurrence are characteristic enough as to differentiate themselves again into several types. These different types were formed successively one after the other, and a continuous series of mineralisation with sometimes overlapping relations in one single occurrence can be traced. Several stages of mineralisations may be distinguished as follows:

The first stage is represented by magnetite-apatite-actinolite (now largely altered into jenkinsite) intergrowth which occurs either in narrow and regular veins or as irregular replacement bodies of limited extent. It was formed under high temperature conditions and at great to moderate depth. The solution from which the iron deposits were separated has evidently been derived from the same magmatic source as the diorite, but it has emanated after the complete consolidation of the igneous rocks.

The second stage of mineralisation is of a mesothermal type, as with it was developed extensive alterations, such as silicification, sericitisation, alunitisation and kaolinisation in both the diorite and the volcanic series. The alteration of actinolite into jenkinsite is believed to be performed at the same time and by the same agent. The ore consists essentially of hematite which not only has filled the fissures and fractures in the country rocks, but has also replaced the previously existing magnetite, about which microscopic investigation of polished surfaces has furnished us conclusive evidences.

The third stage of mineralisation is represented by the association of specularite, hematite, quartz, adularia, chalcedony and a little apatite. It was formed from the same mineralizing solution that has genetic relations with the diorite, but has deposited under lower temperature and at shallower depth, probably equivalent to epithermal conditions. In shape, this type of deposits may vary from small to moderate bodies of irregular forms to regular and prominent vein of considerable sizes, as, for example, the iron vein of Ch'anglungshan.* The latest mineral found under this or the next stage is a barite, which occurs as veinlets in the ore body.

Microscopic study of specimens collected by L. F. Yih near Wuhu shows small amount of iron filling up the interstices of quartz grains and barite crystals. This represents perhaps the fourth stage of iron deposition which took place probably under cold water condition.

Lastly, we must not forget to mention the atmospheric agents which are responsible for the change of a considerable part of the iron ore into limonite, yellow ochre and clayey like substances as are most extensively developed in the Tangt'u iron deposits.

Since both the contact metamorphic and the hydrothermal deposits were formed after the intrusion of the diorite, and since the age of intrusion of the latter has been assigned to late Mesozoic or early Tertiary, the age of iron deposition in S. Anhui may be regard as falling largely within the Tertiary.

Table to show different types of iron deposits in S. Anhui.

Type of Deposits	Mineralisation	Mode of occurrence	Distribution
Contact Metamorphic Deposits.	a) Formation of marble, garnet, babingtonite,	Thick beds of zones	T'ungkuanshan, Takoshan, Hsiankoshan, Ch'anglungshan
	b) Magnetite hematite, Chalcopyrite.	Irregular to tabular bodies of replacement origin	T'ungkuanshan, Chikuanshan, Takoshan.

* The iron vein of Ch'anglungshan is still of doubtful origin and is only provisionally assigned to this type.

Hydrothermal Deposits	Hypothermal to pneumetolytic deposit.	Magnitite-apatite-actinolite.	Fissure-filling to replacement bodies of small sizes.	Tawashan, Lopushan.
	Mesothermal deposits stage a	Silicification, sericitisation alunitisation kaolinilisation, alteration of actinolite into jenkensite.	Largely replacement deposits of irregular shape. Some are of considerable sizes.	Tawashan, Nanshan, Tahsiaotungshan, Lopushan.
	stage b	Hematite..........		
	Epithermal deposits	Specularite, hematite, apatite, adularia, quartz, chalcedony.	Irregular replacement bodies to prominent veins.	Tahsiaokushan. Chungshan, Tiaoyushan, Hsiaonanshan, Ch'anglungshan.
	Cold water deposits.	Barite, hematite	Small veinlets	Near Wuhu.
	Weathering	Limonite, yellow ochre, clay etc.	Networks of veinlets, superficial alteration etc.	All districts.

A few words may be said about the comparison with other known Chinese iron deposits. Aside from close similarity with the deposits of Niushoushan and Fenghuangshan near Nanking, with which our deposits of epithermal and mesothermal origin are intimately related, a strong resemblance is also shown with the iron deposits of Linhsiang in southeastern Hupeh, about which L. F. Yih and K. P. Chao (6) have made a comprehensive study.

While the contact metamorphic deposit at Tungkuanshan is quite common and may be compared with the deposits at Tayeh in Hupeh, Hungshan in Honan etc., the high temperature veins with magnitite, apatite, actinolite etc., are, so far as known, of comparatively rare occurence in China.

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Explanation of

Plate I.

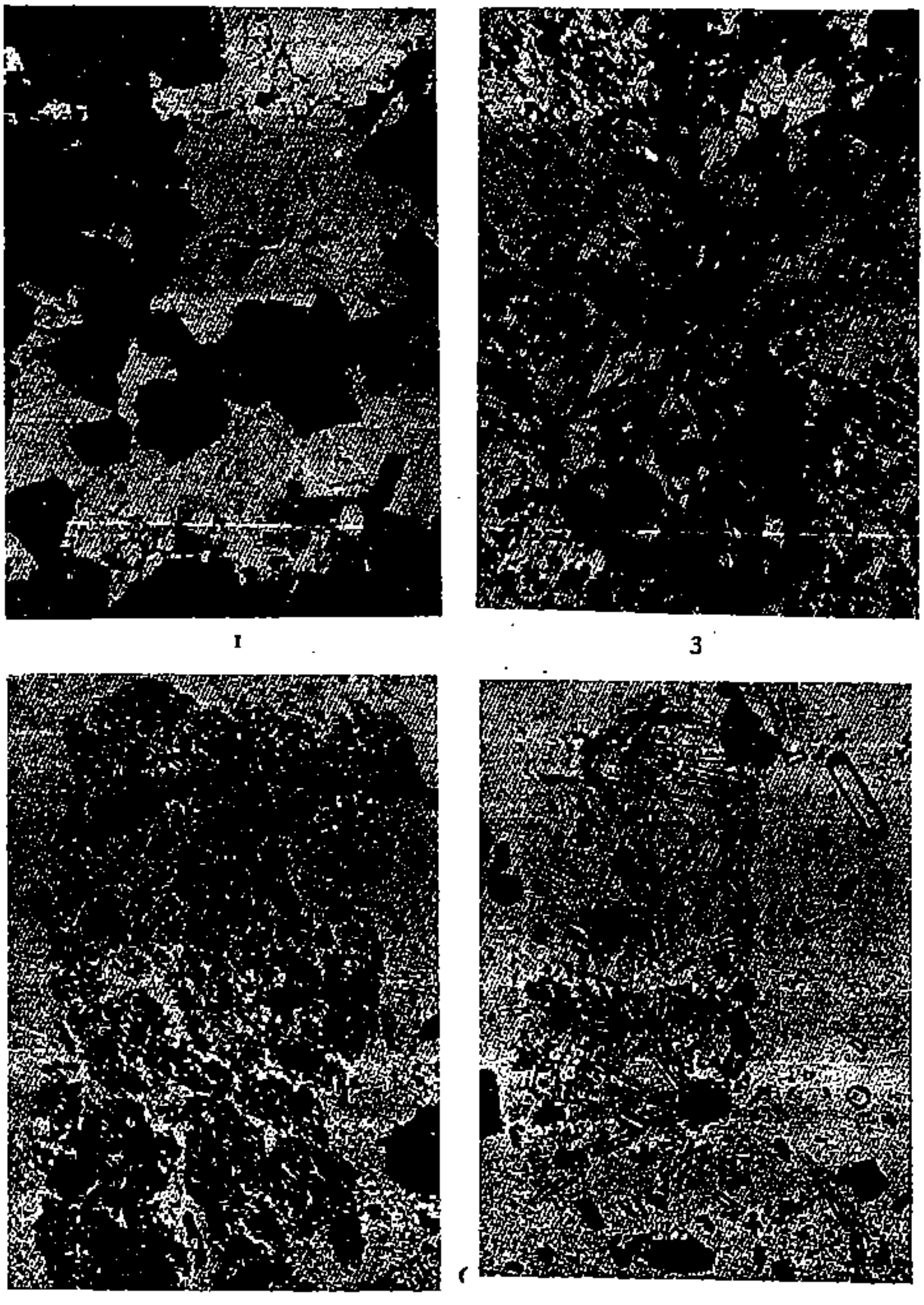
EXPLANATION OF PLATE I.

Fig. 1. Granular aggregates of magnetite (black), apatite (rectangular crystals) and jenkinsite (fibrous) Lopushan, Tangt'u district. ×60

Fig. 2. Entire crystal of plagioclase altered into a fine aggregate of Kaolinite. The ground mass is microfelsitic quartz. Lalishan, Tangt'u district. Crossed nicols. ×34

Fig. 3. Veinlets of kaolinite acrossing ground mass of microfelsitic quartz. Crossed nicols. Lungshan, north of Weipingshan, Tangt'u. ×98

Fig. 4. Chalcedony with inclusions of small apatite crystals. Crushed fragments separated from the iron ore of Hsiaokushan, Tangt'u district. ×115



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Explanation of Plate II.

EXPLANATION OF PLATE II.

Fig. 1. Garnet showing optical anomaly. T'ungkuanshan, T'ungling district. Crossed nicols. × 35

Fig. 2. Thin and bundle-like laminæ of specularite begin to replace calcite (with cleavage). The colourless crystals with sharp boundaries at the lower end are quartz. Ch'anglungshan, Fanch'ang district. × 35

Fig. 3. Prismatic crystal of specularite forming skeleton-like pattern in calcite (with cleavage indistinctly shown). Quartz (colorless) is shown in the lower end. Ch'anglungshan, Fanch'ang district. × 38

Fig. 4. Calcite (with cleavage) replaced by specularite (black). The colorless veinlets are fractures. Ch'anglungshan, Fangch'ang district. × 37

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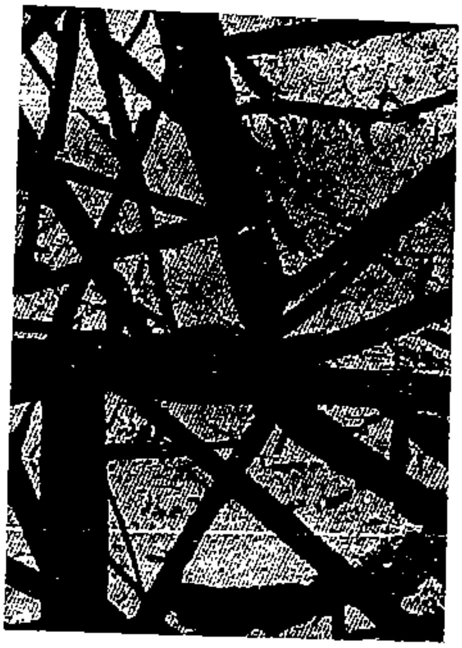

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