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On the Rocks and Metamorphism of Peyinchang Volcanic Series, Kaolan, Kansu*

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With 1 Plate and 4 Text-figures

I. INTRODUCTION

In July, 1946, while investigating the pyrite deposit ot Peyinchang,[1] Kaolan,[2] Kansu [7], the writer noticed that the country rocks of the deposit, formerly recognized as a series of metamorphosed sedimentary rocks consisting mainly of phyllite, quartzite and schist by Mr. P. Chen [2], and Messrs. N. L. Liu, W. Y. Liang and T. C. Liu [4] who visited there in the years of 1940 and 1944 respectively, are far different in rock character as compared with the doubtless metamorphosed sedimentogenous rocks overlying and underlying them. Through several days of careful study in the field of their occurrence and megascopic characters of the less metamorphosed ones, they are interpreted to be volcanic rocks having been metamorphosed to a greater or less degree by dynamic forces and are later confirmed in the laboratory by the microscopic study. Together with some interbedded phyllite layers they are proposed to be called Peyinchang Volcanic Series of a Palaeozoic, most probably Devonian, age. In this paper only the general geological features of the area round Peyinchang, the rather detailed succession of the volcanic rocks and the petrographic description of the specimens collected are given so as to make possible the discussion on the origin of these rocks and the kind of metamorphism they have suffered.

The writer wishes to take this opportunity to express his great indebtedness to Dr. Y. C. Cheng for his careful reading of the whole manuscript. He is also grateful to Mr. S. C. Li for taking the photomicrographs.

II. GENERAL GEOLOGY

Peyinchang is situated at about 100 km NNE of Kaolan (Fig. 1), on the Sungchialiangshan[3] which trends in a WNW-ESE direction and is the

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1. 白银厂 2. 皋兰 3. 宋家梁山

more dissected eastern part of Wushaoling[1] of the Chilianshan system.[2] Topographically the region under consideration is characterized by hills rarely exceeding hundred meters in height above the bottoms of the rather moderately-sloped, open valleys, thus attaining a topography of early maturity.

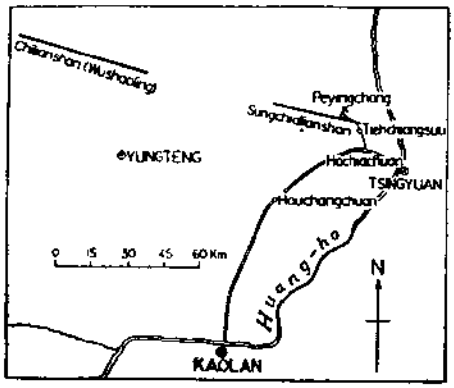

Fig. 1. Map showing the location of Peyinchang

The general geological features may be briefly stated under the following three headings:

Stratigraphy: 1. *Phyllite* Series (Dph). This is the oldest series of this area with its base unexposed. It is rather uniform in rock character and consists chiefly of bluish grey phyllite, commonly with quartz veins of various thickness intruding along the foliated planes. With a thickness estimated approximately at 500 m, this series is supposed to be Devonian in age.

2. *Peyinchang Volcanic Series* (Dp). Disconformably overlying the above stated phyllite series is the Peyinchang Volcanic Series which well displays the following beds* as one proceeds from the phyllite series through Lichuang[3] southwestward to Pelukou[4] in an ascending order (Fig. 2):

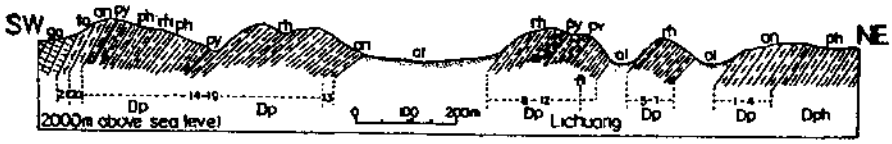

Fig. 2. A section W of Lichuang showing the succession of the Peyinchang Volcanic Series (Dp) and the phyllite series (Dph). Al, alluvium, py, pyrite vein capped with gossan; ga, metagabbro; rh, metamorphosed rhyolitic rocks; an, metamorphosed andesitic rocks; to, metamorphosed toscanite; ph, phyllite; 1-4 etc. refer to the numbers described in the text.

1. Greenish grey calc-chlorite-schist (metamorphosed andesite lava) ..... 20±m
2. Dull green calc-chlorite-schist (metamorphosed andesite lava) ..... 15±m
3. Same as 1, greenish grey calc-chlorite-schist ..... 50±m
4. Light greenish grey porphyroblastic schist (metamorphosed vesicular andesite lava) ..... 8±m
5. Grey sheared and sericitized rhyolite ..... 15±m
6. Grey thin-bedded quartz-sericite-schist with patchy schist of greyish green color in the lower part (metamorphosed rhyolite tuff) ..... 35±m
7. Same as 5, grey sheared and sericitized rhyolite but well-jointed and commonly cut by quartz veins of 2-5 cm thick ..... 20±m

1. 烏鞘嶺 2. 祁連山 3. 平巷 4. 辟路寺

*Partly covered by alluvium in the present section but apparently forming a continuous sequence without any distinct break in the region further W.

8. Yellowish white fine-grained quartz-sericite-schist with gossan in the middle lower part and embedded commonly with nodules made up of rhyolitic tuffaceous material ranging from 1.5 × 2 to 2.5 × 4 cm in size. Intruding along the schistosity there are abundant quartz veins up to 1-2 m in thickness (metamorphosed fine rhyolite tuff) . . . . 90 ± m
9. Gossan of pyrite vein accompanied by highly silicified and brecciated quartz-sericite schist . . . . . 15 ± m
10. Reddish well-banded quartz-schist intruded along the schistosity by abundant quartz veins 1-5 cm in thickness (highly silicified rhyolite tuff) 20 ± m
11. White wrinkled felsitic quartz-sericite-schist (metamorphosed fine rhyolitic tuff) . . . . . 18 ± m
12. Same as 6, grey thin-bedded quartz-sericite-schist occasionally with patches of schist of different textures (metamorphosed rhyolite tuff) . . . . . 30 ± m
13. Same as 1, greenish grey calc-chlorite-schist . . . . . 25 ± m
14. Greyish quartz-sericite-schist* (metamorphosed rhyolite) . . . . . 200 ± m
15. Same as 8, yellowish white, fine-grained, quartz-sericite-schist . . . . . 8 ± m
16. Gossan and thin-bedded purplish red hematitic schist occasionally with white spots (highly silicified and hematitized rhyolite tuff) . . . . . 20 ± m
17. Analogous to 8, yellowish white fine-grained quartz-sericite-schist with many quartz veins and veinlets (metamorphosed fine rhyolite tuff) . . . . . 15 ± m
18. Similar to 10, reddish well-banded quartz-schist (highly silicified metamorphosed rhyolite tuff) . . . . . 12 ± m
19. Bluish phyllite with several layers of grey thin-bedded quartz-sericite-schist same as 6 and 12 with gossan in the upper part . . . . . 150 ± m
20. Greyish green spotted calc-chlorite schist (metamorphosed andesite lava). 50 ± m
21. Dull greenish porphyroblastic schist (metamorphosed toscanite) . . . . . 10 ± m

Suppose there is no repetition of beds in the above section, the thickness of the volcanic series exposed at this particular locality would then amount to more than 800 m. The age of eruption of this series is supposed to be Devonian.

3. *Phyllite and quartzite series.* This series is well-developed in the vicinity and SW part of the village Pelukou and consists dominantly of dull greenish phyllite with grey quartzite and a few layers of impure crystalline limestone. Disconformably overlying the Peyinchang Volcanic Series and underlying a well-bedded, crystallized limestone† it is estimated at a total thickness of more than 450 m and is supposed also to be Devonian in age.

4. *Loess.* Patches of primary loess covering some parts of the hills of this region are noticed, being seldom over 30 m in thickness.

5. *Alluvium.* This is exposed by the terrace 10 m above the dry river bed and consists in the upper part of light reddish clay interbedded with sand and in the lower part of gravel with pebbles rarely larger than 4 cm. It is gold-bearing and was formerly mined for gold.

Intrusion. Two kinds of intrusive rocks are recognized. The one found intruding into the phyllite and quartzite series in the region NW of

†Probably to be correlated with the Chouniukou Series of Lower Carboniferous age but without any fossil evidence.

*Not well exposed, probably containing also other kinds of metamorphosed volcanic rocks.

Tiehchiangsuu[1] is a granodiorite which is supposed to be in genetic relationship with the hydrothermal pyrite deposit of Peyinchang. The other is a lenticular metagabbro (ga, Fig. 2) having a thickness of 80 m at its widest part and is found to have intruded into the uppermost part of the Peyinchang Volcanic Series. As to the age of intrusion they are both considered to be Variscan.

Structure: The structure of the region under study is rather simple. The general strikes of the different series are WNW-ESE with beds dipping to SW at a moderate dip of 40°-85°. Besides the minor fault and fold occasionally found in the volcanic series, structural features of large magnitude are not recognized in this region.

III. PETROGRAPHY

A. *Metamorphosed volcanic rocks:*

1. *Greenish grey calc-chlorite-schist:* This is a greenish grey, fine-grained, rather massive, schistose rock. Microscopically it (S857) is seen to be porphyroblastic in texture and composed dominantly of oligoclase,* calcite, chlorite, muscovite and iron-oxide with accessory epidote, sericite and apatite. The matrix is holocrystalline and made up chiefly of aggregate of clear oligoclase, slightly arranged muscovite, chlorite flakes with a marked pleochroism of X = Y = pale green, X = pale yellowish green and calcite grains. The metacrysts are of two kinds, one is slightly sericitized oligoclase and the other is a group of minerals pseudomorph after the former dark minerals which are most probably pyroxene. The metacryst oligoclase, with or without twin lamellation and up to 0.2 × 0.4 mm in size, is commonly sericitized and corroded with an irregular boundary. Scattered in the groundmass they are more or less arranged. The other type of metacryst consists chiefly of large plates and small grains of calcite dotted with iron-oxide grains, arranged chlorite flakes and occasionally also epidote and quartz. Based upon the mineral association and texture, this rock may also be termed as oligoclase-porphyroblast-calc-chlorite schist.

2. *Dull green calc-chlorite-schist:* Megascopically this is a greyish green, fine-grained, schistose rock with some white spots. In the slice it (S853) is seen that the white spots are large calcite grains or calcite aggregates in association with quartz and hematite grains up to 1 mm across and large chlorite flakes with a positive optical character and a pleochroic scheme of X = Y = green, Z = pale yellowish green. Between and beside these spots is the greenish matrix which is well foliated and consists predominantly of sheaf-like shreds of chlorite and sericite with a minor amount of elongated quartz and calcite grains. Epidote and iron-oxide grains are the only accessories found scattered in the slice. Besides the difference of color, this

*The composition of plagioclase is based upon the determinations of extinction angle and refriegence of the crushed material.

1. 鐵匠牀

calc-chlorite schist is different from the one stated above by the absence of oligoclase metacrysts and the fact that all the feldspars and dark minerals formerly present in the groundmass have been changed to other minerals such as sericite, chlorite, quartz, etc.

3. *Light greenish grey porphyroblastic schist:* In the handspecimen it is a light greenish grey, porphyroblastic, well-puckered, schistose rock with small greenish black metacrysts dotted in a felsitic groundmass. Dirty knoty patches are occasionally seen in this rock but not shown in the specimen collected. Under the microscope the metacrysts (S866; Fig. 3) are more or less ellipsoidal in form and with their longer axes (less than 0.5 mm) arranged along the schistosity. Of them two kinds are recognized, the first is aggregate of iron-oxide granules, chlorite and some small calcite and the second is made chiefly of calcite dotted with iron-oxide and fringed by chlorite flakes. It is the latter that dominates. Rarely the chlorite reaches such a size that it also forms the metacrysts of the rock. These mineral aggregates acting as the metacrysts are most probably the former amygdales of this vesicular andesite lava. The groundmass is composed chiefly of well-arranged sericite flakes dotted with small calcite and iron-oxide grains. Elongated secondary quartz and chlorite flakes are present in a minor amount.

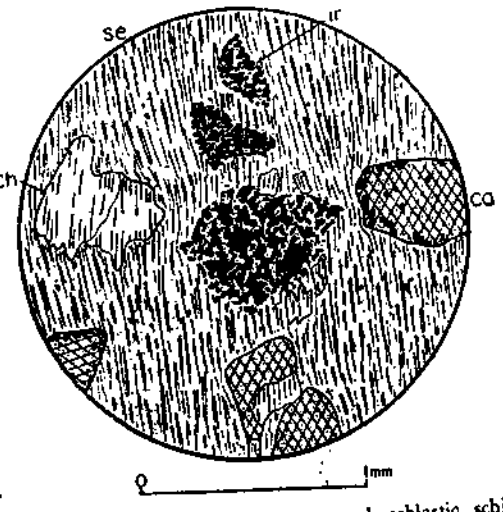

Fig. 3. Light greenish grey porphyroblastic schist. Showing the porphyroblastic texture with aggregate of iron-oxide granules (ir), calcite (ca.) dotted with iron-oxide and large chlorite (ch.) as metacrysts embedded in a groundmass of well-arranged sericite (se.).

4. *Grey sheared and sericitized rhyolite:* Megascopically this is a grey porphyritic rock with poorly-developed schistosity. The phenocrysts are quartz and feldspar up to 2×2 and 1.5×3 mm in size respectively. Microscopically it (S858) (Fig. 3, Pl. I) reveals that the bulk of the rock consists of a microcrystalline groundmass which is made up chiefly of elongated quartz and well-arranged sericite shreds (it is this mineral that causes the schistosity of the rock) dotted with small chlorite flakes, iron-oxide grains and occasionally calcite of varying sizes. Phenocrysts are essentially corroded and embayed quartz, together with an acid plagioclase, ranging from basic albite to medium oligoclase and with common twin-lamellation. Clear and rounded or subrounded quartz often shows strain-shadows and some even are crushed to lenticular pieces with small quartz grains scattered along the boundaries, while the feldspars, in tabular forms,

are commonly cloudy and show a patchy wavy extinction. They are commonly arranged along the schistosity.

5. *Grey quartz-sericite-schist:* This is a light grey, thin-bedded, schistose rock with abundant brownish spots. Microscopically it (S863) is porphyroblastic with feldspar, brownish spots of iron-oxides and quartz of various sizes and different forms scattered as metacrysts in a rather homogeneous groundmass. The feldspars, ranging from 0.03 × 0.06 to 0.3 × 0.6 mm in size and thick tabular to irregular in form, have a composition of basic albite to medium oligoclase. They are altered and looked cloudy and are commonly strained to such a way that some of their twin-lamellae are bent. With a corroded and even broken border they almost show no way of arrangement. Quartz, often also strained and even crushed, is in rounded and subrounded crystals with a corroded and broken border and a similar size as that of the feldspar. The brownish spots are seen to be composed chiefly of iron-oxide and calcite with some quartz grains and may be originated from dark minerals such as augite, etc. The groundmass, beside the well-arranged long bands of sericite (the larger ones are warranted to be called muscovite) which gives the rock a pronounced schistosity, is holocrystalline. It consists principally of quartz with minor feldspar and magnetite grains and shows a granoblastic texture though the crystal grains are not so uniform in size and rather broken in outline. Evidently that is not a rhyolite lava but a rhyolite tuff which has undergone some degree of sorting.

6. *Yellowish white quartz-sericite-schist:* This, megascopically, is a yellowish white, fine-grained, schistose rock. Along the schistosity, greyish white colored small lenses (0.6 × 2 mm) and thin layers (1-2 mm in width) of quartz are not uncommonly seen in the handspecimen. In slice (S865) (Fig. 2, Pl. I) it is not homogeneous and composed chiefly of well-foliated groundmass enclosing single quartz grains or their aggregates of various sizes. These aggregate is dotted with abundant parallel sericite flakes. The groundmass is made up chiefly of long shreds of sericite and small elongated quartz. Scattered magnetite grains are the only accessory minerals noticed. The quartz enclosed in the groundmass commonly shows wavy extinction and some of them are sheared to produce cross and subparallel fractures which are perpendicular and parallel to the schistosity respectively.

7. *Reddish well-banded quartz-schist:* This rock, forming the ridge near the gossan just W of Lichuang, is a reddish well-banded, schistose, hard rock with alternating yellowish and reddish bands. Under the microscope (S848) both bands are made of rather elongated quartz grains dotted with some sericite flakes. The reddish color is due to the ferruginous material scattered throughout the reddish bands. The foliation is revealed by the scattered ferruginous material, the different texture of the interbanded bands (some are coarser and some are finer), the well arrangement of the sericite flakes and lenticular shaped quartz grains. Large lenticular quartz

with broken boundaries at a size of 1-2 mm are often found embedded in the foliated groundmass as metacrysts with their longer axes parallel to the schistosity. This rock is considered to be a highly silicified rhyolite tuff.

8. *White wrinkled felsitic quartz-sericite-schist:* In handspecimen this is a white wrinkled, schistose, soft rock dotted occasionally with black spots. In slice (S864) it is rather heterogeneous, composed principally of fragments of sericitized rhyolite 2 × 3 mm in size and intensely broken or strained quartz 1 mm across embedded in a foliated groundmass. The groundmass shows a well-pronounced schistose texture with long sericite shreds arranged in parallel direction intermingled with elongated quartz grains. It is banded with bands of coarser texture and more quartz with those of fine texture and less quartz. The black spots are iron-oxide, probably hematite, and may be derived from pyrite grains as they are commonly seen scattered in the rock. This rock is also considered to be derived from rhyolite tuff but different from the former in its higher degree of sericitization.

9. *Purplish red hematite-schist:* Megascopically this is a purplish red, felsitic, schistose rock frequently with dark and white spots of hematite and kaolin respectively. In the slice (S852) it is seen to be composed of layers of different coarseness though they are similar in mineral constitution. As a whole it is porphyroblastic with metacrysts of quartz ranging from 0.1 mm across to 1 × 1.5 mm in size. They still preserve their corroded irregular borders but are now largely shattered and somewhat strained. A mass of kaolin at a size of 0.8 mm across embedded in the groundmass may be originated from the alteration of pre-existing feldspar. The groundmass is made up chiefly of quartz, hematite and sericite. The high content of quartz of this rock may be due to a process of silicification while the presence of abundant hematite grains and patches is caused by the complete oxidation of the pyrite formerly disseminated in it. Hense it is derived from a pyrite-bearing rhyolite tuff.

10. *Greyish green spotted calc-chlorite-schist:* Megascopically this is a greyish green schistose rock with abundant flatened dark greenish lenticular grains or spots approximately 1 × 2 mm in size in a light greyish groundmass. Microscopically (S861) (Fig. 4) the scattered dark greenish lenticular spots are elliptical in form

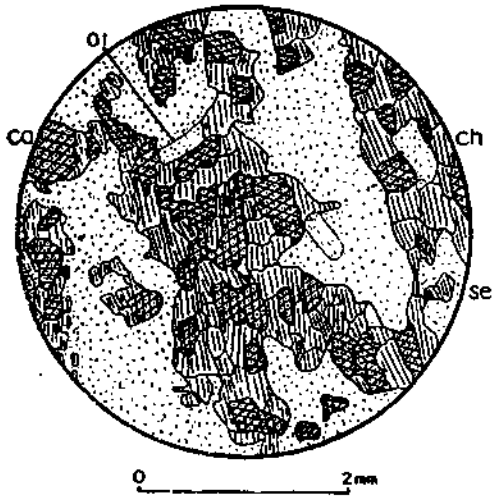

Fig. 4. Greyish green spotted calc-chlorite-schist. A figure showing the lenticular spots consisting mainly of chlorite (ch.) and calcite (ca.) embedded in a groundmass of sericite (se.), the longer axes of the spots being parallel to the schistosity. Ol, altered oligoclase.

with their longer axes roughly parallel to the schistosity. They are composed chiefly of more or less arranged chlorite and sericite flakes and subordinately of calcite and magnetite grains of various sizes. Of the sericites, the larger ones are warranted to be called muscovite. The groundmass is a mass of sericite, altered oligoclase, calcite, chlorite, quartz and magnetite. Some magnetite is in large columnar plate reaching a size of 0.3 × 1 mm. The altered oligoclase of various sizes is commonly twinned and corroded with an irregular border. They are commonly arranged along schistosity though large cyrstals athwart the foliation are also not rarely encountered. This is again supposed to be derived from andesite lava as that stated above (1, 2 and 3).

11. *Dull greenish porphyroblastic schist:* This is a dull greenish grey, porphyroblastic schistose rock. Under the microscope it (S850; Fig. 4, Pl. I) is seen that the metacrysts are mainly feldsapr and quartz. Feldspar in lath shape is up to 0.4 × 1 mm in size and has two ways of twinning. The one is Carlsbad twinning and the other, albite, though both range from basic albite to acid oligoclase in composition. It is often corroded and sericitized and also sheared with the production of bent twinning lamellae and the breaking-up of some crystals. The quartz is commonly eye-shaped and up to 0.5 × 1 mm in size. It is usually corroded and crushed, giving rise to wavy extinction and broken borders. The groundmass is microcrystalline and consists of foliated green layers with thin lenticular bodies of light color. The light colored lenses are made chiefly of quartz grains and altered feldspar scattered with small shreds of sericite and rarely epidote grains, while the green layers consist of well-arranged chlorite flakes, epidote grains and plates, sericite flakes, calcite plates, quartz grains and altered feldspar laths. Chlorite shows a pleochroism of X = Y = pale yellowish green and Z = green and a negative elongation. Magnetite grains are commonly found scattered throughout the rock. The rock is considered to be a metamorphosed toscanite [6] with abundant dark minerals such as hornblende, augite or biotite though these minerals leave no trace of the original features and are now wholly altered to the mineral aggregates which form the green layers.

B. *Associated intrusive rocks:*

1. *Granodiorite:* It is a grey, medium to coarse-grained, granitoid rock composed chiefly of feldspar and quartz with a small amount of biotite. Microscopically it (S862) is hypidiomorphic in texture consisting dominantly of plagioclase, and to a less extent of quartz. Both orthoclase and biotite are rather subordinate. Accessories are epidote, apatite, sphene and magnetite and secondary minerals are muscovite, sericite, calcite and chlorite. Granulated features are commonly seen between the contacts of quartz and feldspar and the quartz themselves. Plagioclase frequently in large subhedral forms is oligoclase of intermediate composition and is universally strongly sericitized but often with a more sodic clear rim occurred especially in the region border-

ing orthoclase and quartz. Some shows a zonary structure. Orthoclase is commonly less altered than oligoclase and is untwinned. Irregularly-scattered biotite plates, commonly bent and chloritized, have a pleochroic scheme of Z = Y = dark brown and X = straw yellow. This rock, as a whole, perhaps has suffered from some kind of hydrothermal alteration. The mineral composition of this rock in the percentage of volume is as follows: oligoclase 41.47%, orthoclase 14.12%, quartz 27.24%, biotite 6.21%, muscovite 4.71%, epidote 1.02%, and others 5.23%. This approximately corresponds with that of the adamellite rock occurring in Ching-daban of the North Richthofen Range of Chilianshan analysed by Du Rietz [6].

2. *Metagabbro:* Megascopically this is a greyish green medium-grained rock. It is schistose with its foliation well in accordance with that of the Peyinchang Volcanic Series, hence it is perhaps metamorphosed *pari passu* with the volcanic rocks and by the same dynamic force. Under the microscope it (S851; Fig. 1, Pl. I) is seen to be composed principally of hornblende pseudomorph of pyroxene and saussuritized plagioclase, together with an appreciable amount of epidote and some iron-oxide. The original ophitic texture is somewhat obliterated, lenticular masses of more or less arranged large plates of hornblende are wrapped by schistose saussurite, giving rise to a remarkable pseudoporphyritic, fluidal texture. Green actinolitic hornblende is commonly in large prismatic plates up to 1 cm long and rarely in short thick prisms averaging 0.6 cm in dimension. It is believed to be derived from pyroxene on the ground that the original shape of pyroxene is still retained by some of the pseudomorphs, though no relics of the orininal pyroxene are observed. Pale green in color it has a pleochroism of X = pale greenish yellow, Y = pale yellowish green and Z = pale green and shows $Z\Lambda c' = 15°$. The plagioclase is wholly saussuritized. It converted into a confused mass of epidote granules, actinolite needles and clear granules of albite and the saussuritization has gone so far that it renders the determination of the plagioclase impossible. Iron-oxide is the only accessory occurring as grains and irregular plates scattered in the slice.

IV. ORIGIN AND METAMORPHISM

Origin: Besides the less metamorphosed "grey sheared and sericitized rhyolite" which can be easily identified even in the field to be derived from normal rhyolite, the original rock types of the other metamorphosed volcanics are nearly impossible to be recognized megascopically. But judging from the nature and kind of primary minerals still preserved, such as quartz and feldspar, and the new ones formed during the metamorphism,* the original rock types can be deduced with certain degree of safty under the microscope. As the mineral constitution of the grey quartz-sericite-schist, the yellowish

*Such as sericite from feldspar and chlorite, calcite, epidote and quartz from dark minerals (hornblende or biotite) [8].

white quartz-sericite-schist and the white wrinkled felsitic quartz-sericite-schist consist dominantly of sericite or sericitized acid plagioclase (albite to oligoclase) and quartz with minor amount of iron oxide and with or without calcite and often contain patches of rock fragments of different color and composition, they are doubtessly derived from rhyolite tuffs; while the greenish grey calc-chlorite-schist and the dull green calc-chlorite-schist consist chiefly of sericite or sericitized oligoclase, chlorite and calcite with a small amount of iron-oxide, secondary quartz, epidote and apatite, they are believed to be derived from andesitic lavas. The light greenish grey porphyroblastic schist,* the reddish well-banded quartz-schist and the dull greenish porphyroblastic schist are inferred to be derived from vesicular andesite lava, rhyolite tuffs but later highly silicified and toscanite respectively. The purplish red hematite-schist is also considered to be derived from rhyolite tuffs but later highly silicified and pyritized by hydrothermal veins with the disseminated pyrite grains now oxidized to hematite.

Due to the overlapping affects of the products of two or more adjacent volcanoes or possible later tectonic disturbances the order of eruption is very difficult to be ascertained. What we can say about this topic is only that the Peyinchang volcanics vary twice in composition from intermediate to acid and finally the intermediate rock appears again. The volcanic activity is marked by epochs of quiescence, during which normal sedimentary rocks were deposited.

Metamorphism: Judging by the megascopic and microscopic characters of the Peyinchang volcanic rocks and their related intrusive, metagabbro, we can safely conclude that they have been deformed and sheared by stress produced by orogenic movement. The mechanical effects easily recognized by the unaided eye are the perfect schistose structure developed almost along the original bedding and the flattened and somewhat drawn-out rock fragments present in the rhyolite tuffs. Those detected microscopically include the bending of the twin-lamellation of the feldspars, the crushing and the shearing of some of the larger quartz grains. These crushing and shearing effects on some quartz grains sometimes go so far that they not only show strain-shadows and broken borders but also cross and subparallel fractures, and a quasi-mortar structure.

Proceeding *pari passu* with the above stated cataclastic processes are recrystallization and chemical reactions to form the "new minerals". The new minerals themselves do not show the effects of crushing as they possess considerable power of regeneration. Four kinds of such highly characteristic chemical changes are noticed, namely sericitization, chloritization, uralitization and saussuritization [3]. Nearly all the feldspars present in the volcanic rocks have suffered sericitization though the intensity varies considerably.

*With aggregated metacrysts of calcite, iron-oxides, chlorite in a groundmass of sericite, calcite, chlorite and iron-oxide.

Chloritization is known to be one of the most common changes undergone by the ferro-magnesian minerals, which are abundant in the andesitic rocks. Uralitization of augite to form hornblende and saussuritization of the plagioclase with the production of a confused mass of epidote, actinolite and quartz are two important processes in the metamorphism of the metagabbro.

The metamorphic process under discussion, including both the mechanical and chemical readjustments, is by no means uniform and is differentially applied to different types of minerals and rocks and even to the same mineral under dissimilar physical status. Thus the thin-bedded and finegrained andesitic lavas and rhyolitic tuffs yield more easily to the said process than the massive rhyolite and the same rhyolitic tuff is more changed in the regions more dynamically disturbed and intruded by quartz veins. The chief determinative factors for such a differentiation are the physico-chemical nature that a particular rock or mineral has possessed and the conditions under which it is subjected to deformation.

This metamorphism, quite analogous to the one studied by Y. C. Cheng in the region of Taofu, Sikang [1], is termed as dynamic metamorphism. The dynamic forces responsible for the metamorphism of the rocks stated above are produced as a result of the folding and thrusting of the rocks during an orogenic movement, taking place most probably during the Variscan epoch far after the cessation of volcanic activity but before or contemporary with the granodiorite intrusion.

V. CONCLUSION

1. So far as the present knowledge goes, Peyinchang is the only region in Chilianshan where metamorphic rocks of definite volcanic origin are discovered. There is a good section which shows the repeated variation in composition of the volcanics from intermediate to acid and then again to intermediate. The volcanic activity is marked by epochs of quiescence, during which normal sedimentary rocks were deposited.

2. The volcanic rocks are strikingly metamorphosed. The process of dynamic metamorphism which they have suffered is manifested by the mechanical breaking-down of the rocks accompanied by recrystallization and chemical reactions, giving rise to "new minerals", believed to be caused by the differential stress set up during the folding and thrusting of the beds related to the Variscan orogenic movement.

3. The age ahd stratigraphy of the thick metamorphosed rocks occurred in the Chilianshan, referred by the geologists as Nanshan Series, has long been questions in debate. These problems could only be attacked with reasonal hope of solution by careful field mapping supplemented by detailed petrographic investigation. Such a study not only helps us to distinguish a metamorphosed rock of igneous origin from a sedimentary one, but also helps us to recognize the break occurred between the overlying and underlying formations as illustrated by the present case under study (a volcanic series

well represents a break between the overlying and underlying fromations). It is thus hoped that the present preliminary work will shed some light on the solution of the problem of the so called Nanshan Series.

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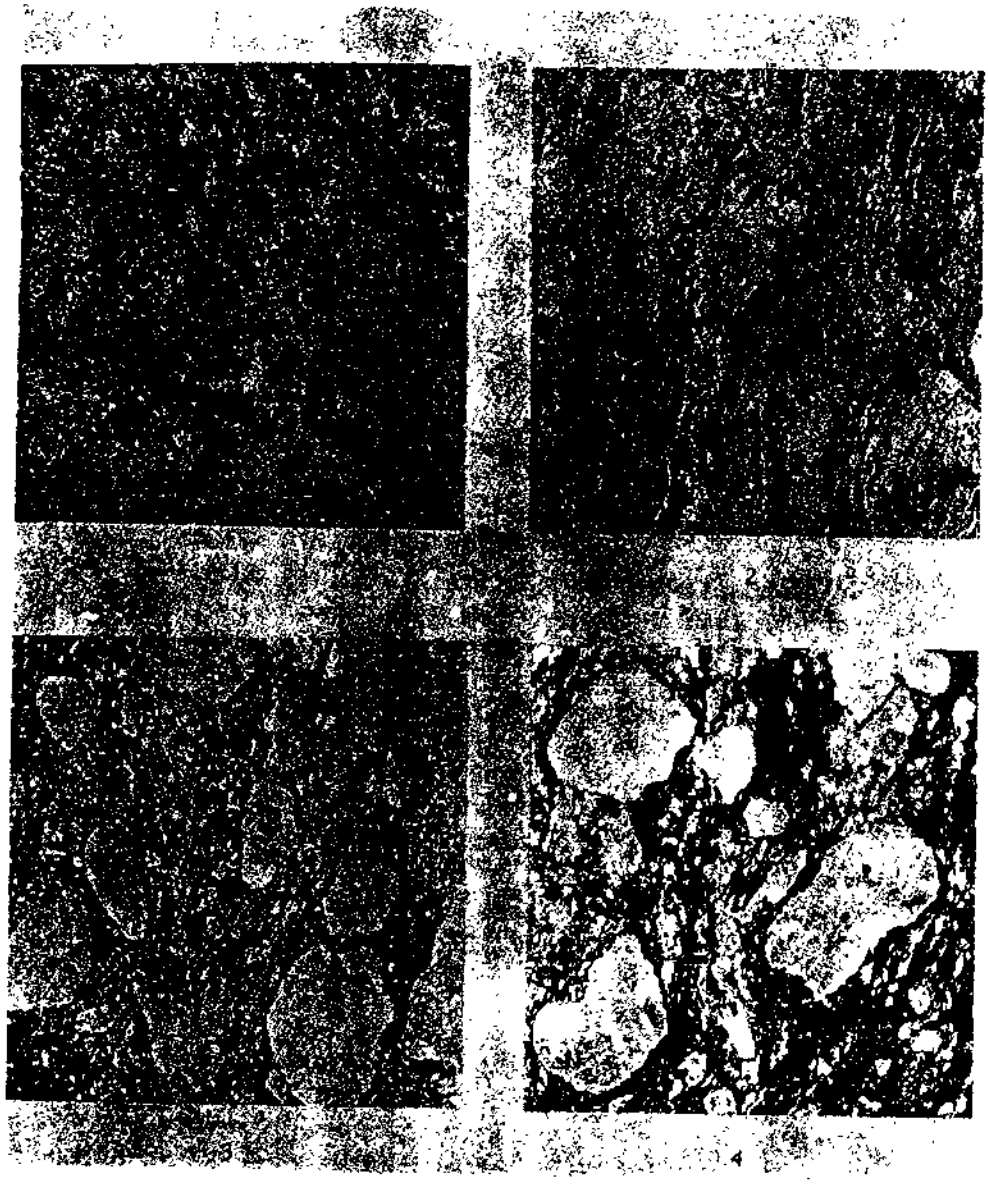
VII. EXPLANATION OF PLATE

Plate I

1. Metagabbro showing hornblende pseudomorph of pyroxene (subrounded crystals) and large plate of hornblende (grey) wrapped by more schistose saussurite (black), giving a pseudoporphyritic texture. S851. × 46. ||nicols.
2. Yellowish white quartz-sericite-schist showing the remarkable foliated texture with the well-foliated groundmass made up chiefly of long shreds of sericite (grey) and small elongated quartz (white), enclosing lenticular quartz (white) or aggregate of quartz grains. The black spots are magnetite grain. S865 × 46, ||nicols.
3. Grey sheared and sericitized rhyolite showing poorly-developed schistosity and a porphyritic texture with corroded and embayed quartz (white) and tabular acid plagioclase (greyish white) as phenocrysts and elongated quartz and well-arranged sericite shreds (black and dark grey) as groundmass. S858. × 13, ||nicols.
4. Dull greenish porphyroblastic schist showing the porphyroblastic and schistose textures with the plagioclase (grey and mottled) and quartz (white and clear) as the metacrysts and with the foliated layers (black) made up chiefly of chlorite plus epidote and lenticular bodies (grey and white) made up of quartz and altered plagioclase as the groundmass. S850. × 22 ||nicols.



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