A SULPHIDES-BEARING PERIDOTITE FROM SZECHUAN[1]

(With I plate)

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A. GENERAL DESCRIPTION

This peridotite is collected from Ching Kuang Shan (青礦山), Hui Li Hsien (會理縣), Szechuan Province Its colour is greenish black The texture is medium coarse grained. The cleavage surfaces of the amphibole-pyroxene minerals are fairly exhibited. Pyrrhotite specks are plentifully sprinkled through the whole mass. On the polished surface a little chalcopyrite, usually associated with pyrrhotite, can be recognized. Plagioclase can hardly be seen by the naked eyes. Thin sections showing the general appearence of the rock are illustrated by the figures in Plate I.

B. MICROSCOPICAL EXAMINATION

Under the microscope this rock shows the following minerals:

Olivine:—Olivine is usually bounded and corroded by silicates and sulphides, as fig. 1. It sometimes streches into or is enclosed by some other minerals. Nearly all the grains of olivine alter to serpentine forming the mesh structure. In some slices the alteration of the rock is more advanced that the olivine entirely alters to serpentine and the serpentine to talc, as fig. 2. This shows that the alteration of olivine consists of the following two successive steps: (1) The olivine begins to alter to serpentine along the cracks and at the borders, while the inner portion which is less fractured remains unchanged. (2) As the alteration goes on, the inner portion is also attacked by the alteration processes and changes to serpentine, and the serpentine, which is already altered from olivine, is more or less affected to change its composition, and some other alteration-mineral may be produced, such as talc. The talc is now found in the place where was formerly occupied by serpentine.

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1) A short description has already been written by Dr. W. H. Wong in his book, "The mineral Resources of China", pp. 213-214, published by the National Geol. Survey of China.

When the altered olivine is entirely enclosed in the silicates, it frequently gives some radial cracks to the enclosing minerals, (here the enclosing mineral is augite), as fig. 3. This is caused by the subsequent expansion of volume due to alteration. And the edge is sometimes bordered by a layer of pyroxene minerals.

Augite:—The augite in the thin section is colourless. It has no definite form, usually forming interstícial masses and moulding on the olivine. It is often replaced by hornblende along the cracks or at the borders with the former forming the kernel, as fig. 4. The inclusions of sulphides and olivine are commonly found in the augite.

Bronzite:—Among the pyroxene minerals, besides the augite, there are some grains of bronzite which is, in some parts, bordered by hornblende. It differs from augite by the longitudinal and symmetrical extinctions and by the rosy pleochroism.

Hornblende:—The hornblende in the slice is brown in colour with strong pleochroism. It is an uralitic variety and is more frequently to be found in the sides towards the olivine or in the spaces between it.

Biotite:—It is the least abundant among the forro-magnesium minerals. The mode of occurrence is essentially the same as the augite and hornblende. Sulphides inclusions are often found in it. The hornblende penetrates biotite frequently along the clavages. In some slice the obitite alters to chlorite.

Feldspar:—A small amount of feldspar is found in the interstices. It is found to be bytownite. Some crossed sections of augite and patches of sulphides are enclosed in it.

Sulphides:—By a careful examination, the rock contains three different kinds of sulphides, viz., (1) pyrrhotite, (2) chalcopyrite and (3) pentlandite. The chalcopyrite can easily be distinguished from the pyrrhotite, because the colour of the former is yellow and that of the latter is bronze. It is difficult to differentiate the pentlandite from the pyrrhotite by ordinary microscope. These two minerals are mixed up in a very intricate manner and both of them are bronze in colour. The study of opaque minerals would be much facilitated by vertical illumination. But this kinds of equipment has not been completely installed in the Survey's petrographical laboratory.

Here the pentlandite is recognized by using strong reflected light under ordinary microscope. It shows a bronze colour, but it is a little whitish when compared with pyrrhotite. They all form irregular patches, often enclosing or embaying silicates and filling the intersticial spaces.

The relation among the sulphides themselves is not clearly shown. But by a close study the chalcopyrite, when it associates with pyrrhotite and pentlandite, is often found at their border from which it yields some small veinlets penetrating into the interior portion. Evidently the chalcopyrite replaces pyrrhotite and pentlandite. The pentlandite in turn replaces pyrrhotite. Their replacement is briefly shown in fig. 5. From this account chalcopyrite is younger than pentlandite and pentlandite younger than pyrrhotite.

The nickel is contained in pentlandite. This is confirmed in the following way: Grind a piece of the rock into fine particles to pass through a fine mesh. Pick up the pyrrhotite by the magnetic shoe. Dissolve the non-magnetic portion, containing the pentlandite which is non-magnetic, in HNO_3. Add NH_4OH to the solution and filter. To the filtrate add several cc. of dimethylglyoxime solution. A scarlet precipitate, which is the salt of dimethylglyoxime, is formed. This chemical test is not only to confirm the nickel derived from pentlandite, but also to prove that the pentlandite is acturally present among the sulphides.

Accessory minerals:—A few accessory minerals such as magnetite and apatite are found. The magnetite is often corroded and only a few grains retain its crystal form. Apatite usually forms rectangular crystals or long slender needles. Both magnetite and apatite form inclusions.

C. MINERALOGICAL AND CHEMICAL PERCENTAGE

This rock is mineralogically analysed by the Wentworth's improved recording micrometer, and the following is the percentage of the essential minerals:

Olivine and serpentine	53.42 %
Mafites (including augite, hornblende & biotite)	30.96
Feldspar	4.84
Sulphides	10.745
	99.965

The following chemical percentage is calculated from the mineralogical composition.

SiO_2	25.27
Fe_2O_3 & FeO	22.87
Al_2O_3	9.38
MgO	20.759
CaO	8.39
K_2O	3.15
Na_2O	0.42
H_2O	0.604
Ni	3.041
S	3.96
Cu	1.73
	99.574

D. CRYSTALLIZATION OF MAGMA

From the result of the microscopical study the crystallization of magma has the following order: Apatite, magnetite, olivine, and probably augite are first crystallized out, and later are formed hornblende, biotite, plagioclase and sulphides. The crystallization of each mineral is not completely one after the other but in a continuous and overlapping manner. The younger minerals often begin their crystallization before the older ones have finished, so that the younger minerals, in many cases, are enclosed in the older ones. Olivine and magnetite after their separation from the magma are corroded or more or less resorbed. At the same time the augite and hornblende are also in separation, so that in one slice the augite and hornblende inclusions are found in olivine. Biotite is the youngest among the ferro-magnesium minerals, yet it is sometimes found in hornblende. As regards the plagioclase, it is the youngest among the silicates. Its crystallization begins at the time of continuous separation of hornblende, thus a few grains of the former are found in that of the latter.

The relation of crystallization of sulphides to other minerals is very complex. They corrode the pre-existing minerals and fill up the interstices, but they also form inclusions in the other minerals. Its separation from the magma may not be later than that of olivine. But the solidification goes on very slowly. A part of the sulphides solution may be in crystallization, while the remaining part is still in fluid until all the other minerals have crystallized. The slow solidification may be due to the presence of vapours or gases in the sulphides solution.

E. ORIGIN OF THE SULPHIDES

Form the microscopical study there is no indication that the sulphides are later introduced into the rock through the metasomatic process. The fact that they corrode the pre-existing minerals and form inclusions is the evidence of their magmatic origin through differentiation.

EXPLANATION OF PLATE I.

Fig. 1.—Olivine is corroded by sulphides.

Fig. 2.—Olivine alters to serpentine (S) and serpentine to talc (T). Black, sulphides.

Fig. 3.—Olivine is bordered by a layer of pyroxene mineral, giving radiating cracks to augite due to the subsequent expansion of volume.

Fig. 4.—Augite is replaced by hornblende.

Fig. 5—Pyrrhotite is replaced by pentlandite and chalcopyrite. Py., Pyrrhotite, Pt., Pentlandite, Ch., Chalcopyrite.

Fig. 1.

Fig. 2.

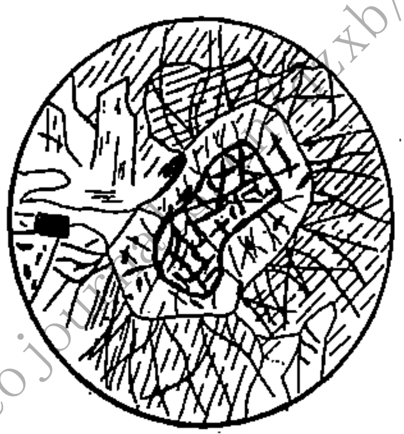

Fig. 3.

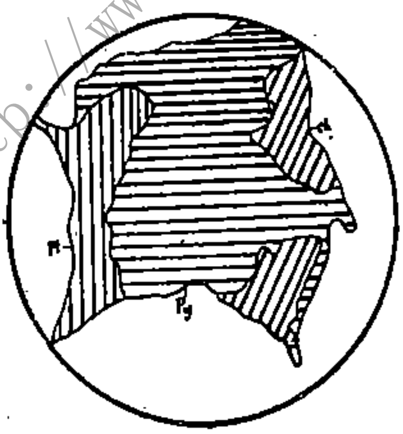

Fig. 5.

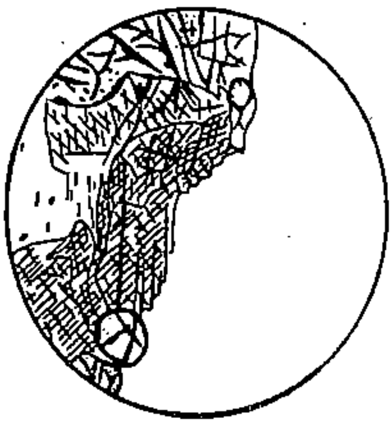

Fig. 4.