Cyanite-Andalusite Deposits in the So-Called Okch'ŏn (Yokusen) System

Takao YAMAGUCHI

1. Preface

It was only in the few years following 1939 that cyanite-andalusite deposits were discovered in the so-called Okch'ŏn (Yokusen) System. The deposits are distributed in schistose rocks, just as in other parts of Korea. The cyanites in the deposits are generally very large crystals. The length along the c-axis is generally about 10 cm and occassionally about 50 cm. The so-called Okch'ŏn System has been considered one of the Archean Systems in Korea, but many geologists, including the author, tend to doubt this because of the lack of conclusive evidence.

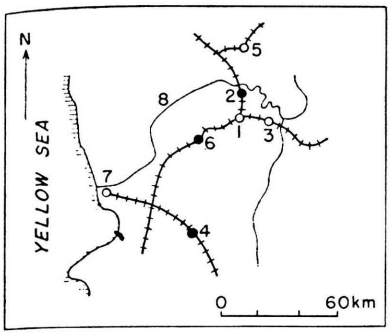
The author surveyed deposits in the three regions as follows:

1. The Okch'ŏn area proper
2. The eastern region of Yŏnsan
3. The vicinity of Chŏnju

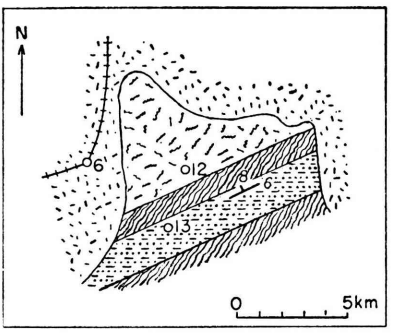
2. Geology and Petrology

1. *Geology of the so-called Okch'ŏn System*: The geological map is shown in Fig. 1. The metamorphic rocks in the three regions are thought to belong to the same geologic system because they have very similar rock layers—mica schist, chiastolite-bearing schist and quartzose schist or granulite. The plane of schistosity and the plane of stratification are thought to be parallel to one another because no evidence to the contrary has been found. The connection between the geological structures of the three regions, therefore, is thought to be a recumbent syncline separated by intrusions of granite (Fig. 2).

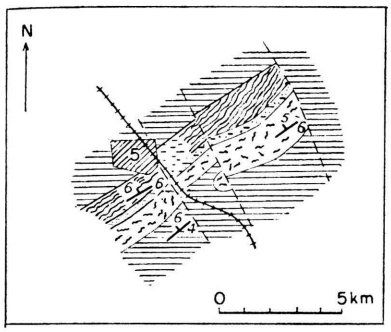
2. *The relationship of granite* (G) *and Gneiss* (N) *to the so-called Okch'ŏn System*: In the Okch'ŏn region and the eastern region of Yŏnsan, the system is intruded by granite (G), perhaps belonging to the Pulguksa Series. The granite (G), therefore, is thought to have intruded after the formation of schistosity in the system. The granite shows almost no thermal metamorphism in the schists even along their contact zones.



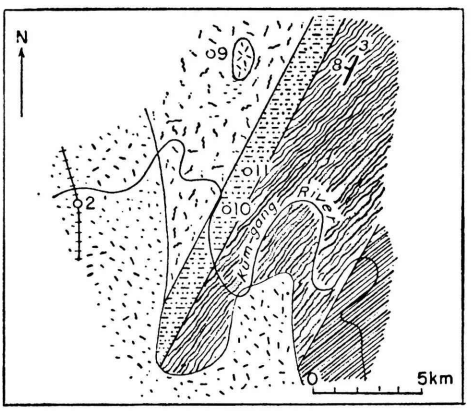
A. Index map



B. Geological map of the eastern part of the Yŏnsan district



C. Geological map of the environs of Ch'ŏngju



D. Geological map of the type localities of the Okch'ŏn system

Fig. 1. Index Map and Geological Maps of Part of Southwestern Korea.

LEGEND

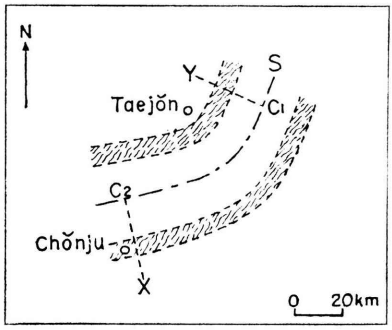
- Conglomeratic phyllite
- Mica-schist
- Chiastolite-schist
- Cyanite andalusite deposit
- Quartzose-schist (Granulite)
- Granite (Pulguksa series?)
- Blasto-mylonitic gneiss
- Strike and dip

NAMES

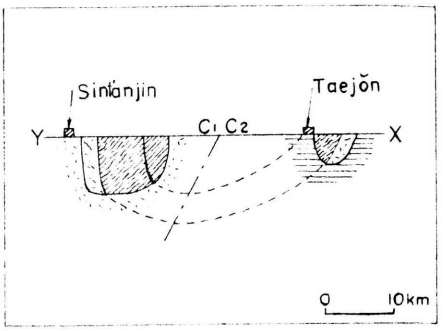
1. Taejŏn
2. Sint'anjin
3. Okch'ŏn
4. Chŏnju
5. Ch'ŏngju
6. Yŏnsan
7. Kunsan
8. Kum-gang
9. Munui
10. Pugong-ni
11. Sansŏ-ri
12. Yangsal-li
13. Tŏngmong-ni

Gneiss (N) is distributed over the Chŏnju region and the plane of schistosity is almost parallel to that of the Okch'ŏn System. The apparent intrusive relationship along the contact zone is disturbed by dynamometamorphism. The gneiss is a blasto-mylonite (Fig. 3) and the "Gefügerelung" of any quartz present shows

the effect of considerable dynamometamorphism (Fig. 4). The original gneiss (granite), therefore, is thought to have intruded before the dynamometamorphism of the system as SHIMAMURA, (1926) and SUZUKI (1926) have ever stated.



A. Horizontal Section showing flexure



B. Vertical section showing recumbent syncline

Fig. 2. Geologic Structure.

LEGEND

- Conglomeratic phyllite
- Mica-schist
- Quartzose-schist (Granulite)
- Granite
- Blasto-mylonitic gneiss

YC_3C_2X Plane of vertical section (B)
S Axis of syncline

STRATIGRAPHICAL SUCCESSION

Upper
- Conglomeratic phyllite (4,000m)
- Mica-schist (8,000m)
- Quartzose-schist (5,000m)

Lower

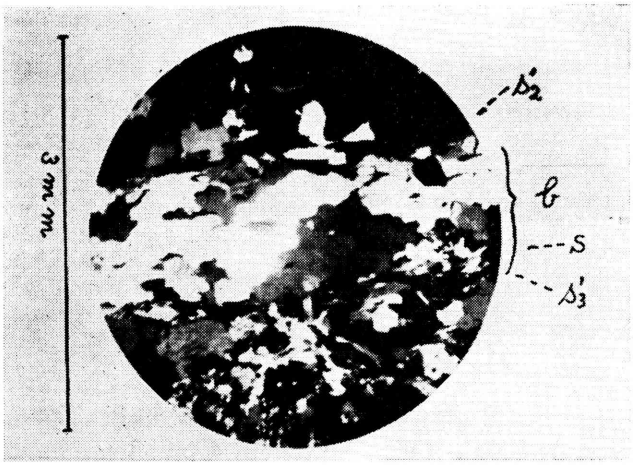


Fig. 3a. Quartzose Band.
(Under crossed nicols)

b Quartzose band parallel to the general schistosity (S)
S'_2, S'_3 Planes of quartz grains showing blasto-mylonitio structure.

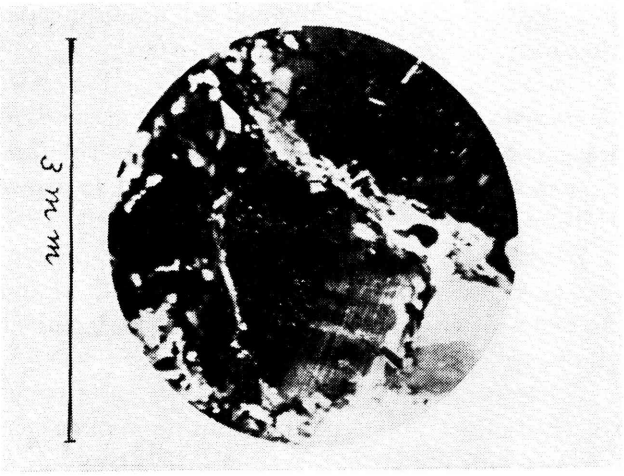


Fig. 3b. Deformed Phenocryst of Plagioclase.
(under crossed nicols)

The phenocrysts of plagioclase show wavy extinction under crossed nicols caused by deformation.

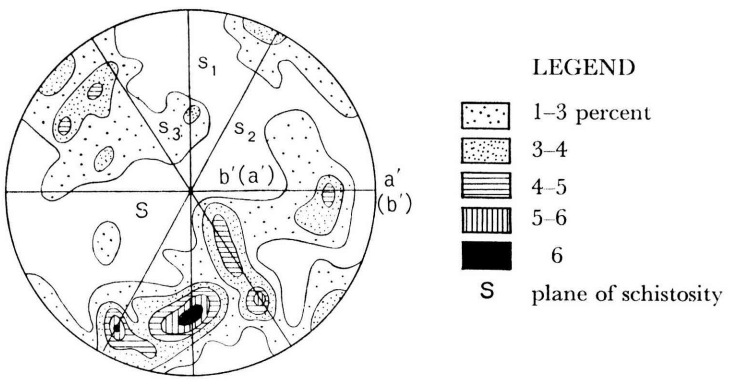


Fig. 4. The "Gefugeregelung" of Quartz in the Quartzose Layer
S_1, S_2, S_3, Latent planes of "Einregelung" (8.5 c-axis)

The field relation between the granite (G) and gneiss (N) was not discovered.

3. *Metamorphic rocks of the so-called Okch'ŏn System*: Metamorphic rocks are generally of a lower grade. According to Eskola's mineral-facies principle, they show chlorite facies~biotite facies. They can be divided roughly into three types: conglomeratic phyllite (P), mica schist (M), including chiastolite-bearing schist (C), and quartzose schist or granulite (Q) (Figs. 1 and 2).

Conglomeratic phyllite (P) The pebbles are derived from quartzite and are relatively sparse. The phyllitic part is composed of chlorite, sericite and quartz. It is similar to the conglomeratic phyllite in the uppermost formation of the so-called

Sangwŏn System to the north of the Yŏnchŏn Metamorphic Group,* but the former has a higher distribution density than the latter.

Mica schist (M), *including chiastolite-bearing schist* (G) The mica schist is composed of biotite-muscovite, together with some chlorite-sericite-quartz schist and chiastolite-bearing graphite. The chiastolite forms large columnar crystals (the length along the c-axis is 1–5cm), which generally tend to crowd one another. The c-axis generally lies on the schistosity plane. In the Okch'ŏn region and the eastern region of Yŏnsan, the cyanite deposits show a very close relationship to the chiastolite-bearing schist. In the mica schist zone, rare cordierite-mica rocks are found (the diameter of the cordierite is as great as 1 cm) along with some garnet-anthophyllite-cordierite rocks.

Quartzose schist (Q) *or granulite* This zone is composed of tremolite or sericite-bearing quartzose schist or granulite, and contains some mica schists and crystalline limestone. Linear schistosity is not found, in general, except at the contact of the sericite-quartz schist and the gneiss south of Chŏnju (Figs. 1 and 4).

3. Cyanite-Andalusite Deposits

Descriptions of the deposits (divided into four groups):

a. Cyanite deposits in the mica schist zone in the Okch'ŏn region
a′. The same as "a" in the eastern region of Yŏnsan
b. Andalusite deposits in the mica schist in the zone of granulite in the Okch'ŏn region
c. Andalusite deposits in the zone of mica schist near Chŏnju

Deposits a and a′ have the same characteristics. "a" and "a′" deposits occur in the chiastolite-bearing schist zone and are closely related to the schist. They are cyanite-bearing veins or pockets which accompany quartz (Fig. 5). In mining, weathered residual blocks are collected. The average cyanite content is about 50 percent. The "a′" deposits are concentrated around Tongmong-ni and the "a" deposits around Sansŏ-ri. The amount of cyanite in the two regions is about 4,000 tons. The "b" type deposit is found near Munŭi. The deposit is an andalusite-bearing vein, accompanied by cyanite, muscovite and quartz, in garnet-biotite-muscovite schist. It resembles the deposits of the Yŏnchŏn Metamorphic Group. The deposits near Chŏnju are andalusite-bearing veins or pockets which accompany quartz and chiastolite-bearing schist in the mica schist zone. The amount of andalusite present may reach 3,000 tons.

Genesis of the deposits—The genesis of deposit "b" is thought to be the same as that in the Yŏnch'ŏn Metamorphic Group. As for deposits closely related to chiastolite-bearing schist (a, a′ and part of c) (Fig. 5), chiastolite is thought to have recrystallized in fissures or cavities. As for deposits in mica schist, the fine needles

* Refer to the author's paper "On the so-called Yŏnch'ŏn System and the Cyanite-andalusite deposit in it".

of sillimanite in the fine veins, composed of sillimanite and chlorite, are the present problems (Fig. 6).

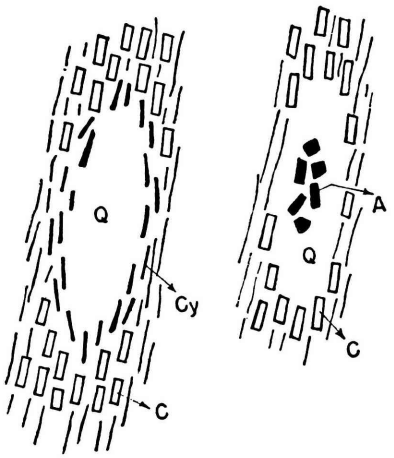


Fig. 5. Sketch of Cynite-Andalusite-Bearing Veins or Pockets in the Chiastolite-Bearing Schist.

Q, Quartz; Cy, Cyanite; A, Andalusite; C, Chiastolite

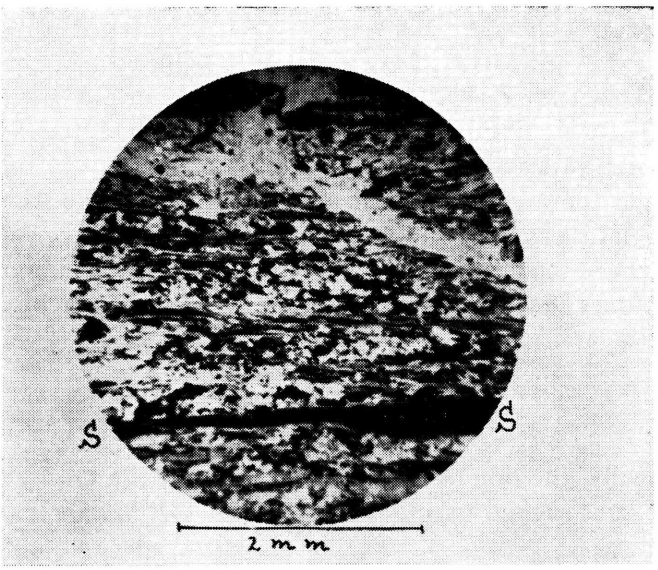


Fig. 6a. Sillimanite-Chlorite Vein.

S, Sillimanite-chlorite vein parallel to the general schistosity. In this vein, many fine needles of sillimanite lie parallel to the vein walls in matrics of chlorite.

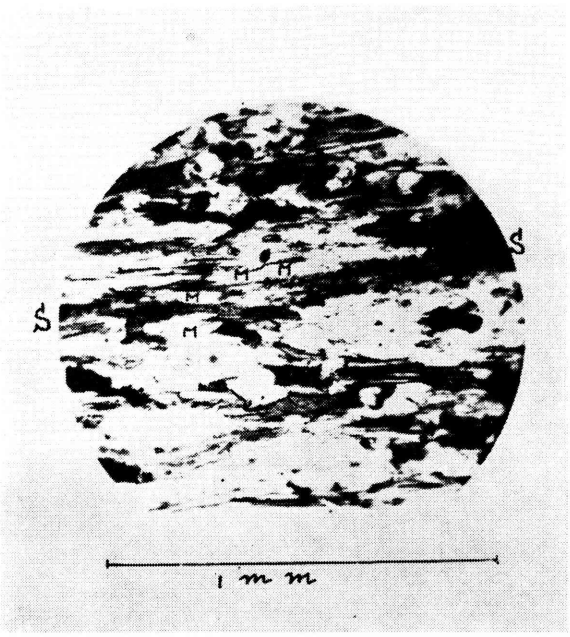


Fig. 6b. Sillimanites after Muscovite.
M, Sillimanite aggregate after muscovite. The sillimanite needles lie parallel to the cleavage planes of muscovite.
S, Sillimanite-chlorite vein.

It seems sure that the fine veins of sillimanite and cholorite were formed by means of a process such as the following:

micas $-K_2O\rightarrow$ sillimanite + chlorite,

where $-K_2O$ means the removal of K_2O.

It is possible that the chiastolite-bearing schist was derived from a mica schist by means of a similar process:

mica schist $-K_2O\rightarrow$ chiastolite-bearing chiorite schist,

even if its original rocks might have been rather rich in Al_2O_3.

The chiastolites are thought to have been formed under dynamometamorphism, because their c-axes lie on the schistosity plane. They were sericitized by the addition of K_2O in a later stage.

4. Summary

1. Chronologically, the original sedimentary rocks of the Okch'ŏn System were formed before the original granite of the gneiss (N), which is older than the granite (G).

2. The dynamometamorphism occurred later than the intrusion of the original granite of the gneiss (N) in the Chŏnju region, and earlier than the intrusion of Pulguksa granite (G).

3. The cyanite-andalusite deposits are divided into two types, according to occurrence: (a) those in mica schist, and (b) those closely related to chiastolite-bearing schist.

4. Genetically, the (a) deposite were formed from mica schist by means of K_2O-removal, and the (b) deposits by means of migration of chiastolite into the fissures or cavities. It is also possible that the chiastolite-bearing schist was derived from the mica schist by means of K_2O-removal.

REFERENCES

1) Shimamura, S. (1926). Geologic Atlas of Korea, no. 5, Chŏnju sheet.
2) Suzuki, J. (1926). *Jour. Geol. Sec. of Japan*, v. XXXIII, p. 443.