

Metamorphic Conditions of Chondrodite-Bearing Calcareous Xenoliths in the Inada Granite, Kasama, Ibaraki

Yusuke Yachi[1], Takashi Miyano[2], Masahide Kono[3]

[1] Geosci., Univ. Tsukuba, [2] Inst. Geosci., Univ. Tsukuba, [3] Takata Co., Ltd

Calcareous xenoliths containing chondrodite occurs in granite quarries of Inada. Chondrodite ($Mg_5(SiO_4)_2(OH,F)_2$) is a member of the humite group. It coexists with calcite, tremolite, dolomite, and diopside, and contains F of about 6.7 wt% with the F/(F+OH) ratio of about 0.63.

In order to estimate the metamorphic condition of the calcareous xenoliths, the phase relations of mineral assemblages were quantitatively analyzed in T-X(CO₂) space at 2 kbar. The constructed isobaric phase relations show that the chondrodite-bearing calcareous xenoliths were formed at the CO₂-poor condition. It is presumably caused by H₂O-infiltration during granite solidification.

The Inada area, Kasama, Ibaraki, is well known for large production of coarse granite in use for building and construction materials. It is situated in the north of the Tsukuba granite district. The Inada granite, which is early Paleogene in age, intruded into late Jurassic-early Cretaceous sedimentary rocks corresponding to the Yamizo Supergroup (Ishihara & Kono, 2000). In granite quarries of Inada, many small to large sized xenoliths of the sedimentary rocks crop out and are metamorphosed. The hornfels are composed mainly of pelitic rocks and psammitic rocks, and occasionally calcareous rocks.

Two calcareous xenoliths were collected from the Nishizawa and Iwakura pits (refer to xenolith 1 and xenolith 2, respectively) in the Inada granite quarry (Takata Co. Ltd). They contain various skarn minerals such as diopside, tremolite, phlogopite, and chondrodite. Each xenolith is composed of carbonate-rich central part and diopside-rich outer part. Chondrodite commonly occurs in the central part. The central part of xenolith 1 consists mainly of coarse-grained calcite and chondrodite with small amounts of tremolite and dolomite. Chondrodite in places coexists with diopside, calcite, and tremolite in the boundary zone of the central and outer parts. The central part of xenolith 2 is composed mainly of fine-grained equigranular calcite and dolomite with lesser amount of chondrodite. This chondrodite coexists with neither tremolite nor diopside.

Chondrodite ($Mg_5(SiO_4)_2(OH,F)_2$) is a member of the humite group including humite, clinohumite, and norbergite. The humite group minerals found in meta-carbonate rocks are typically rich in fluorine. The phase relations of clinohumite in calc-silicate rocks were well examined by Rice (1980). Using a non-ideal F-OH mixing model of Duffy & Greenwood (1979), he noted that the stability of clinohumite in T-X(CO₂) space is enlarged with increasing fluorine substitution. In xenolith 1, chondrodite coexisting with diopside, tremolite, and calcite contains F of about 6.7 wt%. The F/(F+OH) ratio of the mineral is calculated at about 0.63 based on 10 (O, OH, F). Similarly to clinohumite, chondrodite is considered to be stable at higher X(CO₂) than fluorine-free or -poor chondrodite.

In order to estimate the metamorphic conditions of the calcareous xenoliths, the phase relations of mineral assemblages in xenolith 1 were quantitatively analyzed in the system CaO-MgO-SiO₂-H₂O-CO₂, and the isobaric T-X(CO₂) diagram at 2kbar was constructed. As there are present six solid phases of chondrodite, diopside, tremolite, calcite, dolomite, and forsterite, and one fluid phase. Assuming the CO₂-H₂O binary fluid and substantial substitution of OH for F and Mg for Fe in chondrodite, stability fields of chondrodite + diopside and chondrodite + tremolite + calcite are restricted to below X(CO₂)=0.45 and 0.46 at 2Kbar, respectively. Using the calcite-dolomite pair in the central part of xenolith 2, the metamorphic temperature is calculated at 366 to 599C from the calcite-dolomite geothermometry of Anovitz and Essene (1987). The maximum temperature is in agreement with the temperature of roof pendant in the Inada granite reported by Mizuno and Miyano (1995). Using the temperature, X(CO₂) ranges from 0.20 to 0.34 in the central part and below 0.2 in the boundary zone of the central and outer parts of xenolith 1. These results suggest that the calcareous xenoliths were formed at the CO₂-poor (H₂O-rich) condition being presumably caused by H₂O-infiltration during granite solidification.