Garnet and staurolite porphyrobalsts in the Imjingang Metamorphic Belt: Preliminary research for P-T-t-D path

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1. Introduction

The Imjingang metamorphic belt (IMB) in south Korea is located between Pyeongnam Basin and Gyeonggi massif (Fig. 1). The IMB is characterized by the Devonian-Carboniferous Imjin Group composing originally siliciclastic and carbonate sequence with volcanic rock (Fig. 1). The Yeongcheon complex of the western IMB, underlaying the Imjin Group, is divided into the Jingok and Samgok units (Fig. 1). The Jingok unit to the north, studied in this paper, is composed of pelitic to semipelitic schists, phyllite and quartzite with minor marbles.

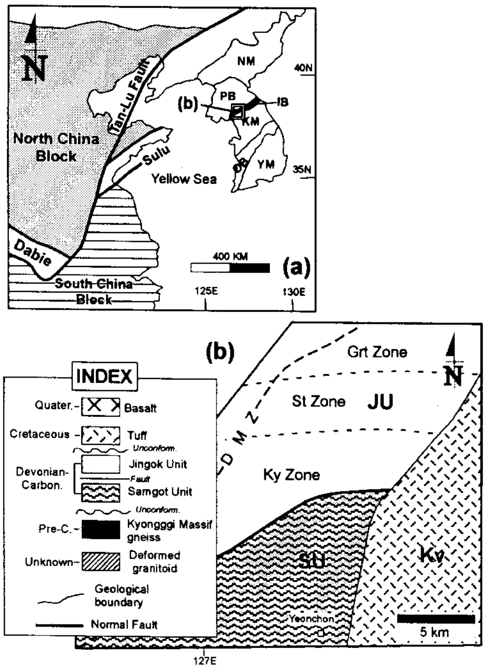

Fig.1. Geological map of the Imjingang metamorphic belt in Yeoncheon Area. Ju=Jingok unit, Su, Samgok unit, Kv=cretaceous(?) tuff, Grt=garnet, St=Staurolite, Ky=kyanite, NM=Nangrim massif, KM=Kyeonggi massif gneiss. After Ree et. al. (1996).

Metapelites in the Jingok unit of the IMB preserve a barrovian paragenetic sequence from garnet zone, staurolite zone to kyanite zone southward. Peak metamorphic P-T conditions are 6.6 ~ 11.0 kbar and 630 ~ 690 °C, and show a clockwise path (Kim, 2002). Ree et al. (1996) suggested that P-T conditions of amphibolite in the Samgok unit are 8.0 ~ 13.0 kbar and 630 ~ 790 °C indicating a high-pressure amphibolite facies metamorphism.

Combining of detailed microtextural investigation on inclusion trails within garnet and staurolite porphyroblasts and the matrix foliations to the metamorphic observations can give rise to a detailed deformation and metamorphic history and P-T-d (deformation) path. In this paper, we have presented an approach that could determine P-T-d paths based on the isopleths of garnet components and inclusion trails geometries preserved within the porphyroblasts. Then, we proposed the quantitative P-T-d paths for the Jingok unit in the IBM and discuss its late Paleozoic tectono-metamorphic implications.

주요어 : Garnet and staurolite porphyroblast, FIA, Pseudosection, Bulk crustal shortening

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2. Results

Garnet and staurolite grains in metapelitic schist in the Jingok unit occur as porphyroblast. Garnet porphyroblasts in three metamorphic zones preserved straight and/or curved inclusion trails recognized by alignment of quartz, biotite, ilmenite and/or rutile. Staurolite porphyroblasts in staurolite and kyanite zone also preserved both S- or Z-shaped and differentiated crenulation cleavage as inclusion trails. Inclusion minerals within staurolite porphyroblast are quartz, ilmenite, biotite. The inclusion trails within staurolite porphyroblast are continued to the matrix foliation.

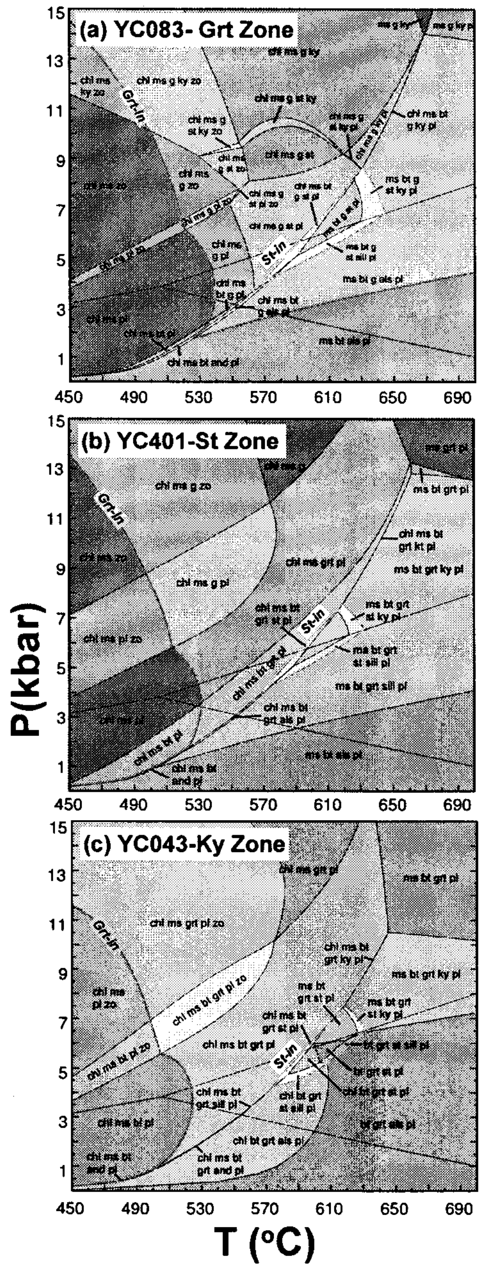

Fig. 2. P-T pseudosections in MnNCKFMASH systems.
(a) sample YC083(Grt zone), (b) sample YC401(St zone)
(c) sample YC043(Ky zone)

A total 10 Foliation Intersection Axes (FIA) trends of garnet and staurolite porphyroblasts were measured from samples collected from the Jingok unit in the IMB. All data are single FIA trend, so it is not possible to distinguish the relative growth phases. Garnet FIA trends in the IMB display a consistent distribution, that is E-W (90~120°), and those of staurolite lie around NE-SW (50~70°). These FIA data indicate that bulk crustal shortening direction may have changed from N-S to NW-SE.

Fe/(Fe+Mg) of garnet in Grt-, St- and Ky-zone ranges 0.92~0.87, and decreases from the core to the rim. X_{Mn} in samples YC047 and YC043 is a little higher than that in sample YC083 (grt zone), and generally decrease towards the rim. X_{Ca} in garnet of sample YC083 is almost flat, whereas that in garnet of staurolite and kyanite zone increases towards the rim. X_{Fe} and X_{Mg} in garnet of three samples range from 0.61 to 0.82, and increase towards the rim. The Fe/(Fe+Mg) ratio of staurolite grains in staurolite and kyanite zone is not much different (0.83~0.88). However, Zn content in staurolite of kyanite zone (sample YC043) is higher than that of staurolite zone (sample YC047). Zn in staurolite of samples YC043 and YC047 appears to decrease from the core to the rim.

The P-T pseudosections for samples from the IMB were calculated in MnNCKFMASH system shown in Figure 2. The fields are labeled with stable mineral assemblages and darker shades are used for higher variance fields. The P-T pseudosections for samples YC083 (garnet zone), YC401 (staurolite zone), and YC043 and YC045 (kyanite zone) reveals that garnet could grew at a moderate P-T conditions (530 °C and 5.0 kbar), and staurolite can be initiated around 590~600 °C at 7.0 kbar with/without appearance of biotite. Staurolite has stability field with muscovite, biotite, garnet, plagioclase around 580~630 °C and 4. 5~7.5 kbar after demise of chlorite and before kyanite appearance (Fig.2)

3. Conclusions

Peak metamorphic conditions for garnet, staurolite and kynite zone are calculated from garnet rim and matrix mineral compositions using the average P-T mode in THERMOCALC (Powell et. al., 1998). The peak metamorphic conditions for each metamorphic zone are 605±29 °C and 8.1±1.0 kbar for garnet zone (YC083), 593~619±29 °C and 8.3~9.1±1.0 kbar for staurolite zone (YC401 and YC047), and 595~603±20 °C and 7. 8~8.1±0.9 kbar for kyanite zone (YC043 and YC045). There are no difference in P-T conditions for three metamorphic zones.

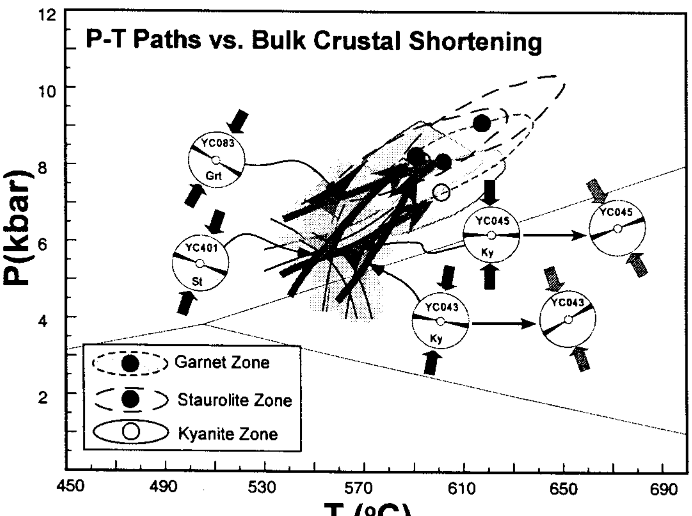

Fig. 3. FIA linked P-T-deformation path for garnet growth in three metamorphic zones in the Jingok unit.

P-T paths for garnet growth in three metamorphic zones can be divided into two types (Fig. 3): (1) sub-isobaric heating (e.g., samples YC083 and YC045), and (2) compressional heating (samples YC401, YC043). The bulk crustal shortening direction during the garnet growth was mainly N-S ~ NNE-SSW. NE-SW~ENE-WSW FIA trends (50~70°) preserved only within staurolite porphyroblast indicate that NW-SE~NNW-SSE bulk shortening was followed. Consequently, garnet porphyroblast in the Jingok unit probably has formed by sub-isobaric heating and/or compressional heating under N-S~NNE-SSW crustal shortening, followed by staurolite growth by decompressional heating and/or cooling under NW-SE~NNW-SSE crustal shortening.

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