Curious Symplectic Textures Associated with Khondalite: The Central Highland Complex, Sri Lanka

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1. Introduction

Symplectic reaction textures are common in high-grade rocks and their formation is usually ascribed to cooling and/or decompression following the metamorphic peak (Pitra and Waal, 2001). However, Spinel-Plagioclase (Spl-Plag) and Corundum-Plagioclase (Cor-Plag) symplectite after Sillimanite (Sil) and Spl-Plag symplectite after Garnet (Grt) in silica saturated matrix are very rare in highly aluminous high grade pelitic granulites. However, such Spl-Plag symplectite after kyanite (Ky) has been reported in many high pressure granulites and eclogite terrains while Spl-Cordierite symplectite after Sil/Andalusite and/or Grt has been encountered in many granulite facies terrains (e.g. Stipska. et al., 2010). Nevertheless the published data on Spl-Plag symplectite after Sil and Grt are very limited (e.g. Hiroi et al., 1997). In this study, we discuss petrological features of Spl-Plag and Cor-Plag symplectite after Sil and Spl-Plag symplectite after Grt in silica saturated Khondalite (graphite-bearing Grt, Sil, K-feldspar, Quartz granulite) which was collected from Matale, in the central Highland Complex Sri Lanka.

2. Geological Setting and Field Relations

The study area lies within Matale district where dominant rock types are meta-sediments such as marble, Grt Sil Biotite (Bt) gneiss, quartzite and calc gneiss. Ortho-gneisses consist with granitoid composition and charnockitic gneisses represent the meta-igneous affinity. Pegmatites and hydrothermal deposits are well exposed in Matale district (Fernando et al., 2011).

Khondalites were collected from two locations (L1 and L2) close to Madawalaulpota, north of Matale (Fig. 1). The collected khondalites were classified into three types (Type A, B and C) based on the mineral textural settings. Samples from location L1 vary in sizes from 20cm to 1.25m. The rocks have stretched quartz (up to 2 cm size) showing intense deformation features probably due to high degree of stress associated with the Highland-Wanni shear boundary. Type A samples are distributed throughout the slope at the location L1, of which the upper part is underlain by granitic gneiss. These samples contain poikilitic features of Spl-Plag and Cor-Plag symplectite after Sil and Grt are very limited (e.g. Hiroi et al., 1997). In this study, we discuss petrological features of Spl-Plag and Cor-Plag symplectite after Sil and Spl-Plag symplectite after Grt in silica saturated Khondalite (graphite-bearing Grt, Sil, K-feldspar, Quartz granulite) which was collected from Matale, in the central Highland Complex Sri Lanka.

Type C khondalites are collected from the lower-middle to lower part of the slope where the muscovite, blue apatite, pink Spl, magnetite and pyrite bearing dolamitic marble being the bed rock (Fig. 2d). In these samples, coarse Grt grains are replaced by Spl-Plag symplectites.
Vein-like greenish Spl orients parallel to the major foliation (Fig. 2c).

Khondalite samples collected from the location L2 are found to be similar mostly to the Type C of the L1 and the rock was found as large boulders (about 0.5 to 3m in scale), which occur in the vicinity of a dolomitic marble (Fig. 2e). The area consists of steep slope and the upper part of the slope is underlain by Sil bearing granitic gneiss. In the location L2, marble is visible in the middle part of the slope. Although the bed rock is not exposed in the vicinity, based on field relationships of the kondalite boulders at L1 and L2 locations, the khondalite bed rock may be located as an interlayer within marble or in between the marble and the granitic gneiss.

3. Methodology

Methodology involves sample collection, study of hand specimens, preparation of petrographic thin sections and study under polarizing microscope to interpret the petrogenesis.

4. Results

In Khondalite Type A, frequently Qtz and sometimes Sil have rimmed by a film of K-feldspar (Kfs) (Fig. 2f). Euhedral to subhedral Kfs and Plag form triple junctions at the grain boundaries. Stretching Qtz and Sil needles are in preferred orientation on the major foliation. Therefore, the mineral textures in this khondalite Type A are very similar to the usual khondalites found in the HC, Sri Lanka (e.g. Hiroi, 1997). In the Type B khondalites, mineral textures are almost similar to those of the rock Type A, except for some domains of Grt (Fig. 2g) and Sil (Fig. 2h) showing initial stages of formation of Spl-Plag symplectites. These Spl are not in direct contact with matrix Qtz and Spl-Plag symplectites around Grt and Sil are not completely rimed. Instead, the reaction apparently has started from one side of the grain and continued towards the core area of the grain. In the Type C khondalite collected from L1 where the rock shows advent stage of the formation of Spl-Plag symplectite replacing Grt (Fig. 2j) and Sil (Fig. 2i) to various degrees leaving clear relics of the original minerals with their shapes. Interestingly contact minerals next to Grt and Sil (mainly plag and Kfs) have not subjected to any reaction (Fig. 2g, h and j).

Figure 1. Sample localities (L1 and L2) at Madawalaulpota, HC of Sri Lanka (litho-tectonic map - modified after Cooray, 1994).

Most of the the Sil needles which were subjected to partial brake-down appear in fibrous nature, probably indicating the braking down of Sil has taken place along the cleavages. Spl grains also show fibrous nature in such domains (Fig. 2k). However, a nhedral spl can be observed at some domains where psudomorphic Spl-Plag symplectites completely replace Sil and Grt. Occasionally, Spl-Plag symplectites are overprinted by Bt too (Fig. 2l). At some portions, tiny Grt containing plenty of Spl inclusions can also be observed close to Spl-Plag symplectites, inferring these Grt has been formed during retrogression via a reaction Spl+Plag=Grt. Rarely, some of these retrograde Grt follows shape of psudomorphic sillimanite (Fig. 2m) Although not abundant, in the Type C Khondalites Sil needles next to Spl-Plag symplectite after Sil have been replaced by Cor-Plag symplectites. In such domains (Fig. 2n), formation of clusters of high relief grains can be observed, where anhedral Cor has frequently embedded at the rim of such clusters. Therefore, these high relief mineral clusters can be inferred as Cor nucleation sites (Fig. 2o). At the same time, it is very clear that replacement of Grt and Sil by symplectic Spl-Plag and Sil
by Cor-Plag have been taken place mainly and Spl-Plag symplectite after Ky from

Figure 2. (a) rock slab of Khondalite type A, (b) rock slab of Khondalite type B, (c) rock sample of Khondalite type C, (d) Marble sample with scattered pyrite, (e) rock slab of Khondalite type C (location 2), (f) petrography of Khondalite type A, (g) Grt has partially replaced by Spl-Plag symplectite in Khondallite type B, (h) Sil has partially replaced by Spl-Plag symplectite in Khondallite type B, (i) Sil has completely replaced by Spl-Plag symplectite in Khondallite type C, (j) Grt has completely replaced by Spl-Plag symplectite in Khondallite type C, (k) Sill has broken down in fibrous manner Khondallite type C (Spl has also shown fibrous nature), (l) Spl-Plag symmelite has overprinted by Bt Khondallite type C, (m) retrograde Grt follows shape of pseudomorphic Sil, (n) Sil has completely replaced by Cor-Plag symplectite in Khondallite type C, (o) Corundum nucleation Sties in Khondallite type C (tiny Cor grains can be observed at the upper margin of the photograph, (p) Spl-Plag and Cor-Plag symplectites intergrowth in Khondallite type C

Note: Cor-Nu = Corundum Nucleation Sites

along foliation planes.
Sometimes, adjacent two Sil in which one Sil needle has been replaced by Spl-Plag and next one has been replaced by Cor-Plag symplectite.
Rarely, Spl-Plag and Cor-Plag symplectites intergrowth can also be observed (Fig.2p).
Stipska et al., (2010) have reported Cor-Plag

Bohemian Massif, Central Europe.
Petrography of khondalite samples collected from L2 are very similar to Type B and C khondalite of L1. However, Cor-Plag symplectites were not observed in samples of L2.
5. Discussion and Conclusions

Based on mineral texture we can infer that Grt-Sil, Qtz, Plag and Kfs could have existed as peak metamorphic assemblage in the studied Khondalite. During the retrogression most of the Grt and Sil have been replaced by Spl-Plag and Sil by Cor–Plag in various degrees. At the same time, there is no any evidence indicating that other matrix minerals in contact with Grt and Sil (mainly Plag, Kfs and Qtz) have participated to any reaction. At the same time, there is no evidence indicating partial melting of the khondalite. Therefore, we can infer that the khondalites may have acted as an open system during retrogression and may have interacted with some external chemical constituents. The source of this chemical constituent could be an external fluid migrated along the lower contact of the marble with the Khondalite.

Since the occurrence of Type A Khondalites from the upper to lower part of the slope and distribution of the Type B and C khondalites towards the mid to lower part of the slope (towards dolamitic marble) supports this interpretation. Hiroi et al., (1997) have argued that replacement of Sil by Spl-Plag symplectite attests to migration of Fe and Mg to reaction site from a single Fe-Mg mineral Grt. It could also be one source of Fe, however, in our samples some of Sil close to Grt are found intact without any brake down. In addition, Sil which are close to Grt and away from Grt have been completely replaced by Spl-Plag symplectites. Therefore, the most plausible candidate for the fluid is the adjoining dolamitic marble from which Fe-Mg-rich fluid can be generated by melting of the pyrite bearing dolamitic marble. Hence, the fluid could be a CO$_2$ rich and contains considerable amount of Ca, Mg and Fe. However, the two textures where Sil needles replaced by Spl-Plag and Cor-Plag symplectites and intergrowth of Spl-Plag and Cor-Plag symplectite are still doubtful. Fibrous nature of Spl on the partially broken down Sil may indicate that the replacements of Sil have been taken place along the cleavages during migration of fluid. Since Cor has nucleated as a meta-stable phase in Qtz saturated matrix, we can infer that these mineral textures have been formed under high pressure and temperature conditions. In order to further elaborate these interpretations, mineral chemistry data by Electron Microprobe Analysis are essential.

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7. References


