Proceedings to 29th Technical Sessions of Geological Society of Sri Lanka, 2013, 45-48
Published Online 22nd February 2013 (http: www.gsslweb.org)

Orthopyroxene-Sillimanite-Quartz Assemblage in Sapphirine Granulites: Sign for Ultra High Temperature Metamorphism in the Central Highland Complex, Sri Lanka

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1. Introduction

Ultra High Temperature (UHT) metamorphism, with temperature >900°C is proposed and documented in major continents with respect to different geological ages (e.g. Harley, 2004). Typical mineral assemblages indicating UHT conditions in pelitic granulites are sapphirine (Spr) + quartz (Qtz), orthopyroxene (Opx) + sillimanite (Sil) + Qtz , spinel (Spl) + Qtz and osumilite. Out of them Opx+Sil+Qtz assemblage is rare but characteristic of UHT metamorphism encountering mainly in pelitic and quartz-rich bulk compositions (e.g. Harley, 2004). Development and preservation of this assemblage determined by quantitative, pressure (>8Kbar), temperature (>850°C) and bulk composition (X_{Mg} >0.60 - 0.65) of the rock (Kelsey *et al.*, 2004). Petrological, geochemical and thermobarometric studies during the last two decades on the Highland Complex (HC) in Sri Lanka have also disclosed appreciable evidence relevant to UHT metamorphism (e.g. Kriegsman and Schumacher, 1999; Sajeev and Osanai, 2004). Those evidence have been encountered so far, in pelitic, mafic and quartzo-feldspathic granulites which frequently occur as boudinaged blocks, disrupted layers or lenses at very restricted localities in the HC (e.g. Osanai *et al.*, 2006).

In this study we discuss multiple modes of occurrence and pertogenesis of Opx-Sil-Qtz assemblage in Spr granulites from central HC, Sri Lanka.

2. Geological Setting and Field Relationships

The study area lies form South-West of Kandy where dominant rock types are meta-sediment such as Grt-Sil-Bt gneiss, Quartzite and marble with ortho-gneiss such as charnockite and meta-granite (Fig. 1).

Sapphirine-bearing Grt-Opx-Sil-Bt gneiss (Rock A) was collected form a quarry SW of Kandy where the rock contains porphyroblasts of Grt (0.5 cm- 3 cm in diameter) and Opx (0.5-2.5 cm in diameter). The stretched Qtz define mineral lineation on the major foliation of the rock. Sillimanite needles show preferred orientation parallel to quartz grains.

Spr, Kyanite(?) (Ky) and Spl bearing Grt, Opx-Sil-cordierite (Cord)-Bt gneiss (Rock B) is exposed as an interlayer within the Rock A. This quartz saturated Rock B comprises porphyroblasts of Grt (0.5- 2.5 cm in diameter) surrounded by Opx-Cord and Opx-Sil symplectites. Tiny Sil needles in the matrix can also be identified with the naked eye. Rarely purple colour coarse grained Cord (~1 cm) can also be observed in the matrix.

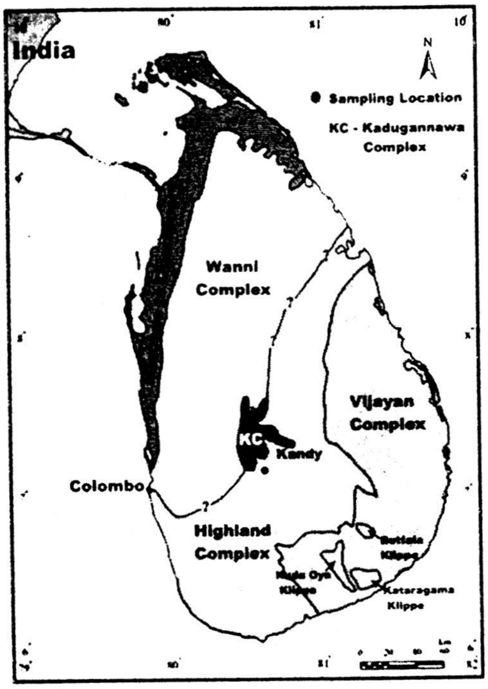


Figure 1 - Sample locality plotted on the HC of Sri Lanka (litho-tectonic modified after Cooray, 1994).

3. Methodology

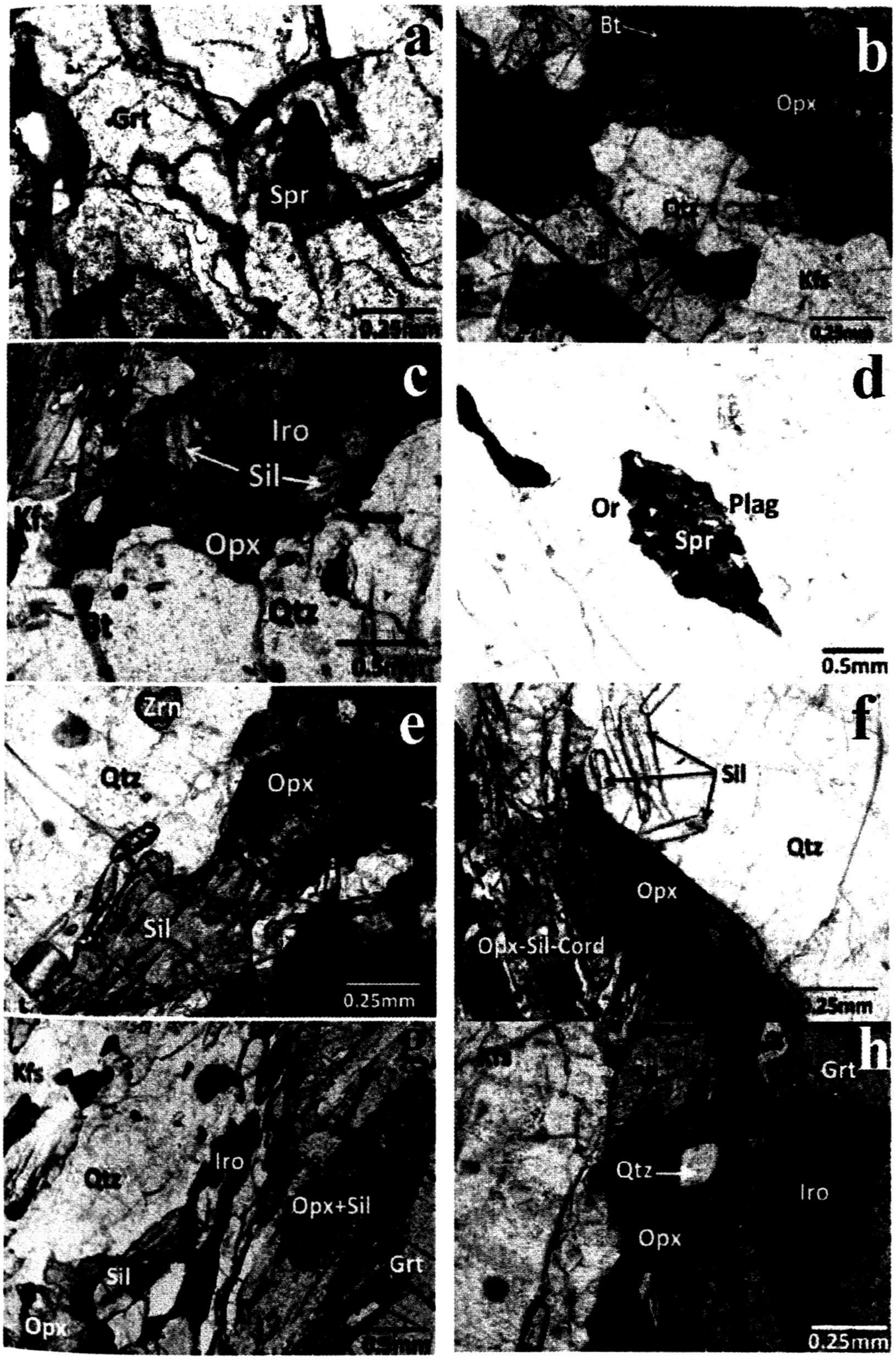
1. Sample collection (Pelitic granulites)
2. Study of hand specimens and preparation of petrographic thin sections.
3. Study under polarizing microscope to interpret the mode of occurrence and petrogenesis of Opx-Sil-Qtz assemblage in sapphirine granulites.

4. Results and Discussion

Rock A, contains porphyroblasts of Grt and Opx with Plagioclase (Plg), Qtz, Bt, K-feldspar (Kfs) and Sil as major phases with Iron ore (Iro) as a minor phase and Spr (Fig 2a) and Zircon (Zrn) as accessory. Porphyroblastic Opx containing Sil inclusions could be considered as prograde and could have been formed after the rock entered to Sil stability field. Grt of this pelitic rock has been subjected to dehydration during retrogression forming Bt-Qtz symplectites observed as narrow needles surrounding and inside the Grt. At some domains, direct co-existence of matrix Opx+Sil+Qtz can be observed (Fig. 2b). At very rare domains Sil are found partially embedded in Opx and are coexisting with matrix Qtz (Fig 2c). Since the Opx are relatively coarser and Qtz and Sil are in a preferred orientation parallel to the major foliation plane of the rock, we can infer that Opx-Sil-Qtz assemblage in the Rock A has been formed at peak/near peak metamorphism under UHT conditions.

Rock B comprises Grt, Opx, Sil, Qtz, Plg, Kfs, Bt and Cord as major constituent minerals with Iron as a minor phase with Spr, Spl and Zrn as accessory (Fig 2d). Opx shows two stages of formation, as porphyroblastic and symplectitic. Porphyroblastic Opx (~ 0.4-3cm) in the matrix sometimes contains Qtz, Plg and Bt inclusions inferring formation at the prograde path of the metamorphism. Symplectitic Opx is formed after garnet during the retrogression. All Opx-Sil-Qtz associations are observed with these symplectitic Opx in the Rock B. Direct coexistence of symplectitic Opx with Sil+Qtz was observed close to Grt (Fig. 2e). Occasionally, some of the matrix Qtz grains of the Rock B contain Sil inclusions. Very rarely, tiny Sil inclusions in the rim area of Qtz are found in-contact with symplectitic Opx (Fig 2f). In some domains matrix Qtz is found directly in contact with Opx-Sil moats after garnet (Fig 2g). Seldom, Opx in these moats also contain tiny quartz inclusions (Fig 2h). This texture infers that the Grt has broken down forming Opx-Sil moat via the reaction, Grt+Qtz = Opx+Sil. There are domains in which Qtz and Opx+Sil association are separated by a thin film of Cord indicating the reaction, Opx + Sil + Qtz = Grt + Cord (Fig 2i).

Accordingly, we can infer that the Opx-Sil-Qtz associations in the rock B are formed at the retrogression after the peak UHT metamorphism.


a
Grt
Spr
b
Bt
Opx
Kfs
c
Iro
Sil
Kfs
Opx
Bt
Qtz
d
Or
Plag
Spr
0.5mm
e
Zrn
Qtz
Opx
Sil
0.25mm
f
Sil
Qtz
Opx
Opx-Sil-Cord
Kfs
Qtz
Iro
Opx+Sil
Grt
Sil
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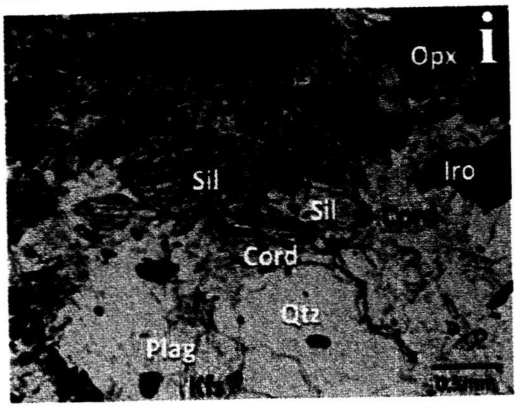

Figure 2. Mineral textures of Rock A (a-c) and Rock B (d-i). (a) Spr as inclusion within Grt (b) direct coexistence of matrix Opx+Sil+Qtz (c) partially embedded Sil inclusions in Opx have rarely co-existed with matrix Qtz (d) porphyroblastic Spr in the matrix (e) coexistence of Opx+Sil+Qtz (f) tiny Sil inclusions within rim area of Qtz in coexistence with Opx (g) matrix Qtz directly in contact with Opx-Sil moat after Grt (h) tiny Qtz inclusions in Opx which form moat with Sil around Grt (i) Qtz and Opx+Sil separated by a film of Cordeiretite.

5. Conclusions

Mineral textural evidence implies that:

1. Coexistence of Opx+Sil+Qtz in the Rock A could be considered as a peak/near peak metamorphic assemblage at UHT conditions

2. Opx-Sil-Qtz associations in the Rock B could have been formed during retrogression after the peak UHT metamorphism.

6. Acknowledgments

We are grateful to the National Research Council (NRC) of Sri Lanka for funding this project and Dr. A. Pitawala, Head, Dept. of Geology for providing necessary facilities. Our thanks are due to Mr. O. K. S. Opatha at the Institute of Fundamental Studies, Kandy for various assistance and Miss Thilini Harischandra for support in preparing petrographic thin sections.

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