Petrological characteristics of granulite/amphibolite-facies “bleached” hydration zones caused by fluid infiltration along fractures at middle crustal conditions in the Sør Rondane Mountains, East Antarctica

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Fluids in the deep crust promotes heat and mass transport, controls rock rheology and fracturing, and plays essential roles on the dynamics of plate boundaries. Although fluid activities are geophysically recognized as migrations of hypocenters and seismic velocity anomalies, their actual relations with geological records are not always clear due to different scales of observations. Exceptionally well-exposed crust-fluid reaction zones in Sør Rondane Mountains (SRM), East Antarctica provides an ideal opportunity to evaluate the fluid flow in the deep crust from mm to km-scale. Here we report the occurrences of fluid-rock reaction zones observed during JARE61 in 2019–2020, and show preliminary descriptions of granulite/amphibolite-facies hydration reaction zones hosted in felsic gneiss (so called “bleached” zones) that are widely distributed in SRM.

Sør Rondane Mountains (SRM) are part of the Pan-African collision zone between East and West Gondwana (650–500 Ma; Osanai et al., 2013), and are dominated by amphibolite- and granulite-facies metamorphic rocks and granitoids. Previous studies have revealed amphibolite-facies hydration reactions along fractures (Adachi et al., 2010; Higashino et al., 2019a; Mindaleva et al., 2020) and Cl-bearing fluid activities during prograde and retrograde metamorphism, that are likely to correlate with km-scale shear zones and/or igneous activities (Higashino et al., 2019b, 2013; Kawakami et al., 2017; Mindaleva et al., 2020; Uno et al., 2017).

Amphibole-bearing hydration reaction zones along fractures were widely recognized in Brattnipane and Meifjell area. Some hydration reaction zones along the fractures are traceable for more than a km for both localities (Fig. 1a). The study area is located at northeastern part of Meifjell area. Amphibolite/granulite-facies mafic gneiss are intruded by felsic gneiss (Fig. 1b and c), and pegmatitic/aplitic dikes cut the both lithologies. Orthopyroxene-bearing felsic gneiss (OFG) are cut by fractures filled with pegmatite, aplite and/or amphibole (Fig. 1d). Brownish OFG are hydrated along the fractures and form cm– to decimeter–scale whitish reaction zones composed of hornblende-biotite-bearing felsic gneiss (HBG), showing “bleached” zones (Fig. 1b and d). The host rock OFG is composed of orthopyroxene, clinopyroxene, K-feldspar, plagioclase, quartz, ilmenite, and secondary anthophyllite, hornblende and biotite (Fig. 1e). Orthopyroxene grains are largely replaced by anthophyllite, and clinopyroxene grains are partly replaced by hornblende ± anthophyllite at its rims. Biotite occur as

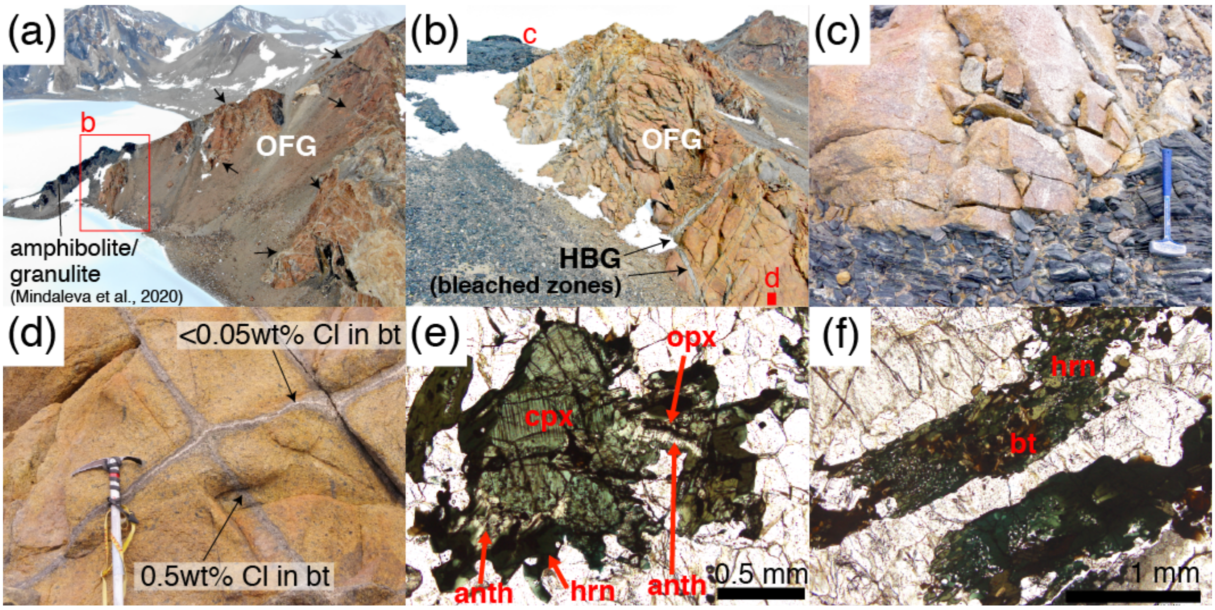

Figure 1 Occurrences of bleaching zones in Meifjell, Sør Rondane Mountains, East Antarctica. (a) A drone image of orthopyoroxene-bearing felsic gneiss (OFG) and amphibolite/granulite mafic gneiss. Note that whitish lineaments of bleaching zones distributed in OFG. Outcrop width is ~2km. (b) Outcrop photograph of OFG hosted bleached zones. (c) Contact of mafic gneiss and OFG. (d) Bleached zones in OFG. (e) Photomicrograph of OFG. (f) Photomicrograph of bleached zone.

aggregates around hornblende. The bleached zones are characterized by complete replacement of clinopyroxene and orthopyroxene grains by hornblende, anthophyllite, biotite and quartz (Fig. 1f). Chlorine contents in biotite are relatively high (0.47–0.58 wt%) in some bleached zones, compared to those in other bleached zones and host OFG (<0.05 wt%), suggesting infiltration of different chemistry of fluids in differently oriented fractures (Fig. 1d).

Two pyroxene thermometer (Wells, 1977) in the host felsic gneiss results in ~840°C for opx and cpx grains, and ~770°C for the orthopyroxene lamellas in clinopyroxene grains. Hornblende-plagioclase thermometery (Holland and Blundy, 1994) gives ~700°C and 660°C for the hornblende-plagiolcase pairs in the host rock and the bleaching zones, respectively. The pressure of the hornblende formation is suggested as 0.35–0.53 GPa by Al-in-hornblende barometery (Anderson and Smith, 1995). These results are consistent with formation of bleached zones at 660–700°C and ~0.5 GPa during retrograde metamorphism, and coincide with the *P–T* conditions of hydration reactions in mafic granulite in the nearby outcrop (Fig. 1a; Mindaleva et al., 2020).

The mineralogy and formation temperature of the bleached zones largely coincides with those reported from Koyubi ridge in Brattnipane area (Adachi et al., 2010), that is ~100 km away from the survey area. Similar bleached zones are observed in fields for Dotten area, Hitosasiyubi and Kusuriyubi ridges of Brattnipane area, and Meifjell area that distribute in ~150 km width. We infer that fluid transport via fractures is one of the dominant modes of fluid transport in middle–lower crustal conditions in SRM, with their fracture lengths may extend more than km.

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