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Orthopyroxene-amphibole bi-phase corona from the Arnøya metagabbro, Norway: an example of open system disequilibrium microstructure

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Corona textures involving olivine-plagioclase are common in metamorphosed mafic rocks. Although the precursors of corona assemblages are olivine and plagioclase, a significant variation in the newly formed mineral species and zonal sequences may be develop through reaction and diffusion between the reactants (olivine and plagioclase) . In this contribution, we describe the sequence of mineral development in bi-phase coronas at the olivine-plagioclase interface from undeformed gabbroic rock, Arnøya, Norway. The metagabbroic rock from Arnoya contains magmatic olivine (Ol), plagioclase (Pl) and clinopyroxene (Cpx). Ilmenite occurs as exolution phase within clinopyroxene. The orthopyroxene (Opx)-amphibole (Amph) bi-phase corona develops extensively at the contact between olivine and plagioclase.

The undeformed part of the rock contains olivine, plagioclase and clinopyroxene, demonstrating the cumulus nature of the rock. Olivine grains are usually fractured and have a wavy grain boundary with adjacent plagioclase grains. Magmatic plagioclase grains (up to 1 mm long) occur either as individual crystals or as polycrystalline aggregates. Most of the plagiclase grains are commonly twinned and locally includes olivine suggesting that olivine predated plagioclase. Grains of plagioclase and olivine are mostly armored by pyroxene.

The metamorphic mineral sequence develops exclusively at the contact between olivine and plagioclase. The sequence of mineral development is as follows: Ol (matrix) $>$ Opx $\pm$ Spl $>$ Amph $\pm$ Ky/Sill $\pm$ calcic Pl $>$ Pl (matrix). Metamorphic orthopyroxene are extremely small in size and the individual grains occur at high angle to the rounded olivine grain boundary. Calcic amphibole is colorless to pale green between the Ol-Pl domains. A very thin zone of amphibole (II) and calcic plagioclase develops at the outer edge of the amphibole corona. Occasionally, blebs of sillimanite/kyanite grains are observed in the amphibole layer.

Except for olivine (X_{Mg} = 0.82), the entire mineral assemblage shows a steep compositional zoning. X_{Mg} of orthopyroxene varies from 0.85 to 0.82 towards the amphibole zone. X_{Mg}in amphibole (*ferrian tshermakite)* varies from 0.82 to 0.79 towards the plagioclase zone. In the symplectite zone amphibole (ferrian tshermakite) becomes slightly less magnesian (X_{Mg} = 0.77). Plagioclase composition changes from X_{An}= 0.87 near the symplectite zone to X_{An}= 0.58 towards the unreacted domain. Geothermometers using local amphibole-plagioclase equilibrium estimate 700-780 ^{0}C at 5 kbar for the development of amphibole corona.

The corona microstructure could be explained through the following reactions: a) Ol + Pl + H_2O -> Opx + Spl + Amph; b) Pl + Opx + H_2O -> Amph + Ky/Sill. However, the presence of a chemical gradients in the orthopyroxene (X_{Mg} = 0.85-0.82) and amphibole layers (X_{Mg}= 0.82-0.77) suggest that diffusion processes have controlled the rate of the reaction. The mineral layering described above could be explained as an open system reaction that removes mainly MgO and produce orthopyroxene (Ol -> Opx + MgO + FeO), spinel and calcic amphibole (Pl + H_2O + MgO + FeO -> Amph + Spl + CaO; Ol + H_2O + CaO -> Amph + MgO + FeO) at the expense of olivine and plagioclase. Removal of MgO by diffusive mass transfer is responsible in destabilizing the olivine plagioclase interface and the presence or absence of fluid phase at the interface will cause the formation of different types of reaction rims.

Spl: Spinel; Ky: Kyanite; Sill: Sillimanite