Fluid infiltration during high-grade metamorphism: a petrological study on whiteschists and associated rocks from Mautia Hill, Tanzania

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Whiteschists are characterised by the critical mineral assemblage talc + kyanite, which is only stable under low geothermal gradients that are realised in the high-pressure part of the amphibolite facies and in the eclogite facies. As they are found to be formed in geodynamic regimes characterized by clockwise P-T paths, it is likely that whiteschists mark the sites of palaeo-collision zones, even in cases where eclogites and blueschists are lacking. Because of their metasomatic formation, whiteschists may be used to study fluid-rock interaction processes during crustal thickening.

Mautia Hill (Tanzania) is situated near the western border of the Pan-African Mozambique Belt, the formation of which is attributed to collision between East and West Gondwana (McWilliams, 1981). To the west is the Palaeoproterozoic (2.0-1.8 Ga) Usagaran Belt, which itself adjoins the Archean (2.6-2.5 Ga) Tanzania Craton. In the small outcrop of Mautia Hill whiteschists are closely associated with metabasites, semipelitic gneisses, marbles and quartzites. Whiteschists and whiteschist-related rocks display a mineralogy either in the chemical system MgO-Al₂O₃-SiO₂-H₂O-Fe₂O₃ (MASH-Fe₂O₃) or CaO-MgO-Al₂O₃-SiO₂-H₂O-CO₂-Fe₂O₃ (CMASH-CO₂-Fe₂O₃). Further components, such as Mn₂O₃, BaO and PbO, are only contained in minor amounts, but are quite important for the mineralogical variety. Very uncommon minerals occur, e.g. yellow sapphirine, boron-free kornerupine, green and purple yoderite, piemontite, manganian andalusite and högbomite.

With the aid of conventional barometry (GASP/GADS equilibria) applied to associated metabasites and semipelites, the peak pressure of whiteschist metamorphism has been evaluated at 10-11 kbar. This is in agreement with the high-fO₂ barometric assemblage hollandite/bixbyite-kyanite-quartz and manganian andalusite that contains up to 19.5% Mn₂SiO₅ component. The maximum metamorphic temperature is constrained to < 720°C by the formation of yoderite + quartz. A clockwise P-T evolution has been deduced from prograde kyanite inclusions in metapelitic garnet and late-stage reaction rims of cordierite between green yoderite and talc in whiteschists, which have been formed 3-4 kbar below peak pressures.

In MASH-Fe₂O₃ and CMASH-CO₂-Fe₂O₃ rocks the observation is made that the peak-metamorphic assemblages, such as talc + kyanite and Mg-hornblende + kyanite, coexisting with ferrian ilmenite, break down to form the uncommon oxidised minerals. Taking into account that peak pressures did not exceed 11 kbar, as well as the reaction history in whiteschists, we deduce that the highly oxidised late-stage assemblages formed due to increase of water activity at peak-metamorphic conditions or in the early stages of uplift. The extremely oxidising conditions are evidenced by rutile-haematite intergrowths formed after ferrian ilmenite. Large amounts of an aqueous fluid infiltrating the rocks may create such conditions. The fluid infiltration and resulting increase of aH₂O/fO₂ is attributed to metamorphic devolatilization of underlying metasediments. In the course of Pan-African nappe stacking or subduction in the boundary region between the Palaeoproterozoic Usagaran Belt and the East African Orogen, they became buried below the rocks of Mautia Hill.

References

Keywords: fluid infiltration, whiteschist, Mozambique Belt, Pan-African, palaeo-collision zone.