

Fluid-mediated polymetamorphism related to Proterozoic collision of Archean Wyoming and Superior provinces in the Black Hills, South Dakota

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ABSTRACT

Late Archean and Early Proterozoic continental margin pelites, graywackes, and quartzites in today's Black Hills were regionally metamorphosed during the collision of the Archean Wyoming and Superior provinces beginning at ~1755 Ma. During east-west regional compression, metamorphism reached incipient garnet-biotite grade conditions at ~400 °C. Unzoned garnet (Sps₄₄Alm₄₄Pyr₃Grs₉) characterizes the mineral assemblage in graphitic metapelites. The low-temperature onset of the garnet-biotite assemblage is attributed to high Mn concentrations and low $a_{\text{H}_2\text{O}}$ due to the presence of CH₄ and CO₂.

During late stages of the collision, the rocks were intruded by the Harney Peak leucogranite (HPG). Vigorous fluid flow, evidenced by abundant quartz veins, metasomatism, and consumption of graphite from metapelites, occurred in the granite aureole. The lowest-grade aureole assemblage includes chlorite that overgrows the early regional foliation and new, clear, almandine rims on garnet. Higher-grade facies include staurolite, then sillimanite, and finally second-sillimanite. The prograde mineral assemblages are consistent with calculated pseudosection assemblages for the average metapelite. Beginning with the sillimanite zone, almandine garnet is mostly inclusion-free. Textures suggest that this new garnet grew after dissolution of the old garnet, for which the only remaining evidence are remnant inclusions or coarse quartz-biotite clots. The new garnet grew in response to more elevated temperatures. Garnet compositions projected onto the pseudosection indicate nearly isobaric heating between 3.5–4.5 kbar during prograde metamorphism. Occasional replacements of staurolite by muscovite and biotite are attributed to infiltration of the rocks by K-bearing magmatic fluids.

Andalusite occurs as euhedral crystals in quartz veins or as late poikiloblasts along foliations planes, where it appears to have grown while Si-rich fluids passed through the rocks. Typically, it replaces earlier muscovite, suggesting that the fluids had low $a_{\text{H}_2\text{O}}$. The andalusite indicates decompression of the still hot, buoyant, fault-bounded block that included the HPG magma, relative to surrounding blocks in the terrane. This decompression contributed to the high-*T*/low-*P* conditions that existed in this portion of the thickened orogen and suggests that the various fault-bounded blocks in the Black Hills may have had different *P-T* histories.

Keywords: Metamorphism, metapelites, Black Hills, low-pressure/high-temperature, garnet, pseudosection