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Petrogenetic and tectonic interpretation of strongly peraluminous granitic rocks and their significance in the Archean rock record

Carol D. Frost[1,*] and Fabio A. Da Prat[1,*,†]

[1]Department of Geology and Geophysics, University of Wyoming, Laramie, Wyoming 82071, U.S.A.

Abstract

Strongly peraluminous granitic rocks (SPG), defined by an aluminum saturation index ≥1.1, become abundant in the rock record in the Neoarchean. This study identifies three different varieties of Neoarchean SPG in the Archean Wyoming Province, U.S.A. These include calcic SPG, represented by the Webb Canyon Gneiss and Bitch Creek Gneiss of the Teton Range; calc-alkalic to alkali-calcic suites composed entirely of SPG, including the Rocky Ridge garnet granite gneiss of the northern Laramie Mountains and the Bear Mountain granite in the Black Hills; and calc-alkalic to alkali-calcic suites that include both weakly and strongly peraluminous granitic rocks, such as the Mount Owen batholith, Wyoming batholith, and Bears Ears granite. Although the petrogenesis of all the SPG suites involves partial melting of crustal sources, the composition of those sources, the melting conditions, and the tectonic settings vary. The calcic suites originate by dehydration melting or water excess melting of hornblende-plagioclase rocks at relatively high temperature. The suites composed entirely of SPG formed by partial melting of metasedimentary rocks by reactions involving muscovite at lower temperatures. Suites with both weakly and strongly peraluminous granite may form by partial melting of metasedimentary rocks by reactions involving biotite or by assimilation of aluminous melts of felsic crust by differentiated calc-alkalic magma. Most of the Wyoming SPG appear to have formed in collisional orogens, but SPG of the Wyoming batholith and Bears Ears granite are associated with continental arc magmatism. The appearance of SPG in the Neoarchean rock record marks the time when subduction enabled the formation of strong, thick, increasingly felsic continental crust, which in turn allowed the development of a mature, clastic sedimentary cover. Lateral movement of crustal blocks led to collisional orogeny, SPG magma genesis, and the formation of the first supercontinents.

Keywords: Strongly peraluminous granite, crustal evolution, Neoarchean, petrogenesis