American Mineralogist, Volume 101, pages 1332–1347, 2016

SPECIAL COLLECTION: PERSPECTIVES ON ORIGINS AND EVOLUTION OF CRUSTAL MAGMAS

The origin of extensive Neoarchean high-silica batholiths and the nature of intrusive complements to silicic ignimbrites: Insights from the Wyoming batholith, U.S.A.

Davin A. Bagdonas[1,*], Carol D. Frost[1,*], and C. Mark Fanning[2]

[1]Department of Geology and Geophysics, University of Wyoming, Laramie, Wyoming 82071, U.S.A.
[2]Research School of Earth Sciences, Australian National University, ACT 0200, Canberra, Australia

Abstract

Extensive intrusions composed entirely of biotite granite are common in Neoarchean cratons. These granites, which have high silica and potassium contents, are not associated with intermediate and mafic phases. One such Neoarchean granite batholith, herein named the Wyoming batholith, extends more than 200 km across central Wyoming in the Granite and the Laramie Mountains. From field characterization, petrology, geochemistry, and Nd isotopic data we establish that the magnesian Wyoming batholith exhibits continental arc chemical and isotopic signatures. It is best interpreted as a large, upper crustal silicic batholith that likely formed when the subducting oceanic plate steepened or foundered, bringing mantle heat and mass to the base of the crust. Similar Cenozoic settings, such as the Altiplano-Puna plateau of the Andes and the volcanic provinces of the western United States, host large volumes of silicic ignimbrite. The magma chambers supplying these eruptions are inferred to be silicic, but the structural, petrologic, and geochemical details are unknown because the batholiths are not exposed. We suggest that the Wyoming batholith represents an analog for the plutonic complex underlying these ignimbrite systems, and provides an opportunity to examine the shallow magma chamber directly. Our work establishes that, aside from more leucocratic margins, the sill-like magma chamber is petrologically and chemically homogeneous, consistent with effective mixing by vertical convection. Nd isotopic variations across the batholith indicate that horizontal homogenization is incomplete, preserving information about the feeder system to the batholith and variations in magma sources. The late Archean Earth may present optimal conditions for the formation of extensive granite batholiths like the Wyoming batholith. By this time the majority of the planet's continental crust had formed, providing the environment in which differentiation, distillation, and assimilation could occur. Moreover, the Neoarchean Earth's relatively high radioactive heat production provided the power to drive these processes.

Keywords: Granite, ignimbrite, continental arc, batholith, Archean