The Granite Problem as Exposed in the Southern Snake Range, Nevada

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Abstract. A geochemically and mineralogically diverse group of granitoids is present within an area of 900 km² in the southern Snake Range of eastern Nevada. The granitoids exposed range in age from Jurassic through Cretaceous to Oligocene and include two calcic intrusions, two different types of two-mica granites, and aplites. The younger intrusions appear to have been emplaced at progressively more shallow depths. All of these granitoid types are represented elsewhere in the eastern Great Basin, but the southern Snake Range is distinguished by the grouping of all these types within a relatively small area.

The Jurassic calcic pluton of the Snake Creek-Williams Canyon area displays large and systematic chemical and mineralogical zonation over a horizontal distance of five km. Although major element variations in the pluton compare closely with Daly's average andesite-dacite-rhyolite over an SiO₂ range of 63 to 76 percent, trace element (Rb, Sr, Ba) variations show that the zonation is the result of in situ fractional crystallization, with the formation of relatively mafic cumulates on at least one wall of the magma chamber. Models of trace element and isotopic data indicate that relatively little assimilation took place at the level of crystallization. Nonetheless, an initial ⁸⁷Sr/⁸⁶Sr value of 0.7071 and δ¹⁸O values of 10.2 to 12.2 permil suggest a lower crustal magma that was contaminated by upper crustal elastic sedimentary rocks before crystallization. The involvement of mantle-derived magmas in its genesis is difficult to rule out. Two other Jurassic plutons show isotopic and chemical similarities to the Snake Creek-Williams Canyon pluton.

Cretaceous granites from eastern Nevada that contain phenocrystic muscovite are strongly peraluminous, and have high initial Sr-isotope ratios and other features characteristic of S-type granitoids. They were probably derived from Proterozoic metasediments and granite gneisses that comprise the middle crust of this region.

Another group of granitoids (including the Tertiary aplites) show chemical, mineralogic, and isotopic characteristics intermediate between the first two groups and may have been derived by contamination of magmas from the lower crust by the midcrustal metasediments.

Introduction

Faure and Powell (1972, p 43) stated: "The crux of the granite problem is that it is possible that granite rocks of igneous aspect can form as products of different processes..." Within an area of 900 km² in the southern Snake Range, White Pine County, Nevada, six igneous masses are well exposed in discrete outcrops. These granitoids range in age from Jurassic to Oligocene, in SiO₂ content from 63 to 76 wt.%, in δ¹⁸O from -2.6 to +13.2 permil, and in initial ⁸⁷Sr/⁸⁶Sr from 0.7071 to 0.7157. The petrologic types exposed include two calcic (Peacock 1931) intrusions, two different kinds of two-mica granites, and aplites. The purpose of this report is to summarize and integrate the information in some 30 papers on the petrology, age relations, and systematic mineralogy of these rocks, and to speculate on the processes that may have been involved in their formation.

We first describe a well-studied pluton from the southern Snake Range using models of its trace element and isotopic composition to demonstrate the role of fractional crystallization in developing its strong compositional zonation. We then compare it with other plutons from the area and attempt to explain their origins from Sr and O isotope relationships.

In this report we refer to a classification of granites according to source materials (Chappell and White 1974). In the scheme, granites inferred to be derived from predominantly sedimentary protoliths are S-types, whereas those derived from igneous source materials are I-types. The chemical, mineralogical, and isotopic criteria used to distinguish between S- and I-type granites have been summarized by Chappell and White (1974), O'Neil and Chappell (1977), Beckinsale (1979), and Furgeson et al. (1980). As is apparent in the discussion to follow, application of these criteria to a particular pluton sometimes leads to ambiguous results.

The central part of the area studied is about 60 km southeast of Ely, Nevada, in the southern part of the Snake Range of eastern Nevada (Fig. 1). The granitoid rocks of this area intruded part of a lower Paleozoic miogeosynclinal sequence of predominantly quartzite and carbonate rocks; they are exposed east of the Mississippian Antler orogenic belt (Gilluly 1963, pp 139, 140) and just west of the Cretaceous Sevier orogenic belt (Armstrong 1968, p 436). None of these plutons has been deeply unroofed. With the possible exception of the Osceola intrusion, probably none of these granitoid masses has been eroded to a depth of more than 300 m. All of the plutons to be described (Fig. 2) are exposed beneath the Snake Range decollement. Parts or all of the area studied have been mapped by Drewes (1958), Misch and Hazzard (1962), Whitebread (1969), and Hose and Blake (1976).
Intrusive Types Exposed

Snake Creek-Williams Canyon Intrusion

Geology. The Middle Jurassic (155 ± 4 m.y.; Lee et al. 1983) pluton of the Snake Creek-Williams Canyon area is the oldest igneous mass present in the southern Snake Range. Within a horizontal distance of 5 km this well-exposed pluton grades from a tonalite (63% SiO₂) where the host rock is limestone to granite (76% SiO₂) where the host rock is quartzite. (The IUGS classification is used throughout this paper; Streckeisen 1973). When the large and systematic variation in the petrology of the pluton (Fig. 3) was recognized, it became apparent that this intrusive mass is ideal for a study of igneous processes. The intrusive rock is well exposed in contact with chemically distinct host rocks, and the chemical and mineralogical trends are developed over large enough distances to be defined with assurance, yet the distances are still small enough to allow detailed field study of the concentration gradients.

The eroded roof of this granitoid body probably was not much higher than the present outcrop. Thus the intrusion probably has not been unroofed to a depth of much more than 300 m. This intrusion is essentially domelike (Drewes 1958, p 231) and roughly concordant with bedding in the overlying sedimentary rocks. Both the general concordance and the most notable discordance are well shown where the pluton crops out at the crest of the range between Snake Creek and Williams Canyon. At the northern edge of this outcrop, beneath Pyramid Peak, the intrusive contact nears the flat bedding of the overlying quartzite, but at the southern edge of this outcrop, the intrusive contact cuts across about 300 m of quartzite bedding at a very high angle.

Locally, along steep contacts, the host rock has been dragged upward and appears to have been shouldered aside (Drewes 1958, p 231). This is apparent in the extreme eastern part of the intrusive outcrop, where Pioche Shale and Pole Canyon Limestone have been folded into an overturned syncline. However, just north of this shale outcrop, an apophysis of the intrusion has engulfed part of the limestone. This, as well as the discordant intrusive rock-quartzite contact at the crest of the range, indicates that some stoping took place.

The eastern half of the intrusive outcrop in Snake Creek drainage contains many xenoliths-fragments of Pioche Shale that are partly assimilated. The smallest of these is the size and shape of a walnut; the largest crops out over an area of about 9,000 m². In several places where the larger xenoliths are about a foot long, they comprise as much as 5% of the intrusion. These xenoliths tend to be ellipsoidal and to stand out on weathered surfaces. Strikes tend to parallel the nearest intrusive contact, and dips usually are within 20° of vertical. From this we infer that at least this part of the intrusive must have undergone magmatic flow.