Compositions of micas in peraluminous granitoids of the eastern Arabian Shield

Implications for petrogenesis and tectonic setting of highly evolved, rare-metal enriched granites

Edward A. du Bray
U.S. Geological Survey-MS 905, Box 25046, DFC, Denver, CO 80225, USA

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Abstract. Compositions and pleochroism of micas in fourteen peraluminous alkali-feldspar granites in the eastern part of the Late Proterozoic Arabian Shield are unlike those of micas (principally biotite) in most calc-alkaline granitoid rocks. Compositions of these micas are distinguished by elevated abundances of Li₂O, F, and numerous cations and by low MgO abundances. These micas, constituents of highly evolved rare-metal enriched granitoids, represent an iron-lithium substitution series that ranges from lithium-poor siderophyllite to lithium-rich ferroan lepidolite. The eastern Arabian Shield also hosts six epizonal granitoids that contain colorless micas. Compositions of these micas, mostly muscovite, and their host granitoids are distinct from those of the iron-lithium micas and their host granitoids. Compositions of the analyzed micas have a number of petrogenetic implications. The twenty granitoids containing these micas form three compositional groups that reflect genesis in particular tectonic regimes; mica compositions define the same three groups. The presence of magmatic muscovite in six of these shallowly crystallized granitoids conflicts with experimental data indicating muscovite stability at pressures greater than 3 kbar. Muscovite in the Arabian granitoids probably results from its non-ideal composition; the presence of muscovite cannot be used as a pressure indicator. Finally, mineral/matrix partition coefficients are significantly greater than 1.0 for a number of cations, the rare-earth elements in particular, in many of the analyzed iron-lithium micas. Involvement of these types of micas in partial melting or fractionation processes can have a major influence on silicate liquid compositions.

Introduction

The pleochroism of macroscopically black, primary micas in fourteen peraluminous granitoids of the eastern Arabian Shield is unlike that of biotite, the common mica in calc-alkaline granitoid rocks. Micas in these granitoids are pleochroic in shades of green and blue green to pale brown, but intensities of these hues are less than those of biotite and greater than those of muscovite. Colorless mica was identified in eight granitoids (including two also containing pleochroic micas) of the eastern Arabian Shield. The observation that micas in the Arabian peraluminous granitoids were not biotite provided the impetus for this study.

This study presents new major oxide data for micas in 20 Late Proterozoic granitoids of the eastern Arabian Shield (Fig. 1); new trace element data for the micas and their host granitoids are also presented. Compositions of pleochroic micas in thirteen of the granitoids are those of variously lithium-enriched, iron-bearing trioctahedral micas spanning the siderophyllite-ferroan lepidolite composition spectrum. Because these micas have distinctive iron and lithium contents they are hereafter referred to as Fe-Li micas. Compositions of six of the eight colorless micas are that of muscovite. However, compositions of two of the colorless micas (from Khazaz and Qutn) and one of the pleochroic micas (Minya) are intermediate between those of the Fe-Li micas and muscovite, and are hereafter referred to as transitional micas.

Elsewhere in the world, Fe-Li micas occur only in highly evolved alkali-feldspar granites, granite pegmatites, and mineralized rock (greisen) associated with rare-metal deposits. Data and interpretations presented herein are limited to micas in plutonic rocks. E.E. Foord (written communication, 1993) suggests that major oxide compositions of Fe-Li micas in pegmatites and plutonic rocks are broadly similar, although their trace element abundances may be distinctive and reflect variable petrogenetic processes, source compositions, and host rocks. Deer et al. (1966) indicate that composition data for Fe-Li micas are limited and that these micas are characterized by a large array of cation substitutions including Ti, Sn, Fe³⁺, Fe²⁺, Mg, Mn, Zn, and Li in the octahedral site and K, Ca, Ba, Na, Rb, and Cs in the interlayer site. The major oxide compositions of these micas have become better known (Rieder 1970; Haapala 1977; Imeokparia 1982; Shihua 1982) because their highly evolved
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The granitoids containing the analyzed micas are fully described by du Bray (1987) and du Bray et al. (1988). Fourteen of these granitoids (the Eastern Arabian shield Fe-Li mica-bearing granitoids, EAFL group) are potential rare-metal deposit hosts (du Bray et al. 1982; Moore 1984); two of these, Silsilah (du Bray 1988) and Baid al Jimalah (Cole et al. 1981), have associated, subeconomic deposits of tin and tungsten, respectively. The EAFL granitoids, spread throughout the 1000-km length of the eastern Arabian Shield (Fig. 1), are peraluminous A-type (Collins et al. 1982) alkali-feldspar granites. Seven granitoids of the eastern Arabian Shield containing muscovite or transitional mica are granodiorites and alkali-feldspar granites. Composition and tectonic setting were used to subdivide these seven granitoids further into two groups. Four granitoids form the geographically coherent Madha group (Fig. 1) in the southern Arabian Shield. Two granitoids (Mahail and Kebad) 30 km apart, and a third (Khazaz), 500 km to the north, form the MKK group.

Granitoids containing the analyzed micas crop out in at least two litho-tectonic terranes and represent at least two magmatic periods. The Madha group is west of the north-trending Nabitah suture (Fig. 1), an inferred Late Proterozoic suture (Stoeser and Camp 1985); the other granitoids are east of this boundary. Rocks west of the suture comprise ensimatic island-arc terranes accreted to the Arabian Shield by 630 Ma, whereas rocks east of the suture comprise ensialic molasse and intermediate to silicic intrusive and