Evaluating mechanisms for rare earth element mineralization in Proterozoic gneiss, Music Valley, CA

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Monazite and xenotime occur in ore-grade concentrations within Proterozoic gneiss in the Music Valley region (MVR) of southern California. However, the age and petrogenesis of this potentially economically significant rare earth element (REE) deposit remain uncertain. A combined petrologic and geochronologic approach using SEM imaging, EPMA x-ray mapping and LA-MC-ICPMS geochronology reveals textural and temporal relationships between REE mineralization and the surrounding geology. Monazite and xenotime are restricted to biotite folia within the host Pinto Gneiss with highest concentrations occuring in close proximity to contacts between the host gneiss and diorite bodies (Gold Park Diorite), the latter of which are cut by felsic pegmatite veins that appear to have been generated by partial melting of the Pinto Gneiss. SEM imaging and EPMA x-ray mapping reveal anhedral to subhedral ore-forming monazite and subhedral to euhedral xenotime with complex internal elemental zoning. Dissolution/re-precipitation textures overprint relict oscillitory zoning with xenotime and uranothorite forming from breakdown of monazite and vice-versa (monazite and uranothorite forming from original xenotime), suggesting a later metasomatic event affected the ore body. Petrographic evidence for a reaction involving breakdown of monazite, anorthite, and biotite to form apatite and allanite also suggests later-stage metasomatism. Monazite and xenotime U-Th/Pb geochronology constrains REE mineralization to ~1785 Ma, consistent with zircon ages obtained from the same rocks. Zircons from the Gold Park Diorite yield ages of ~1400 Ma while those of the cross-cutting pegmatite veins yield ages of ~166 Ma. The relatively narrow range of ages and uniform Th/U ratios of zircons from the Pinto Gneiss suggest an igneous protolith. The similarity in ages between the monazite, xenotime and zircon along with the relict igneous zoning in the phosphate minerals indicates that REE-mineralization in the Pinto Gneiss occurred during crystallization of the igneous protolith. Pegmatite genesis at ~166 Ma post-dates the main phase of REE-mineralization but may be related to fluid-assisted alteration of the ore body.