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U–Pb zircon geochronology of Mesoproterozoic postorogenic rocks and implications for post-Ottawan magmatism and metallogenesis, New Jersey Highlands and contiguous areas, USA

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Abstract

Postorogenic rocks are widespread in Grenville terranes of the north-central Appalachians where they form small, discordant, largely pegmatitic felsic intrusive bodies, veins, and dikes, and also metasomatic calcic skarns that are unfoliated and postdate the regional 1090 to 1030 Ma upper amphibolite- to granulite-facies metamorphism related to the Grenville (Ottawan) Orogeny. Zircons from magmatic and nonmagmatic rocks from northern New Jersey and southern New York were dated to provide information on the regional tectonomagmatic and metallogenic history following Ottawan orogenesis.

We obtained U–Th–Pb zircon ages of 1004 ± 3 Ma for pegmatite associated with the 1020 ± 4 Ma Mount Eve Granite near Big Island, New York, 986 ± 4 Ma for unfoliated, discordant pegmatite that intrudes supracrustal marble at the Buckwheat open cut, Franklin, New Jersey, ∼990 Ma for a silicate-borate skarn layer in the Franklin Marble at Rudeville, New Jersey, and 940 ± 2 Ma for a calc-silicate skarn layer at Lower Twin Lake, New York. This new data, together with previously published ages of 1020 ± 4 to 965 ± 10 Ma for postorogenic rocks from New Jersey and southern New York, provide evidence of magmatic activity that lasted for up to 60 Ma past the peak of high-grade metamorphism. Postorogenic magmatism was almost exclusively felsic and involved relatively small volumes of metaluminous to mildly peraluminous melt that fractionated from an A-type granite parent source. Field relationships suggest the melts were emplaced along lithosphere-scale fault zones in the Highlands that were undergoing extension and that emplacement followed orogenic collapse by least 30 Ma. Postorogenic felsic intrusions correspond to the niobium–yttrium–fluorine (NYF) class of pegmatites of Černý (1992a).

Geochronologic data provide a temporal constraint on late-stage hydrothermal activity and a metallogenic event in New Jersey at ∼990 to 940 Ma that mineralized pegmatites with subeconomic to economic deposits of magnetite ± U ± Th ± rare earth element (REE) and formed metasomatic calcic skarn bodies in marble and reactive carbonate rocks. Mineralization associated with this event overlaps the timing of pegmatite emplacement, suggesting a petrogenetic relationship. Coeval metallogeny at

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975 to 950 Ma in the New York Hudson Highlands and 980 to 937 Ma in the Canadian Grenville Province implies that this event was widespread following the Ottawan phase of the Grenville Orogeny.

Keywords: Mesoproterozoic; Grenville; Postorogenic rocks; U–Pb geochronology; Metallogeny

1. Introduction

The extent of post-Ottawan magmatism in the northeastern North American Grenville is quite widespread and occurs nearly continuously from the north-central Appalachians northward to Canada. In the Hudson Highlands, U–Pb zircon ages of postorogenic intrusive rocks include the 1010 ± 6 Ma Canada Hill Granite (Aleinikoff and Grauch, 1990), 1008 ± 4 Ma Lake Tioroti diorite (Gates et al., 2004), and felsic pegmatites dated at 965 ± 10 Ma (Grauch and Aleinikoff, 1985). Elsewhere regionally, felsic igneous rocks in the Southern Green Mountains and Chester Dome in Vermont and Massachusetts have provided U–Pb zircon ages of 965 ± 4 Ma to 945 ± 7 Ma (Karabinos and Aleinikoff, 1990), and in the Adirondack Highlands a U–Pb zircon age of 935 ± 9 Ma (McLelland et al., 2001). Postorogenic granite and pegmatite in Ontario and Quebec have yielded Rb–Sr whole-rock isochron ages of 980 to 937 Ma (Fowler and Doig, 1983) and brief, but widespread, postorogenic felsic magmatism in eastern Labrador has provided U–Pb zircon ages between 980 and 956 Ma (Gower et al., 1991; Wasteneys et al., 1997).

This paper presents the results of U–Pb zircon dating of some highly representative postorogenic magmatic and nonmagmatic rocks from the northern New Jersey Highlands and contiguous southern New York Hudson Highlands. Field relationships and available geochemical and geochronologic data for postorogenic rocks are discussed in terms of their regional tectonic significance and their relationship to post-Ottawan metallogeny. Our intent is not a detailed treatment of the origin of postorogenic mineralization, nor of the composition of associated hydrothermal fluids. Rather, we seek to describe the types of mineralization and to fix the relative timing of magmatism and metallogeny within a geodynamic framework based on the geochronology. The terminology proposed by Moore and Thompson (1980) for the terminal orogenic event constituting the Grenville orogenic cycle, the Ottawan Orogeny at ca. 1100 to 1000 Ma, is followed in this paper.

2. Geologic setting

The New Jersey Highlands, along with the Hudson Highlands in southern New York and Reading Prong in eastern Pennsylvania, constitute one of the largest Grenville terranes that extend along eastern North America (Fig. 1). Most of the 1000 km^2 area of the New Jersey Highlands is underlain by Mesoproterozoic orthogneiss, paragniess, and marble separated into western and eastern domains (Fig. 2) by downfaulted, unmetamorphosed Paleozoic-age cover rocks. Mesoproterozoic rocks were metamorphosed at upper amphibolite to granulite facies during the Grenville (Ottawan) Orogeny at 1090 to 1030 Ma (Volkert, 2004a).

Basement rocks consist of a calc-alkaline continental magmatic arc assemblage of dacite, tonalite, trondhjemite, and basalt (Puffer and Volkert, 1991) of the Losee Metamorphic Suite (Drake, 1984; Volkert and Drake, 1999) that have an inferred age of ≥1200 Ma based on correlation with similar dated calc-alkaline rocks in the Central Metasedimentary Belt in southeastern Canada (e.g., Corfu and Easton, 1995), the Adirondack Highlands (McLelland and Chiarenzelli, 1990) and Adirondack Lowlands (Wasteneys et al., 1999), and Green Mountains (Ratcliffe et al., 1991). Similar calc-alkaline rocks are also recognized in the New York Hudson Highlands (Hotz, 1952; Offield, 1967; Gates et al., 2001). Widespread and abundant supracrustal rocks consist of quartzofeldspathic gneisses, quartzite, calc-silicate rocks, marble, and amphibolite (Volkert and Drake, 1999). In New Jersey this succession is thickest in the western Highlands where the Franklin Marble hosts two world-class metamorphosed zinc deposits (Hague et al., 1956). Supracrustal rocks maintain continuity along strike to the north and are abundantly exposed in the New York Hudson Highlands where