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Postorogenic carbonatites at Eden Lake, Trans-Hudson Orogen (northern Manitoba, Canada): Geological setting, mineralogy and geochemistry

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Abstract

The Eden Lake pluton in the Trans-Hudson Orogen is the first known occurrence of carbonatites in Manitoba. The pluton is largely made up of modally and geochemically diverse syenitic rocks derived from postorogenic magma(s) of shoshonitic affinity. Their diversity can be accounted for by a combination of crystal fractionation and fluid release in the final evolutionary stage (crystallization of quartz alkali-feldspar syenite). At Eden Lake, carbonatites, represented predominantly by coarse-grained massive to foliated sövite, occur as branching veins and lenticular bodies up to 4 m in thickness showing crosscutting relations with respect to all of the syenitic units. The host rocks are intensely fenitized at the contact, and there is also abundant mineralogical and textural evidence for assimilation of silicate material by carbonatitic magma through wallrock reaction and xenolith fragmentation and digestion. The bulk of the carbonatites are composed of (in order of crystallization): Sr–REE-rich fluorapatite, aegirine–augite, and coarse calcite crystals surrounded by fine-grained calcite (on average, ~90 vol.% of the rock). Noteworthy accessory constituents are celestine, bastnäsite-(Ce) (both as primary inclusions in calcite), Nb–Zr–rich titanite, low-Hf zircon, allanite-(Ce) and andradite. The calcite is chemically uniform (Sr-rich, Mg–Mn–Fe-poor and low in ^{13}C), but shows clear evidence of ductile deformation and syndeformational cataclasis. Geochemically, the carbonatites are enriched in Sr, Ba, light rare-earth elements, Th and U, but depleted in high-field-strength elements (particularly, Ti, Nb and Ta). The stable-isotope composition of coarse- and fine-grained calcite from the carbonatites and interstitial calcite from syenites is remarkably uniform: ca. -8.16 ± 0.27‰ $\delta^{13}C$ (PDB) and $+8.04\pm0.19$‰ $\delta^{18}O$ (SMOW). The available textural and geochemical evidence indicates that the Eden Lake carbonatites are not consanguineous with the associated syenites and may have been derived from a Nb–Ti-retentive and ^{13}C-depleted source such as the subducted crustal material underlying the Eden Lake deformation corridor.

Keywords: Carbonatite; Syenite; Postorogenic magmatism; Trans-Hudson Orogen; Manitoba; Canada

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1. Introduction

The bedrock geology of Manitoba (Canada) is a complex collage of Precambrian structural domains partially (ca. 40%) overlain by Phanerozoic sedimentary rocks. The Precambrian basement, exposed in a 400–650-km wide corridor extending NW-SE across the entire Province, can be crudely subdivided into the Paleoproterozoic Trans-Hudson Orogen (THO) in the northwest, Archean Superior craton in the southeast, and a boundary zone contouring the Superior craton (Fig. 1). The basement rocks underwent several extensional and rifting episodes, the youngest of which took place ca. 1880 Ma, heralding the closure of the Manikewan Ocean and the emergence of the THO (Zhai et al., 1994; Halls and Heaman, 2000; Ernst and Buchan, 2004). The adjacent part of the Superior craton just east of the Manitoba–Ontario provincial border contains evidence of an even younger extensional tectonic episode at ca. 1140 Ma (Heaman et al., 2005). It is, thus, surprising that neither alkali-rich silica-undersaturated nor carbonatitic rocks, commonly associated with extensional tectonics, had been reported from Manitoba in the 100-plus years of active exploration history. The discovery of carbonatites at Eden Lake in Manitoba (Mumin, 2002) is an important step forward in the study and interpretation of the geological history of this part of the Canadian Shield. This is particularly so because the Eden Lake carbonatites occur in an unusual petrographic milieu lacking undersaturated silicate rocks commonly found in spatial association with carbonatites elsewhere in the world. This locality is also the first confirmed occurrence of carbonatites in the THO. The present work is our first report on the geological setting, petrology and geochemistry of the Eden Lake carbonatites.

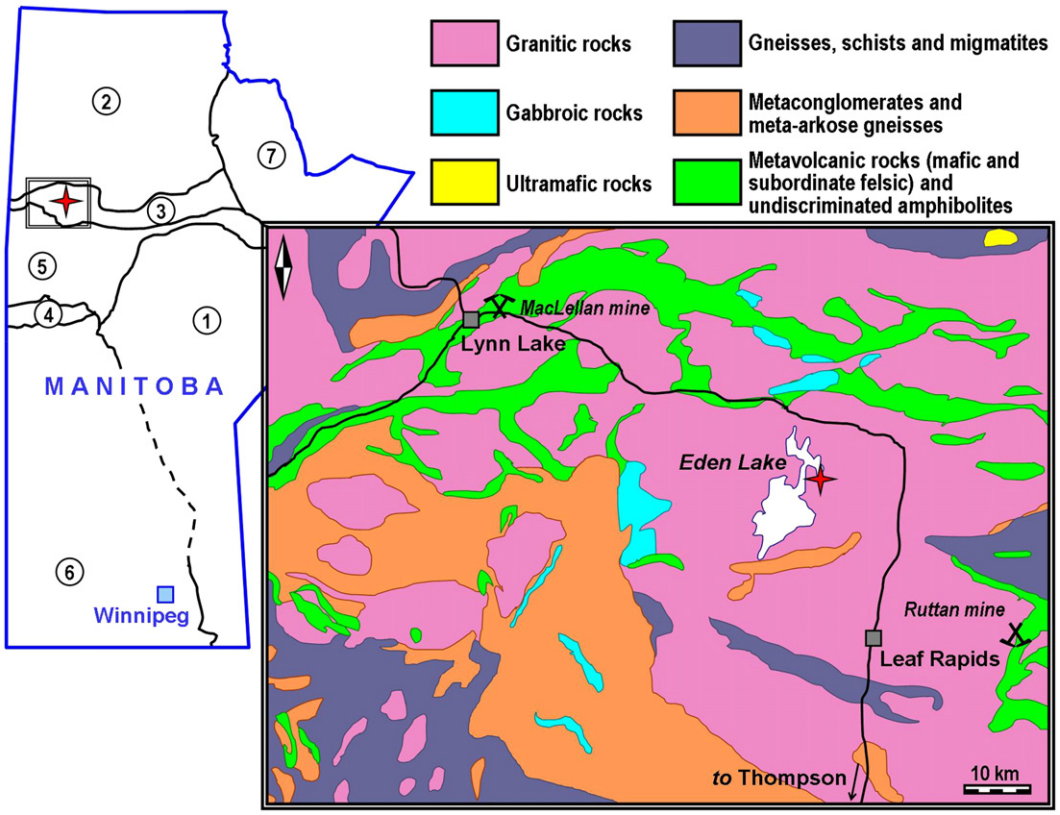

Fig. 1. Location map and simplified regional geological map of the study area; Manitoba provincial boundaries are indicated with a thick blue line, and the Eden Lake complex with a star. Numbers on the map at left correspond to the following major structural units: (1) Archean (3.5–2.7 Ga) Superior craton; (2) reworked and deformed margin of the Archean Hearne craton; (3) Lynn Lake–LaRonge domain (see Section 2.1 for details); (4) Flin Flon domain comprising Paleoproterozoic (1.92–1.88 Ga) ocean-floor and arc volcanics; (5) Kisseynew domain comprising mostly Paleoproterozoic (1.86–1.83) metasedimentary rocks; (6) and (7) Phanerozoic (<460 Ma) sedimentary rocks of the Williston and Hudson Bay basins, respectively. Units (2–5) constitute the northeastern segment of the Trans-Hudson Orogen.