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# Limited lithium isotopic fractionation during progressive metamorphic dehydration in metapelites: A case study from the Onawa contact aureole, Maine

Fang-Zhen Teng [a,*], William F. McDonough [a], Roberta L. Rudnick [a], Boswell A. Wing [a,b,1]

[a] *Geochemistry Laboratory, Department of Geology, University of Maryland, College Park, MD 20742, USA*
[b] *Earth System Science Interdisciplinary Center, University of Maryland, College Park, MD 20742, USA*

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**Abstract**

The major, trace element, and Li isotopic compositions of granodiorite and metapelites from the Onawa pluton and surrounding contact aureole have been measured to document the behavior of Li and its isotopes during progressive metamorphic dehydration. Major and trace element concentrations in metapelites of the contact aureole change little, while loss on ignition (LOI) decreases with increasing metamorphic grade, which ranges from regional chlorite-zone metamorphism far removed from the pluton to partially melted rocks adjacent to the pluton. Lithium concentrations in metapelites from all zones correlate with LOI and abundances of the main Li-bearing minerals, chlorite + biotite + muscovite, decreasing by a factor of two (from 130 ppm far removed from the pluton to 64 ppm adjacent to the pluton). In contrast, Li isotopic compositions remain relatively unchanged across the aureole ($\delta^7$Li = −3.5 to +1.0), and are comparable to the range observed in schists and unmetamorphosed shales. Compared to the surrounding metasediments, the granodiorite has a lower Li content (45 ppm) and a comparable $\delta^7$Li value of −0.2, similar to those of other granites and the average upper crust (0±2).

These observations are consistent with the removal of Li from metapelites via Rayleigh distillation during progressive metamorphic dehydration, with isotopic fractionation factors between fluids and rocks ranging between 1.001 and 1.004. These values are similar to those of a recent experimental study and produce isotopic fractionation that is barely beyond analytical uncertainty (±1‰) for the observed degree of Li depletion. The good correlations between Li concentrations and LOI with mineralogical abundances reflect the importance of mineralogy in controlling Li concentrations and isotopic compositions of metamorphic rocks. Comparison of these results with those from a study of a contact halo around the Tin Mountain pegmatite suggests that the nature of the intrusion plays a critical role in controlling the behavior of Li in country rocks. Large, diffusive-driven isotopic fractionation over a small scale is expected to occur when rocks are infiltrated by Li-rich magmatic fluids, while metamorphic devolatilization results in minor isotopic fractionation on the aureole scale.
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* Corresponding author. Present address: Department of Geology, The Field Museum, Chicago, IL 60605, USA. Tel.: +1 312 665 7656; fax: +1 312 665 7641.
*E-mail address:* fteng@fieldmuseum.org (F.-Z. Teng).
[1] Present address: Department of Earth and Planetary Sciences, McGill University, Montreal, Quebec H3A2A7, Canada.

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## 1. Introduction

In order to fully utilize Li isotopes as geochemical tracers, it is necessary to characterize the Li isotopic compositions of different geological reservoirs, and quantify the magnitude of isotopic fractionations for various conditions. The continental crust appears to have a lighter Li isotopic composition than the upper mantle, from which it was derived (Teng et al., 2004a,b). Given that Li isotopes do not fractionate during high-*T* igneous differentiation (Tomascak et al., 1999), juvenile crust and the mantle should have identical Li isotopic compositions. The isotopically light continental crust, therefore, is likely a result of post-formational processes, such as weathering, low-*T* intracrustal melting and metamorphism. Recent studies have demonstrated large Li isotopic fractionation during diffusion (Richter et al., 2003; Lundstrom et al., 2005; Teng et al., 2006a), terrestrial weathering (Pistiner and Henderson, 2003; Huh et al., 2004; Rudnick et al., 2004; Kisakurek et al., 2004), hydrothermal alteration (Chan et al., 1992, 1993, 1994; Seyfried et al., 1998; Chan and Kastner, 2000; Chan et al., 2002; James et al., 2003; Bouman et al., 2004; Foustoukos et al., 2004; Williams and Hervig, 2005) and smaller Li isotopic fractionation during granite differentiation (Bryant et al., 2004; Teng et al., 2004a, 2006b). The nature of Li isotopic fractionation during progressive metamorphism, however, is not yet well established.

Studying Li isotopic fractionation during metamorphism will shed light on the Li isotopic composition and evolution of the crust and Li behavior during subduction processes. Some eclogites and granulites have very light Li isotopic compositions (down to −18‰) (Zack et al., 2003; Teng et al., 2004b), while forearc serpentinites, which are interpreted to have interacted with slab-derived fluids, have both light and heavy Li isotopic compositions (Benton et al., 2004). These observations have been explained by Li isotopic fractionation associated with metamorphic dehydration, with isotopically heavy Li preferring fluids to rocks. However, to date, no comprehensive study of Li isotopic fractionation as a function of metamorphic grade has been carried out.

We present here the Li concentration and isotopic data for a suite of metapelites from the well-

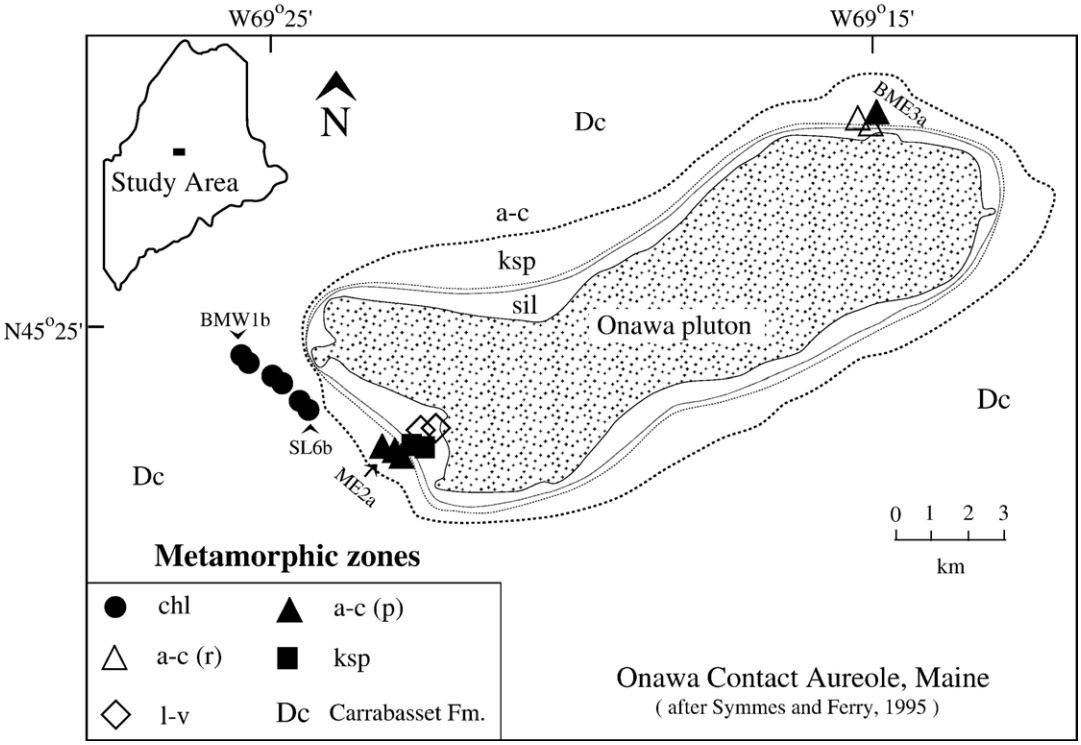


Fig. 1. Metamorphic map of study area with sample locations. Inset at upper left shows location of field area in central Maine. Sample locations and isograds are illustrated. Modified from Symmes and Ferry (1995). See Table 1 for abbreviations of metamorphic zones.