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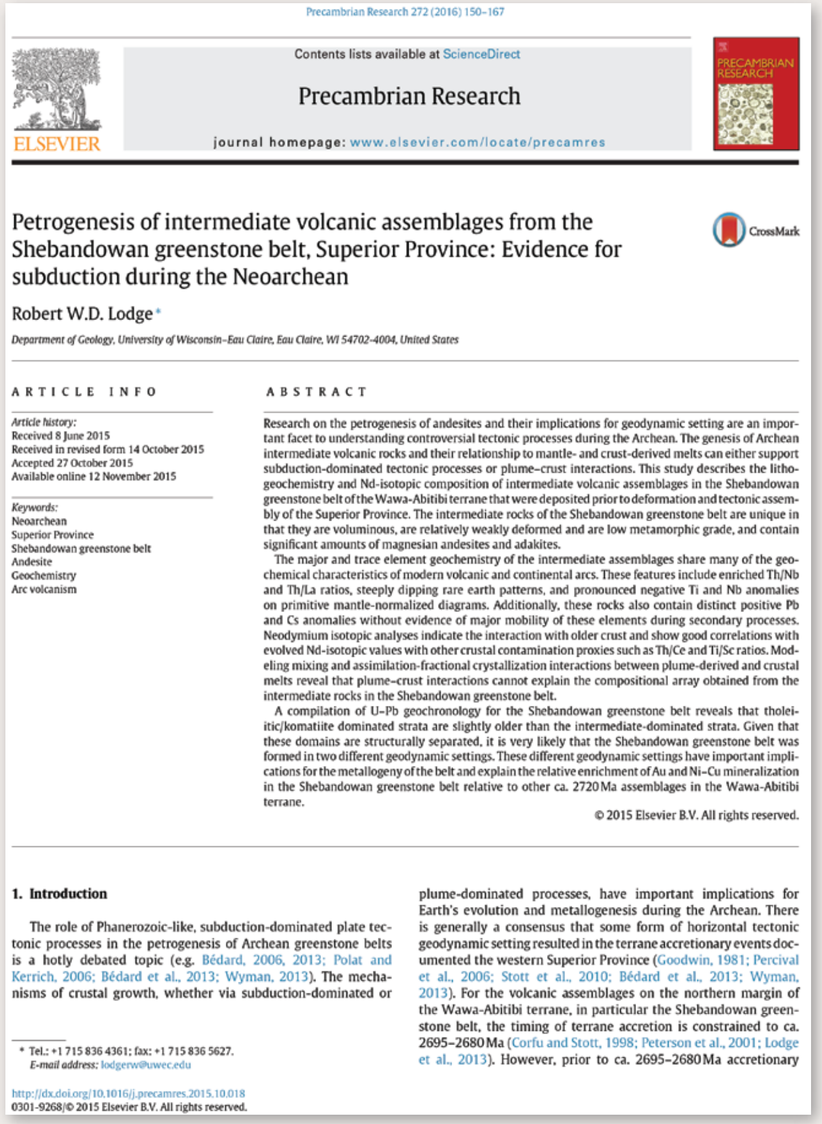
Petrogenesis of Intermediate Volcanic Assemblages from the Shebandowan Greenstone Belt, Superior Province: Evidence for Subduction during the Neoarchean

Precambrian Research

This manuscript documents the unusual occurrence of Andean-style volcanic assemblages at a time in Earth's history when these types of rocks are very rare because of fundamental differences in early Earth tectonic processes to modern plate tectonic theory. These rocks near Thunder Bay, Ontario, are well preserved and provide an excellent opportunity to study their chemistry without hindrance from post-deposition modification by structural events or metamorphism. These 2.72 billion year old rocks record some of the earliest evidence of modern plate tectonic processes and have important implications for the geologic development of North America.



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Petrogenesis of intermediate volcanic assemblages from the Shebandowan greenstone belt, Superior Province: Evidence for subduction during the Neoarchean

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ABSTRACT

Research on the petrogenesis of andesites and their implications for geodynamic setting are an important facet to understanding controversial tectonic processes during the Archean. The genesis of Archean intermediate volcanic rocks and their relationship to mantle- and crust-derived melts can either support subduction-dominated tectonic processes or plume–crust interactions. This study describes the lithogeochemistry and Nd-isotopic composition of intermediate volcanic assemblages in the Shebandowan greenstone belt of the Wawa-Abitibi terrane that were deposited prior to deformation and tectonic assembly of the Superior Province. The intermediate rocks of the Shebandowan greenstone belt are unique in that they are voluminous, are relatively weakly deformed and are low metamorphic grade, and contain significant amounts of magnesian andesites and adakites.

The major and trace element geochemistry of the intermediate assemblages share many of the geochemical characteristics of modern volcanic and continental arcs. These features include enriched Th/Nb and Th/La ratios, steeply dipping rare earth patterns, and pronounced negative Ti and Nb anomalies on primitive mantle-normalized diagrams. Additionally, these rocks also contain distinct positive Pb and Cs anomalies without evidence of major mobility of these elements during secondary processes. Neodymium isotopic analyses indicate the interaction with older crust and show good correlations with evolved Nd-isotopic values with other crustal contamination proxies such as Th/Ce and Ti/Sc ratios. Modeling mixing and assimilation-fractional crystallization interactions between plume-derived and crustal melts reveal that plume–crust interactions cannot explain the compositional array obtained from the intermediate rocks in the Shebandowan greenstone belt.

A compilation of U–Pb geochronology for the Shebandowan greenstone belt reveals that tholeiitic/komatiite dominated strata are slightly older than the intermediate-dominated strata. Given that these domains are structurally separated, it is very likely that the Shebandowan greenstone belt was formed in two different geodynamic settings. These different geodynamic settings have important implications for the metallogeny of the belt and explain the relative enrichment of Au and Ni–Cu mineralization in the Shebandowan greenstone belt relative to other ca. 2720 Ma assemblages in the Wawa-Abitibi terrane.

1. Introduction

The role of Phanerozoic-like, subduction-dominated plate tectonic processes in the petrogenesis of Archean greenstone belts is a hotly debated topic (e.g. Bédard, 2006, 2013; Polat and Kerrich, 2006; Bédard et al., 2013; Wyman, 2013). The mechanisms of crustal growth, whether via subduction-dominated or plume-dominated processes, have important implications for Earth's evolution and metallogenesis during the Archean. There is generally a consensus that some form of horizontal tectonic geodynamic setting resulted in the terrane accretionary events documented the western Superior Province (Goodwin, 1981; Percival et al., 2006; Stott et al., 2010; Bédard et al., 2013; Wyman, 2013). For the volcanic assemblages on the northern margin of the Wawa-Abitibi terrane, in particular the Shebandowan greenstone belt, the timing of terrane accretion is constrained to ca. 2695–2680 Ma (Corfu and Stott, 1998; Peterson et al., 2001; Lodge et al., 2013). However, prior to ca. 2695–2680 Ma accretionary

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