Journal of Asian Earth Sciences 42 (2011) 191–207

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Geochemical diversity in oceanic basalts hosted by the Zasur'ya accretionary complex, NW Russian Altai, Central Asia: Implications from trace elements and Nd isotopes

I.Yu. Safonova [a,b,*], N.V. Sennikov [c], T. Komiya [d], Y.V. Bychkova [e], E.V. Kurganskaya [a]

[a] Sobolev Institute of Geology and Mineralogy SB RAS, Koptyuga ave. 3, Novosibirsk 630090, Russia
[b] Korean Institute of Geoscience and Mineral Resources (KIGAM), 92 Gwahang-no, Daejeon 305-350, South Korea
[c] Trofimuk Institute of Petroleum Geology and Geophysics SB RAS, Koptyuga ave. 3, Novosibirsk 630090, Russia
[d] The University of Tokyo, 3-8-1 Komaba, Meguro, Tokyo 153-8902, Japan
[e] Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Kosygina 19, Moscow 19991, Russia

ARTICLE INFO

Article history:
Available online 1 March 2011

Keywords:
Central Asian Orogenic Belt
Late Cambrian–Early Ordovician
Paleo-Asian Ocean
Oceanic island
Oceanic floor
Mantle plume

ABSTRACT

Diverse types of Late Cambrian–Early Ordovician basalts are present as tectonic sheets and fragments in the Early–Middle Paleozoic Charysh-Terekta suture-shear zone of NE Russian Altai. La and Nb depleted, transitional and enriched basalts coexist within this geological structure. Mg# varies from 56 to 20 over a relatively narrow range of SiO_2 (46–52 wt.%). Iron, Zr, Nb, Y, LREE Ti, Cr, Ni and Th variably decrease with Mg#. Depleted tholeiitic basalts have weakly to undepleted LREE (La/Sm_n = 0.6–1.0), weakly fractionated HREE patterns (Gd/Yb_n = 1.1–1.3), relatively high ε_{Nd} (7.7–10.3) and negative Nb and Th anomalies relative to La (Nb/La_{pm} = 0.37–0.8, Th/La_{pm} = 0.4–0.85). Transitional basalts have moderately fractionated REE (La/Sm_n = 1.6–2.0, Gd/Yb_n = 1.3–2.4), medium ε_{Nd} (5.6–5.7) and positive Nb and negative Th anomalies relative to La (Nb/La_{pm} = 1.2–1.6, Th/La_{pm} = 0.7–0.9). Enriched basalts are the prevalent volcanic rock type characterized by LREE-enriched patterns with fractionated HREE (La/Sm_n = 1.9–4.7, Gd/Yb_n = 1.5–2.5), low ε_{Nd} (2.6–3.3), positive Nb and zero to positive Th anomalies (Nb/La_{pm} = 1.0–1.8, Th/La_{pm} = 0.6–1.15). Mantle melting processes, crustal contamination, or fractional crystallization can be ruled out as the main cause of the anomalies except for the moderate effect of alteration and metamorphism on the major-element composition of basalts. The enriched basalts show stronger REE fractionation (La/Yb_n = 6–9), higher positive Nb anomalies, like Phanerozoic HIMU ocean island basalts, than the transitional counterparts (La/Yb_n = 3–4), and also higher Al_2O_3 contents with convex-up trace-element patterns through Th–Nb–La. Both varieties have higher Zr/Hf ratios than depleted basalts and ε_{Nd} values close to those in HIMU. The LREE-depleted basalts are interpreted to have been a mid-oceanic ridge, whereas the transitional and LREE-enriched basalts – a chain of oceanic islands derived from a heterogeneous multi-component plume tapping the moving oceanic lithosphere. The oceanic islands were fragmented in the accretionary complex and tectonically mixed with underlying MOR tholeiites.

1. Introduction

In recent years, numerous oceanic crust fragments have been found and identified in accretionary complexes of different ages recognized within the Altai-Sayan foldbelt – a north-western part of the Central Asian Orogenic Belt (e.g., Buslov et al., 2001, 2004a; Dobretsov et al., 2004; Safonova et al., 2004, 2008; Ota et al., 2007; Xiao et al., 2010; Wong et al., 2010). Nevertheless, the fragments of ophiolites, oceanic islands and seamounts are generally less common in foldbelts than those of island arcs that may be explained by their smaller volume and poor identification in structures comprising numerous tectonically mixed sedimentary and basaltic-sedimentary terranes (Safonova, 2009). The ophiolites and oceanic islands/seamounts, the fragments of which have been found in Altai-Sayan, were formed in the Paleo-Asian Ocean (PAO). The PAO opened in the Late Neoproterozoic due to the breakup of the Rodinia supercontinent (Maruyama et al., 2007) and existed until the Early Carboniferous (e.g., Zonenshain et al., 1990; Dobretsov et al., 1995; Buslov et al., 2001). Oceanic subduction resulted in the accretion of paleoislands and the underlying oceanic lithosphere to the island arcs bounding the PAO and then

* Corresponding author at: Sobolev Institute of Geology and Mineralogy SB RAS, Koptyuga ave. 3, Novosibirsk 630090, Russia. Tel.: +7 383 3356452; fax: +7 383 3333414.

E-mail address: inna@uiggm.nsc.ru (I.Yu. Safonova).

1367-9120/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jseaes.2011.02.010

to the active continental margin of the Siberian continent. Later oceanic rock units experienced the influence of the processes of collision and subsequent faulting (Buslov et al., 2004b).

The Altai-Sayan foldbelt is a collage of terranes of different ages separated by numerous large-scale thrusts, strike-slip faults and nappes (Buslov et al., 1993, 2004b; Berzin and Dobretsov, 1994; Xiao et al., 2010). The terranes are classified mainly based on Vendian–Cambrian geodynamic units of the Paleo-Asian Ocean. Fig. 1 shows the major structural units that form the Altai-Sayan foldbelt, which is located between the Kazakhstan and Siberian continents (Buslov et al., 2001, 2004a). The tectonic pattern of the western Altai-Sayan comprises the Gondwana-derived Altai-Mongolian terrane, which separated from the margins of East Gondwana (Kurenkov et al., 2002) and later collided with the SW margin of the Siberian continent by a system of strike-slip faults (see Fig. 1 and Buslov et al., 2004b).

However, there are other models for the evolution of this part of the Central Asian Orogenic Belt based on the accretion of oceanic arcs and/or Gondwana-derived continental blocks to the Siberian, Russian, and North China cratons (e.g., Zonenshain et al., 1990; Didenko et al., 1994; Windley et al., 2007; Xiao et al., 2008; Yakubchuk, 2004; Rojas-Agramonte et al., in press) or accumulation of Paleozoic subduction-accretion materials against a few extended magmatic arcs (Sengör and Natal'in, 1996).

The north-western part of Altai-Sayan, Rudny Altai in Russian literature, belongs to a reactivated suture zone (Charysh-Terekta) which extends into the Altai-Mongolian terrane and hosts fragments of the Late Cambrian–Early Ordovician oceanic lithosphere (Fig. 1). Based on geochemically and geochronologically distinct volcanic and sedimentary rocks, tectonically juxtaposed in a tectonic mélange, and regional scale transpressional structural characteristics, Buslov et al. (2000, 2004b) interpreted the late Devonian Charysh-Terekta strike-slip or suture-shear zone as a subduction–accretion complex that formed along an Devonian convergent plate margin as a result of the Late Devonian collision of the Gondwana-derived Altai-Mongolian microcontinent and Siberian continent (Fig. 1; Buslov et al., 2001, 2004a). In this geodynamic framework, based on a very limited amount of geochemical data, tholeiitic and alkaline basalts were previously interpreted as dismembered fragments of the oceanic lithosphere of the PAO formed in mid-oceanic ridge and oceanic island settings (Buslov et al., 2000, 2001; Safonova et al., 2004).

The geochemical characteristics of Paleozoic oceanic basalts are of particular interest for understanding mantle evolution, petrogenesis and geodynamic processes. Besides, the study of oceanic magmatism is very important because it is an integral part of the study of orogenic belts incorporating many commercially valuable mineral deposits. The mutually correlated geochronological and compositional data on ophiolites and intra-plate basalts are necessary for reconstructing the histories of the paleo-oceans and their related accretionary processes, which significantly contributed to the Paleozoic continental growth of Central and East Asia. Last but not least, identification of OIB-type basalts (oceanic island basalts) is important for mantle plume modeling and global geodynamic paleoreconstructions (e.g., Maruyama et al., 1997; Safonova et al., 2009; Zhang et al., 2010).

This paper reviews few already published geochemical data (Sennikov et al., 2003, 2004; Safonova et al., 2004) and presents new high-precision ICP-MS trace element data for compositionally diverse basalts from the Zasur'ya unit or accretionary complex (Late Cambrian–Early Ordovician) of the Charysh-Terekta strike-slip zone located in Rudny Altai (Figs. 1 and 2). We also report first Nd–Sr isotope data for Zasur'ya basalts. Based on these results we attempt to resolve different components in the mantle sources from which the basalts were derived, and address the geodynamic settings of basalt eruption.

2. Geology

The geological structure of the Charysh-Terekta zone comprising the Zasur'ya accretionary complex with oceanic crust

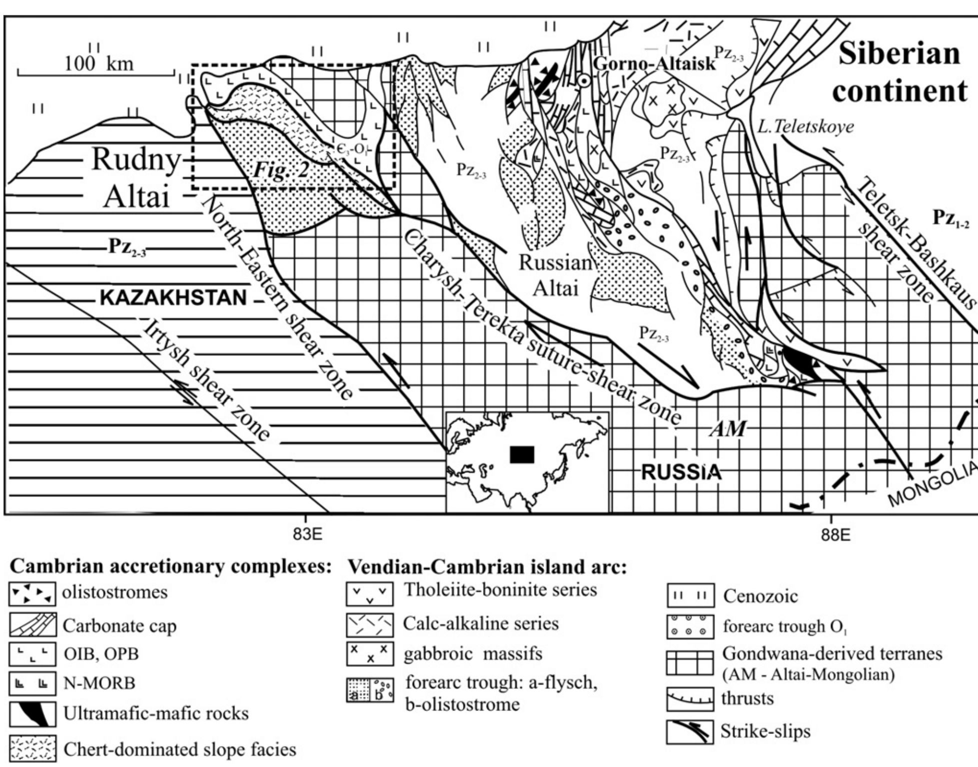

Fig. 1. Regional geology of the western Altay-Sayan foldbelt. NW Gorny Altai is outlined by a dotted rectangle. Modified from (Buslov et al., 2001).