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Conditions of basalt formation in the Dzhida zone of the Paleoasian Ocean

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Abstract

Petrological and geochemical studies performed with invoking data on the compositions of clinopyroxenes have clarified the conditions of formation of Vendian–Cambrian basaltic complexes in the Dzhida zone of the Paleoasian Ocean (northern Mongolia and southwestern Transbaikalia). The research was based on a comparative analysis with reference igneous basaltic associations. Of special importance are our microprobe data on trace and rare-earth elements in clinopyroxenes from igneous rocks of different present-day geodynamic settings, namely, N-MORB (Mid-Atlantic Ridge, Central Atlantic), OIB (Bouvet Island, South Atlantic), WPB (within-plate tholeiitic plateau basalts of the Siberian Platform), and boninites of ensimatic arcs (Izu-Bonin island arc, Pacific). The studies have shown that the paleo-oceanic structures in the district of the Urgol guyot formed during geodynamic processes under the impact of mantle plumes on oceanic spreading crust, which resulted in oceanic basaltic plateaus and within-plate oceanic islands. All these structures were later superposed by typical island-arc structure-lithologic associations. Formation of basalt complexes in the Dzhidot guyot district proceeded with a stronger effect of enriched plume melts of within-plate oceanic islands as compared with the Urgol guyot. This is evidenced from petrochemical and geochemical data showing the development of OIB-type magmatic systems on the oceanic basement. Data on clinopyroxenes confirm the participation of mantle plume in this process, which led to the evolution of magmas from typical oceanic basalts (MORB) to plateau basalts and OIB.

Keywords: basaltic complexes; clinopyroxenes; Dzhida zone; Paleoasian Ocean

Introduction

Basaltic complexes in paleo-oceanic and paleoisland-arc structures of the Dzhida zone in northern Mongolia and southwestern Transbaikalia are considered elsewhere (Al'mukhamedov et al., 1996; Kuz'min et al., 1995; Gordienko et al., 2007; Gordienko and Filimonov, 2005; Gordienko and Mikhal'tsov, 2001; Simonov et al., 2009, 2012). Studies showed the existence of structure-petrologic associations of ensimatic island arc, guyots (seamounts), and forearc and back-arc paleobasins of the Paleoasian Ocean in this region. In position and structure the Vendian–Cambrian guyots (Urgol and Dzhidot) of the Dzhida zone, localized in the central part of the Central Asian Fold Belt, are similar to the Early Paleozoic paleoseamounts of Gorny Altai (Gordienko and Filimonov, 2005) and the guyots of the Tien Shan sector of the Turkestan paleo-ocean (Gordienko et al., 2007). Analysis of the published works on Gorny Altai paleoseamounts (Safonova et al., 2008, 2011; Simonov et al., 2010) confirms this similarity.

Basalts of the Dzhida zone guyots were considerably transformed during secondary and metamorphic processes; therefore, study of primary magmatogene minerals is of great significance for the elucidation of their formation conditions. In particular, pyroxenes are in equilibrium with melt and thus bear much important genetic information. Melt inclusions (MIs) in these minerals give an insight into the physicochemical parameters of magmatic systems. For this reason, we paid much attention to the examination of magmatogene clinopyroxenes and MIs in them.

In this article we present new data obtained by analysis of a collection of basalts sampled by us in the Urgol guyot region,

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northern Mongolia, in 2011. The analysis was carried out at the Institute of Geology and Mineralogy, Novosibirsk. We also give the results of study of basalts from this guyot and the Dzhidot guyot, southwestern Transbaikalia, sampled earlier by geologists from the Geological Institute, Ulan-Ude.

Methods

The petrochemical compositions of basalts from the Dzhida zone were determined by chemical X-ray fluorescence analysis. The contents of trace and rare-earth elements were measured by ICP MS (with decomposition of solid samples into a standard set of 25 elements) and AAS at the Institute of Geology and Mineralogy, Novosibirsk. Part of the samples was analyzed by the X-ray fluorescence method, AAS, and ICP MS at the Institute of Geochemistry, Irkutsk.

Much attention was focused on study of preserved magmatogene minerals and MIs bearing direct information on ancient magmatic systems. The compositions of minerals were determined on a Camebax-Micro probe at the Institute of Geology and Mineralogy, Novosibirsk. Melt inclusions in clinopyroxenes were examined in the Laboratory of Geodynamics and Magmatism of the same institute. High-temperature experiments with MIs were carried out on a heating microstage with inert medium (Sobolev and Slutskii, 1984) using known techniques (Simonov, 1993; Sobolev and Danyushevksy, 1994). The contents of trace and rare-earth elements in clinopyroxenes were measured by SIMS on an IMS-4f microprobe at the Institute of Microelectronics, Yaroslavl, following Sobolev's (1996) technique.

The studies were based on a comparative analysis of results obtained for the collections of rocks sampled from reference igneous basalt complexes in different geodynamic settings and of data donated by other researchers of the Institute of Geology and Mineralogy (Novosibirsk), Far Eastern Geological Institute (Vladivostok), and University of Hawaii (Honolulu, USA). We used original data on basalts of the Mid-Atlantic Ridge (MORB) (Simonov et al., 1999), oceanic Bouvet Island in the South Atlantic (OIB) (Simonov et al., 1996, 2000), underwater Ontong Java Plateau in the Pacific (Simonov et al., 2004, 2005), and Siberian Platform (WPB) (Simonov et al., 2005). As a reference, we took the ion microprobe data on the contents of trace and rare-earth elements in clinopyroxenes from basalts and other igneous rocks of different geodynamic settings: N-MORB (Mid-Atlantic Ridge, Central Atlantic), OIB (Bouvet Island, South Atlantic), WPB (tholeiitic plateau basalts of the Siberian Platform), and ensimatic-arc boninites (Izu-Bonin island arc, Pacific). Thus, ion probe microanalysis of clinopyroxenes made it possible to find a few reference minerals, which help to obtain representative data for the identification of the paleogeodynamic settings of igneous-complex formation.

Geologic structure of the Urgol and Dzhidot guyots in the Dzhida zone

The petrologic complexes of the Urgol and Dzhidot guyots in the Dzhida zone are of special significance (Fig. 1).

The basement of the Urgol guyot is composed of melange with blocks of apoperidotite serpentinites, banded and isotropic gabbro, gabbro-pyroxenites, and dikes of gabbro-

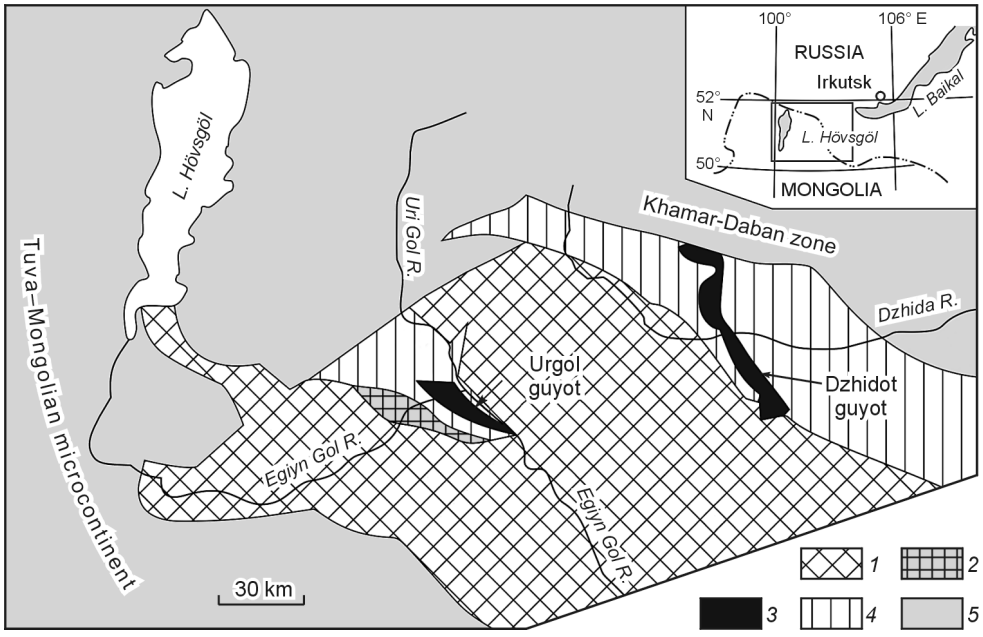

Fig. 1. Structure of the Dzhida zone (northern Mongolia and southwestern Transbaikalia), after Gordienko et al. (2007). *1–4*, paleo-oceanic and paleoisland arc complexes of the Dzhida zone: *1*, *2*, island-arc (*1*, without division; *2*, of accretionary prism); *3*, of guyots; *4*, flysch; *5*, petrologic complexes enclosing the Dzhida zone.