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Geochemistry of silver in Permo-Triassic traps of the Siberian Platform

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Abstract

The first data on the silver content in volcanics of the West Siberian Plate are presented, and data on basalts of the Siberian Platform are supplemented. The silver contents in all studied rocks do not depend on the fractionation of initial melts and contamination of the host rocks and average 0.07–0.10 ppm. The high silver contents can be associated only with sulfide formation.

Keywords: volcanics; silver; Siberian Platform; West Siberian Plate

Introduction

Metallic silver has been long known to the mankind. It is less oxyphile, more chalcophile, and more siderophile than copper; therefore, much of it was trapped by the metallic and sulfide phases during the Earth's core formation (Ryabchikov et al., 1999). The geochemistry of silver in igneous rocks has been poorly studied. The main difficulty of its study, especially at the clarke level, is caused by the presence of silver in different species in mineral phases and by its problematic analysis. The available literature data are concerned mainly with the metallogeny of silver and its concentration in ore deposits and provide no information about its behavior at different stages of evolution of magmatic systems (Grigor'ev, 2007; Orlova et al., 1983; Ryabchikov et al., 1999; Sidorov et al., 1989). Earlier we considered the distribution of silver in platform flood basalts (Medvedev and Al'mukhamedov, 1995). Since that time we have obtained a lot of new data on the Siberian Platform basalts. We were the first to determine silver in the volcanics of the West Siberian Plate. The sampling localities are shown in Fig. 1. In this work we consider the geochemistry of silver from the Permo-Triassic volcanics of East and West Siberia. These rocks were chosen for study for particular reasons. We established that the buried volcanics of the West Siberian Plate and exposing effusions of the Siberian Platform form the world-largest igneous province (LIP); at least in the Cambrian these regions were a single territory (Bochkarev et al., 2010; Kontorovich et al., 2008). On the North Asian craton, Permo-Triassic volcanics occupy an area of more than 2.6×10^6 km^2. The volume of the effused volcanics is estimated at ~2.3×10^6 km^3. The interest to this LIP is due to several factors. First, volcanism occurred in all areas of the North Asian craton nearly at the same time (Reichow et al., 2009). Second, during the large-scale volcanism (at ~251 Ma), mass extinction of live organisms took place, which was probably related to the effusion of huge batches of magma. And third, the trap formation of the Siberian Platform bears unique Cu–Ni deposits, and the West Siberian Plate has unique hydrocarbon pools.

It was proved earlier that volcanism was intraplate in both regions (Al'mukhamedov et al., 2004; Medvedev et al., 2003) and was caused by the activity of superplume or two plumes (Dobretsov, 1997). Basites in traps and rift zones are rich in incompatible elements and are similar in chemical composition to oceanic-plateau basalts (Simonov et al., 2004). The Siberian superplume was 2000–3500 km across (Dobretsov, 2010) and probably had two head projections. One of them was beneath the central part of the West Siberian Plate and caused mass rifting, and the other was likely beneath the western part of the Yenisei–Khatanga basin, where a rift zone is assumed to exist.

The magmatism in West Siberia and that in East Siberia have much in common. In both regions, basaltoids are predominant rocks. In the Tunguska syneclise area, however, their lithologic composition evolved in time and space. We recognized three types of volcanic sections: primitive (monotonous), normal (with periodic changes in composition), and anomalous (sandwich-like) (Al'mukhamedov et al., 2004; Sharapov et al., 2003). The first-type sections are predominant

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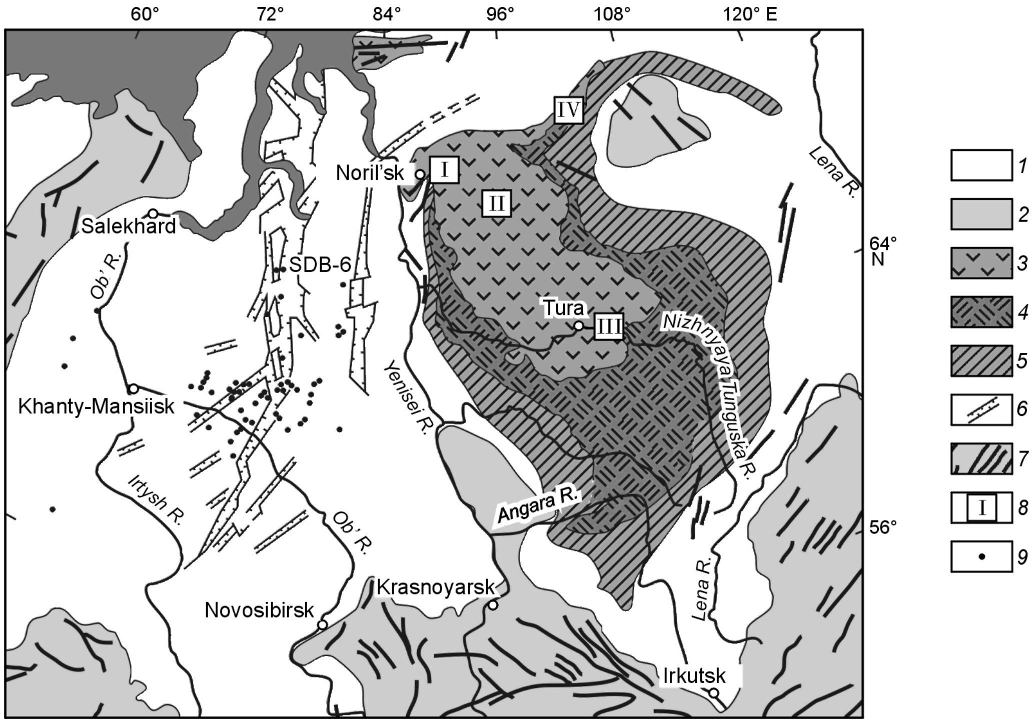

Fig. 1. Schematic occurrence of Permo-Triassic traps of the Siberian Platform and paleorift structures of the West Siberian Plate and the study regions. Scale 1 : 20,000,000. *1*, Phanerozoic sedimentary cover; *2*, fold belts and uplifts of the Precambrian basement; *3*, effusions; *4*, basaltic tuffs and tuffites; *5*, areas of occurrence of intrusive traps; *6*, surface projections of revealed and predicted rift structures of the pre-Jurassic basement of the West Siberian Plate; *7*, main disjunctions; *8*, sites of detailed studies of the Tunguska syneclise volcanogenic strata; *9*, localities of boreholes stripped a Triassic volcanic complex in West Siberia.

in basalt areas and are composed mainly of low-K tholeiites. The second-type sections are dominated by a differentiated series of alkaline and subalkalic rocks in the lower horizons. The third-type sections are formed by irregularly alternating subalkalic (alkaline) and tholeiitic rocks. Study of the spatial distribution of different types of rocks showed that normal and anomalous sections are specific only for the northern and northwestern margins of the Tunguska syneclise and are confined to the shoulders of paleorift structures, whereas primitive sections occupy most of the studied area. Based on all the above data, we recognized two stages of magmatic activity in the region: initial (rift formation) and final (beyond-rift blanket formation). According to statistical data, the rift formation took place somewhat earlier than the blanket formation (normal sections), but locally, the eruption of magmas of different alkalinity might have proceeded almost synchronously with the rift formation (anomalous sections). Thus, all volcanics of the Tunguska syneclise are basic rocks with different degrees of alkalinity and basicity.

The situation in West Siberia is somewhat different. Volcanics in this area vary widely in composition: from basalts to rhyolites, including alkaline rocks—trachybasalts and phonolites (Medvedev et al., 2003). All Permo-Triassic volcanics in the region are considered to be products of rift magmatism. This agrees with the presence of a huge system of rift structures in the Precambrian basement, which completed their evolution in the Triassic (Surkov et al., 2003). It was established that all West Siberian volcanics occur either in rift zones or on interrift uplifts and were generated at the rift formation stage. Remind that despite the great diversity of volcanics, basalts prevail. No zoning in the distribution of volcanics throughout the West Siberian area has been revealed because of lack of factual data.

It is of crucial importance to determine the content of Ag in similar rocks generated in both regions at the rift and blanket formation stages.

Some basalt samples from the Noril'sk region which bear visible sulfide minerals contain up to 86 ppm Ag; therefore, we studied samples free of visible sulfides. As a rule, the Ag-richest samples have the maximum content of Pb. Probably they contain galena grains. To eliminate the influence of sulfides, we chose samples with the maximum Ag content of 0.31 ppm.

The content of silver was determined by atomic-emission spectroscopy (AES) with the use of a discharge arc (Smirnova et al., 1993), following a special technique (Kuznetsova et al., 2007), which ensures results consistent with ICP MS data and a detection limit of 0.01 ppm.

The contents of Ag in different rocks are listed in Table 1. Despite the wide scatter of values for each type of rocks, the average contents are close, 0.06–0.10 ppm. In most types of volcanics from both regions, the Ag contents are below the element clarke in basites (after Vinogradov's theory). On the Siberian Platform, the rocks produced at the rift stage have somewhat higher contents of Ag than all other volcanics. We cannot state the same for West Siberia, since all studied rocks there were generated at the rift stage. The basalts from both regions show no difference between tholeiitic and subalkalic