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Идентификация конечных членов магматических серий моногенного конуса Зеленый, Малко-Петропавловская зона поперечных дислокаций, Камчатка

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Многочисленные проявления моногенного вулканизма локализованны в пределах Малко-Петропавловской зоны поперечных дислокаций (МПЗ), находящейся на границе между северным и южным сегментом Камчатки. Моногенный шлаковый конус Зелёный, расположенный в южной части МПЗ, представляет собой один из представительных примеров формирования питающих систем моногенного вулканизма в субдукционных обстановках. В данной работе продемонстрированы данные по содержанию основных оксидов и микроэлементов в изверженных породах конуса Зелёный. Проведено сравнение с данными по соседним вулканам, таким как конус Шлаковая, кальдера Карымшина и другими моногенными вулканами, расположенными вдоль МПЗ. Состав пород конуса Зелёный позволяет выделить две отдельные серии: серию I (мафитовую) и серию II (фельзитовую). Понимание происхождения отдельных моногенных конусов важно для выявления зон с высоким риском извержения в будущем.

Identifications of End-Members of Magmatic Series of Monogenetic Cone Zelenyi, Malko-Petropavlovsk Zone of Transverse Dislocation, Kamchatka

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The Malko-Petropavlovsk zone of transverse dislocations (MPZ) on the Kamchatka peninsula, which separates southern and northern Kamchatka, hosts numerous monogenic volcanic manifestations.The study of the monogenetic cinder cone, Zelenyi, located in the southern part of MPZ, is a representative example of the formation magma plumbing systems in monogenetic volcanic activity in subduction zones. Here we present the major oxide and trace element variation of erupted products from Zelenyi cone and their corelation with neighbouring volcanism such as Shlakovaya cone, Karymshina caldera, and several other monogenic volcanoes along MPZ. The composition of Zelenyi sample defines two distinct compositional series: Series-I (Mafic) and Series-II (Felsic). Understanding the nature of such individual monogenic cones are significant for identifying zones with imminent eruption potential.

Introduction

The Kamchatka peninsula sits on the overriding plate of North-West Pacific subduction zone with a long history of accretionary events, such as Late Cretaceous Achaivayam-Valagin arc terrane in Early Eocene and then accretion of Campanian-Eocene Kronotsky arc terrane at 6–10 Ma [1, 2]. The MPZ was formed as the extension of the deep Avachinsky transform fault system, which forms a geodynamic division between deep earthquake-prone Southern Kamchatka and their absence to the north [3, 4]. MPZ with exposed dense fractures feeds numerous monogenic cinder cones in the south with northern segment comprising of extrusive domes [5] (Fig. 1). Recent findings using seismic tomographical study demonstrated the presence of small-scale low-velocity anomalies at shallow depths in the northern (10−15km) segment and southern (<10 km) segment of MPZ, raising concerns of future hazards [6]. The general nature of volcanism across the MPZ is characterised by evolved extrusive domes neighbouring the stratovolcanoes and more primitive cinder cones along the Paratunka and Vilyui river valleys [6].

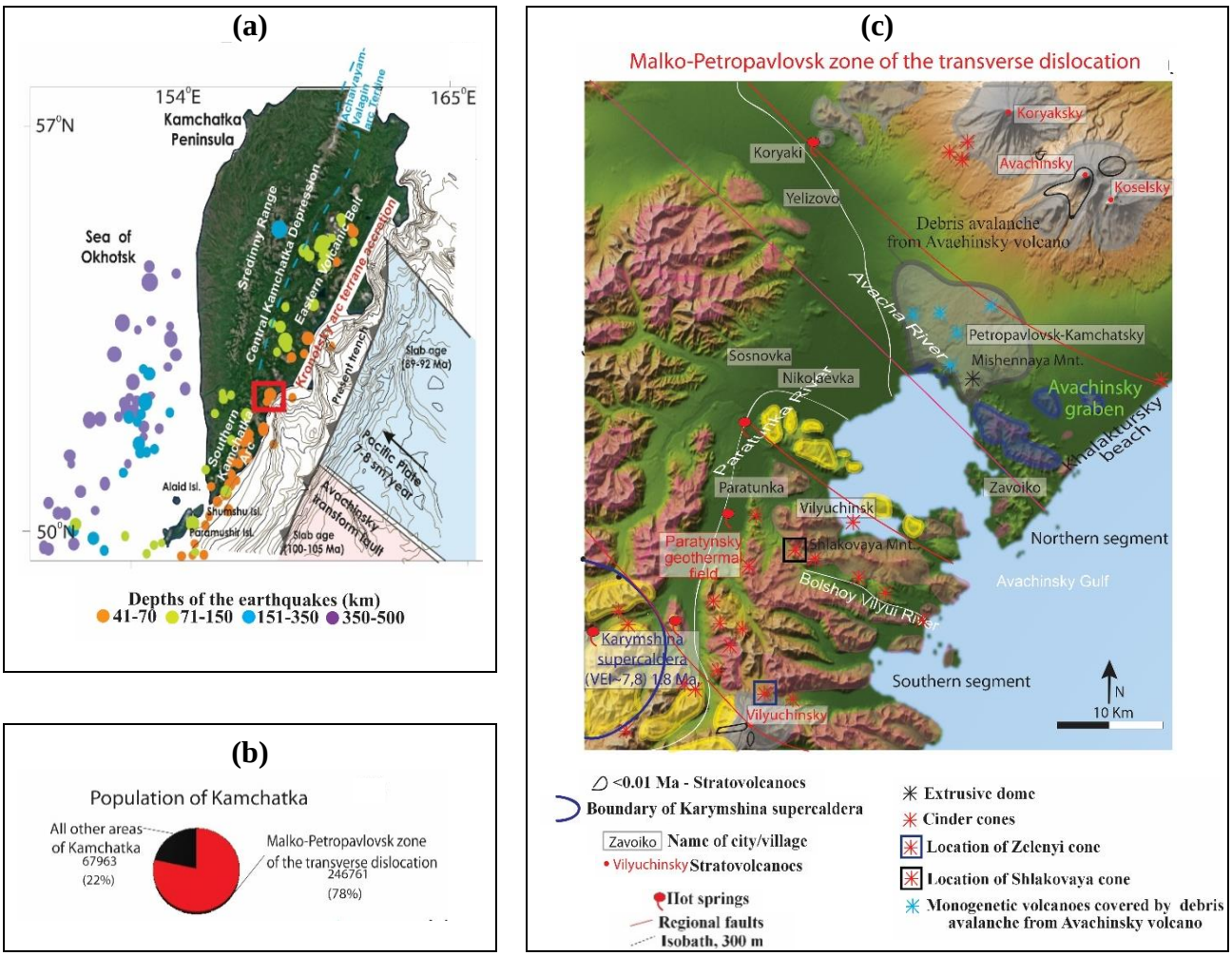


Figure 1 – (a) Geodynamic setting of Kamchatka (b) Pie chart showing population density of Kamchatka Vs MPZ (c)Map showing the location of Zelenyi cone, Shlakovaya cone and extrusive domes in MPZ with location of Karymshina super caldera, after [5]

Zelenyi monogenic cinder cone

Zelenyi monogenic cinder cone located on the southern section of MPZ represent one such cone exposed in volcanic field along the Paratunka river valley. Here we discuss the major element and whole rock data from Zelenyi cone to understand its magmatic evolution and compare it with published data sets of Shlakovaya cone, extrusive domes and data from different sections of monogenic fields in MPZ, which is required for reconstructing the volcanism along this transverse segment. Geochemistry of published data sets from Karymshina volcano which neighbours the Zelenyi cone is also analysed to investigate any possible corelations.

The samples collected from lava flow and lava bomb segments of the Zelenyi cone show drastic variation in their geochemistry, showing primitive basaltic to evolved rhyolitic nature with SiO_2 ranging from 49 wt% to 74 wt%, which can be corroborated by Mg# values (19−37) and negative binary trends of MgO, CaO and TiO_2 (Fig. 2). Even though the common evolutionary trend suggests fractional crystallization process, it alone cannot explain such a major compositional shift. Trace element behaviour of Zelenyi cone shows contrasting nature with evolved sample showing crustal contamination with high Th/La values, suggesting ponding of the magma before emplacement. The REE spider diagram displays classical arc signatures and points out significant variations in REE values, showing evolved and primitive natures.

Geochemical corelations

We demonstrate here, the coexistence two magma series, with series-I of mafic type and series-II of evolved felsic type (Fig. 2). Series-I have geochemistry of 49 wt% SiO_2, 6 wt% MgO and 3 wt% $Na_2O + K_2O$ with LREE enriched, slight HREE depleted REE pattern, elevated incompatible elements (Ce, Ba, Th, U) and Sr (446 ppm), Cr (201 ppm), Nd (13 ppm) values. Series-II is characterized by felsic features having 74 wt% SiO_2, 0.6 wt% MgO and 6 wt% $Na_2O + K_2O$ with typical arc magmatic trace element behaviour, including negative Sc (2 ppm) and Ni (4 ppm) anomalies and enriched Rb (37 ppm) and Ba (573 ppm) values compared to series-I.

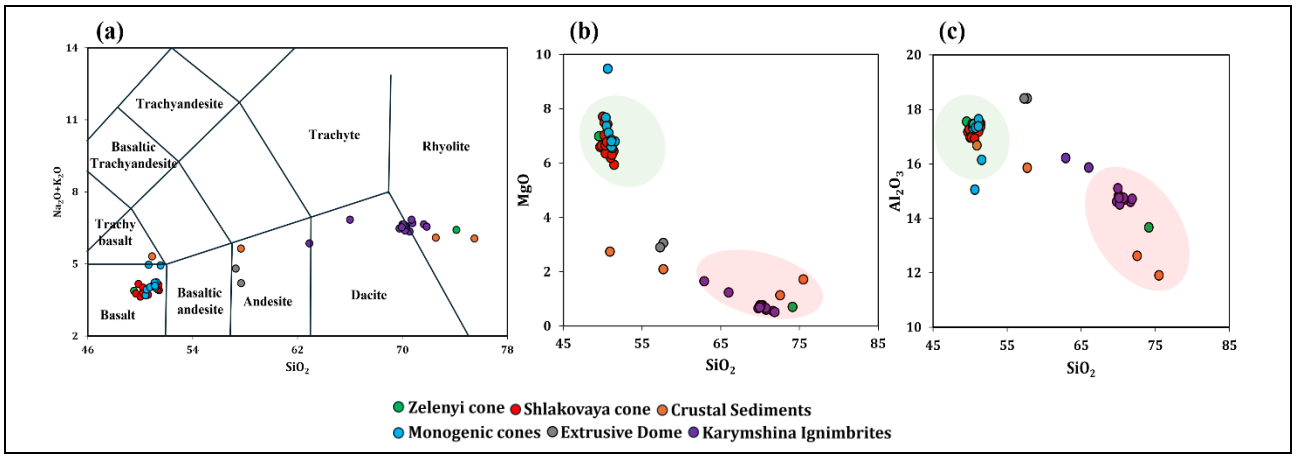


Figure 2 – Total alkali-silica (TAS) diagram (a) and Major oxide variation diagrams for Zelenyi cone and it's neighbouring volcanism (b) and (c). Green region: clustering of samples from Zelenyi cone (lava flow), Shlakovaya cone from [7] and monogenic cone from [5], Pink shade region: Karymishina ignimbrites from [8] and Zelenyi cone (lava bomb)

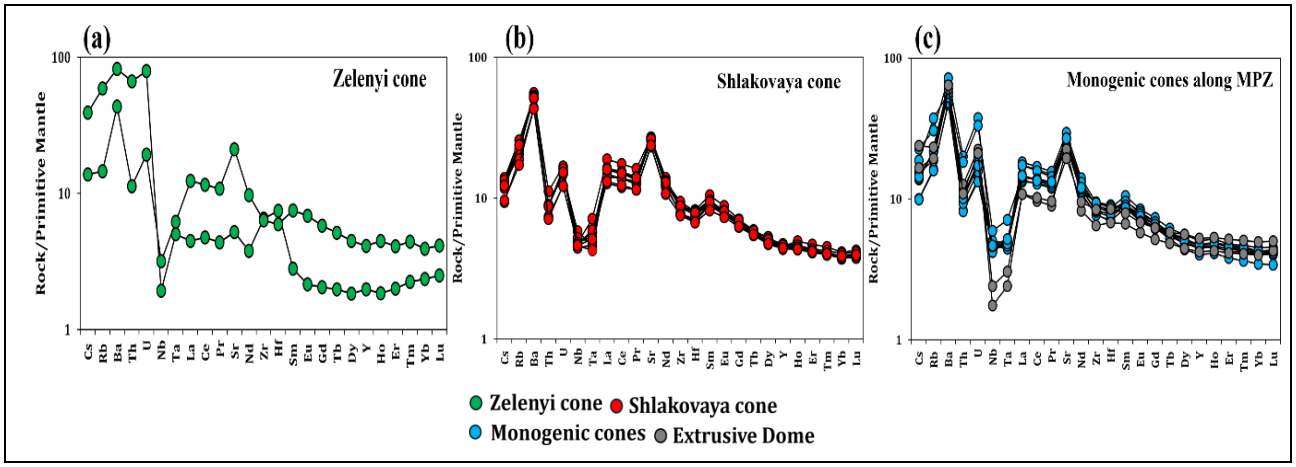


Figure 3 – Trace element variation daigrams normlaized to prtimitive for Zelenyi cone and it's neighbouring volcanism. The Shlakovaya cone data from [7] and monogenic cones and extrusive dome data of MPZ from [5]

A geochemical comparison of Zelenyi cone with known data from neighbouring volcanism showed two distinct clustered behaviour: Series-I, Shlakovaya cone and the regional data set of monogenic cones form a single cluster while Series-II samples group with Karymishina data (Fig. 2, 3). The extrusive dome samples were shown to be independent in nature with no clear corelation with other volcanisms. Such similarity also observed in REE pattern can be an indication of a genetic link between adjacent volcanic features, although enough data sets are not currently present to substantiate this speculation.

Conclusion

Our new data shown are significant for linking the evolutionary pattern of individual monogenic cones in this volcanic field and for identifying genetic links between adjacent volcanic centres. The hazardous nature of such monogenic cones along with identification of active melt zones underneath MPZ, raises the possibilities of future eruptions. MPZ, being located in the most populated city of Petropavlovsk-Kamchatsky, drives a complete scientific study on monogenic volcanoes to assess their hazard potential.

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