Origin of monogenetic volcanoes in Malko-Petropavlovsk zone of the transverse dislocation (Kamchatka): geological setting, geophysical parameters and geochemical data

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Keywords: monogenetic volcanoes, Malko-Petropavlovsk zone of the transverse dislocation, Kamchatka

Geodynamic setting of Kamchatka has a complicated structure and was formed by the accretion of various aged terrains on north from the Malko-Petropavlovsk zone of transverse dislocations (MPZD) and a long-lived volcanic arc in southern Kamchatka (Lander and Shapiro, 2007). MPZD is located on trajectory of deep transform fault (Seliverstov, 2009) and can be considered as a boundary between various aged slabs and generated volcanic belts on Eastern volcanic belt, Sredinny Range and southern Kamchatka (Fig. 1).

On the Earth's surface MPZD detected by numerous regional faults, which are orthogonal to the present location of subduction zone (Geological map, 2000) (Fig. 1b). Geophysical researches using the earthquake converted-wave method and magnetotelluric sounding suggest for fragmentations of the crust and intrusions of magmatic bodies in various depths inside the MPZD (Nurmukhamedov, Sidorov, 2019).

Complex geological structure of Kamchatka region can be seen also from seismic recordings. Firstly, operating seismic stations can be divided into three groups considering the frequency content of its waveforms (Gusev, Skorkina, 2020) on “southern”, “northern” stations and Bering (BKI), with a boundary within Russkaya-Nalychevo (RUS-NLC) stations. Another feature which can be seen from seismic data is a shift of the third corner frequency. Source spectra for earthquakes of Kamchatka region are known to have a complex shape which in the broad frequency range fits best the three-corners source spectra model (Skorkina, Gusev, 2017). It was found that for subduction earthquakes of 2011–2014 with $K_S = 10–12$ registered between 52–54°N the shift of third corner frequency can be observed from 7 Hz around 54°N to 4.5 Hz around 52°N. The origin of this shift should be studied further because there are two controversial hypotheses: it can be either a source effect or propagation effect. However, in both cases it indicates the complex geological media.

Geological and geochemical studies of magmatic complexes in MPDZ give a unique chance to investigate genesis of their formations and evolution throw the time. The oldest rocks (>38 Ma) in MPDZ are pillow lavas with basaltic-andesitic compositions in north-west edging of Avacha bay (Fig. 1). The next stage of magmatic evolution are magmatic rocks, e.g. lava flows, extrusive domes, which were formed 14.4–11.5 Ma. Large caldera-forming eruption were active since 5.1–1.6 Ma, e.g. the Karymshina caldera (Leonov and Rogozin, 2007) and Verhneavachinskaya caldera (Bergal-Kuvikas et al, 2019). In Pleistocene-Holocene time magmatic activities presented by stratovolcanoes and monogenic cinder cones. Locations of stratovolcanoes controlled by slab and situated on 213–230 km from the trench. Whereas locations of monogenic volcanoes are independent from the slab and localized on 197– 233 km from the trench (Fig. 1). Monogenetic volcanoes represented by numerous basaltic andesitic cinder cones in the valley of Paratunka river, coastline of Pacific ocean and extrusive andesitic domes in north edging of Avacha bay (Fig. 1).

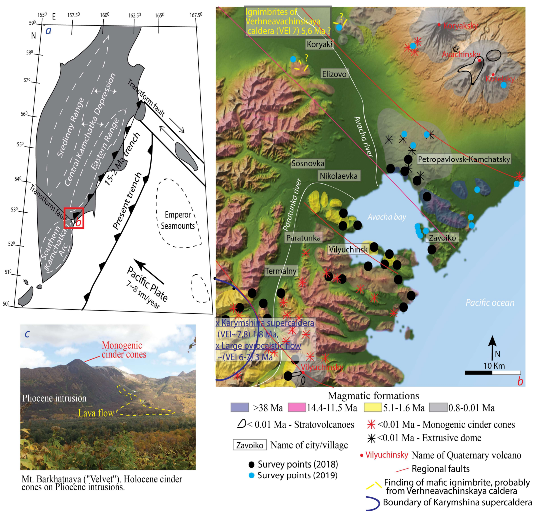

Fig. 1. (a) General tectonic setting of Kamchatka, (b) Geological formations of MPZD according to Geological map (2000) in survey points, (c) Monogenic cinder cone in MPZD.

Compositions of magmatic rocks in MPDZ vary from basalts to rhyolites (47–76 wt.% SiO_2). Large caldera-forming eruptions of the Karymshina caldera have more acid compositions (>60 wt.% SiO_2), at the same time with acid intrusions in the valley of Paratunka river. Most mafic, low alkali magma (50–53 wt. % SiO_2, 6.5–7.7 wt.% MgO, 0.8–0.9 wt.% K_2O) belong to monogenic cinder cones in the valley of Paratunka river, near the Vilyuchinsky volcano. Monogenic cinder cones were formed during two stages of activities: 7000–10000 BP and 2000–4000 BP (Dirksen, 2009). Localizations of monogenic cinder cones were controlled by deep regional faults (Florensky and Bazanova, 1989; Sheimovich and Patoka, 2000). Extrusive domes (e.g. Mishennaya Mount) in north edging of Avacha bay characterized by hornblende bearing andesites. They are localized on thick sedimentary deposits in basement and consequently more fractionated in comparing with monogenic cinder cones in valley of Paratunka river.

Preliminary results of seismic data analyses and morphological structures on the Earth surface enable identify deep dislocation zone (e.g. deep regional faults) in MPDZ. They have control localizations of monogenic volcanism. Magma compositions of monogenic volcanoes are more mafic and low alkali in comparing with other various aged magmatic formations in MPZD. The effect of crystal process (e.g. assimilation, fractional crystallization) is suggested to be a minimum in comparing with other magmatic formations in MPDZ.

Acknowledgements

We are gratefully thanking grant N14.W03.31.0033 from the Russian Ministry of Education and Science of the Russian Federation for support field works and grant 19-17-00241 of Russian Science Foundation for analytical measurements.

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