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КРУПНЫЕ ИЗВЕРЖЕННЫЕ ПРОВИНЦИИ В ИСТОРИИ ЗЕМЛИ: МАНТИЙНЫЕ ПЛЮМЫ, СУПЕРКОНТИНЕНТЫ, КЛИМАТИЧЕСКИЕ ИЗМЕНЕНИЯ, МЕТАЛЛОГЕНИЯ, ФОРМИРОВАНИЕ НЕФТИ И ГАЗА, ПЛАНЕТЫ ЗЕМНОЙ ГРУППЫ (КИП – 2019)

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ORIGIN OF ULTRAMAFIC XENOLITHS FROM CANARY ISLANDS

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Introduction

The Canaries are an age progressive volcanic island chain located ~100 km off the coast of northwest Africa. The Canaries span a lateral distance of ~500 km, trending roughly east–west and are comprised of seven main islands: Lanzarote, Fuerteventura, Gran Canaria, Tenerife, La Gomera, La Palma, and El Hierro. The entire island chain has sub-aerial lavas dated from 20.6 million years old to recent historical eruptions (Abdel-Monem et al., 1972; Guillou et al., 1996; 1998; Paris et al., 2005). The westward trending age progression of the Canary Islands has been interpreted as a symptom of a slow-moving mantle 'hotspot' with a low buoyancy flux (Abdel-Monen et al., 1972; Carracedo et al., 2001, 2002).

Results

An important aspect in interpreting nature of ultramafic xenoliths is their mineralogical composition. Presence of plagioclase (Traver & Caitlin Mary, 2013) does not let us consider these inclusions as real mantle xenoliths, as products of sub asthenosphere mantle. Our mineralogy analyses of ultramafic xenoliths from La Palma Island suggest capturing of ultramafic crystallization fragments in an intermediate deep magma chamber at a border between lithospheric mantle and lower crust (Krylova et al., 2018). Compositions of rock-forming minerals confirm this interpretation. In particular, presence of endiopside and basic plagioclase, as well as orientation of olivine grains (that corresponds to the olivine analogue of dunites from Yoko-Dovyren layered Massif in Northern Trans Baikal) indicates potential crust nature for these xenoliths. This orientation shows reflects cumulative nature of olivine, which does not suggest the mineral deformation in restite ultrabasites.

We have chosen cumulative dunites from Yoko-Dovyren layered pluton and "restite" peridotites from Kuznetsk Alatau (dunites from chromite mineralization zone of Barkhatny Massif) as standards. Analysis of olivine grain orientations from studied xenolith by EBSD method shows obvious axis maximum [001], which means Nm that corresponds to maximum extension of olivine crystal and shows/reflects orientation of its earlier crystals in magmatic melts.

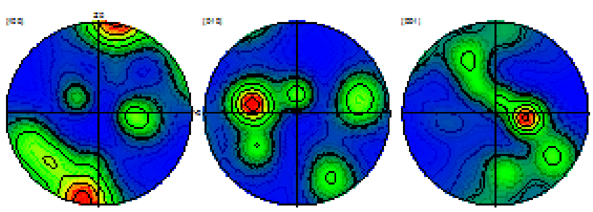

Figure 1. Diagram of olivine optical orientation from dunites of Yoko-Dovyren massif.

One of the signs of olivine's cumulative nature is an obvious axis maximum [001] and belted/ dissipation/scattering of two other crystallographic axes, which is observed in dunites from Yoko-Dovyren massif and xenoliths from Canary basalts.

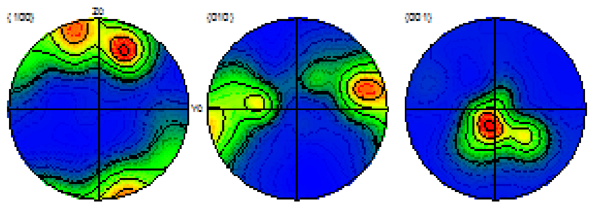

Figure 2. Diagram of olivine optical orientation of xenoliths from Canary Islands.

Such petro fabric pattern is caused by quite chaotic olivine grain orientations in magmatic melt. In addition, introducing magma flow suggests orientation of early olivine crystals to be parallel the flow itself, i.e. orientation of maximum grain extension in this direction. Other axes while having crystal lattice-like parameters are characterized by "blurred" zones/ belts, which possibly indicate grain rotations along two flat surfaces.

Conclusions

Considering specifics of mineral composition of studied xenoliths, namely presence of plagioclase and quite ferruginous olivine (same level as in chrysotile), we can assume a cumulative nature of xenoliths from ultrabasic rocks, which was caused by early crystallization in an intermediate magmatic chamber at a significant depth. The results of our petro fabric study confirm this assumption.

Acknowledgements

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PALEOMAGNETISM OF THE PERMIAN-TRIASSIC INTRUSIONS OF THE NORILSK REGION: IMPLICATIONS OF THE SIBERIAN TRAPS EMPLACEMENT AND THE CU-NI-PGE DEPOSITS ORIGIN

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The Norilsk region of the Siberian platform is an area of the great scientific interest due to the unique Cu-Ni-PGE sulfide deposits. These deposits are related to the layered mafic-ultramafic intrusions which are associated with the Permian-Triassic Siberian Traps Large Igneous Province. The Norilsk region is located in the northwestern part of the platform and contains the thickest tuff-lava section of the Siberian Traps (up to 3500 m). According to the current schedule, trap intrusions of the Norilsk region are subdivided into seven complexes. One of them, namely Norilsk complex, contains four intrusive types. Ore deposits of economic importance are found only in the Norilsk-type intrusions of the Norilsk complex.

Despite the continuous and extensive investigation of the Norilsk intrusions, many aspects of the ore genesis and relationship of ore-bearing intrusions with the volcanic sequence of the Norilsk region are still debated. Most of the ore genesis models predict the different versions of correlation of ore-bearing Norilsk-type intrusions with the Siberian Traps volcanic sequence of the Norilsk region. According to various models, Norilsk-type intrusions are considered to be coeval with the lavas of Mokulaevsky (Rad'ko, 1991), Nadezhdinsky – Lower Morongovsky (Naldrett et al., 1992), or high-Mg picrites of Gudchikhinsky and Tuklonsky formations (Zolotukhin et al., 1986). Furthermore, some researchers assume that since Norilsk-type intrusions are the products of the specific magma type, not related to any volcanic formation, they could not be directly correlated with the tuff-lava sequence of the Norilsk region (Czamanske et al., 1994; Latypov, 2002). Thus, different models demonstrate a wide variety of correlation between lavas and ore-bearing intrusions.

Recently, we obtained the detailed flow-to-flow record of geomagnetic secular variations in the tuff-lava section of Norilsk as well as the preliminary paleomagnetic results on the Norilsk-2 intrusion, which is attributed to the Norilsk type (Pavlov et al., 2019). Here we present the results of detailed paleomagnetic investigation of the intrusions of Norilsk region, including economically important intrusive bodies of the Norilsk type. Based on the geomagnetic secular variations analysis, we obtained the new constraints on the timing of ore-bearing intrusions emplacement and suggested the correlation scheme of the intrusions with the volcanic sequence of the Norilsk region. Our method is based on the suggestion that if two magmatic bodies are formed simultaneously, their paleomagnetic directions have to be statistically indistinguishable, and, on the contrary, products of different magmatic events would likely have different directions. Using this approach, we compared the mean paleomagnetic directions for the studied intrusions with the directions of different stratigraphic levels from the tuff-lava sequence of Norilsk.

Our comparison demonstrated that all studied ore-bearing intrusions of the Norilsk region (including economically important Norilsk-1, Kharaelakh and Talnakh intrusions) and their satellites have paleomagnetic directions which are statistically indistinguishable from some volcanic units (volcanic pulses or individual flows) within the Morongovsky and Mokulaevsky formations in the middle part of the Norilsk tuff-lava sequence. It is the strong argument that the emplacement of all ore-bearing intrusions occurred during the same stage of the Siberian Traps magmatic activity. Within this stage, we were able to distinguish discrete magmatic events corresponding to the emplacement of three main ore-bearing intrusions, namely Norilsk-1, Kharaelakh and Talnakh, and some bodies spatially related to them. According to our paleomagnetic results, weakly differentiated Kruglogorsky-type intrusions and barren sills of the Oganer complex were at the same stage too. Finally, we obtained very close paleomagnetic directions from thin inclined dikes of the southern slope of the Kharaelakh plateau and Arylakh intrusion (the Norilsk type), and attributed them to the same phase, corresponding to the Morongovsky-Mokulaevsky level of the volcanic sequence.

The emplacement duration of the ore-bearing intrusions is another vital question of the Norilsk region geology. Since the mean virtual geomagnetic poles for the most intrusions differ statistically from the Permian-Triassic "Siberian Traps" paleomagnetic pole of the Siberian craton NMK (Pavlov et al., 2019), we suggest that geomagnetic secular variations re-