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Petro- and paleomagnetic studies of basalts of the upper devonian appainskaya suite (Western Yakutia)

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Abstract

Introduction. One of the main tasks of paleomagnetic studies is to obtain a framework of reference poles for calculating the kinematic characteristics of lithospheric taxones as a basis for geodynamic reconstructions. Each paleomagnetic reference point must have a precise (±10 Ma) geochronological dating and a maximum paleomagnetic reliability index. A correct paleomagnetic pole (PMP) can be obtained from the data of geochronological and paleomagnetic studies conducted in one and the same geological object, such as a suite, an intrusive complex etc. In the Yakutian diamondiferous province (YDP), such objects include basalt nappes of the Upper Devonian Appainskaya suite, which stratigraphic position is undoubted (Fran, 385-375 Ma). Geological setting (in brief). In the eastern segments of the Siberian platform, a powerful cycle of tectonic and magmatic activity in the Middle Paleozoic produced transgressive and sheet intrusions, volcanic pipes, lava and tuff formations comprised of basites, as well as all the currently known industrial diamondiferous kimberlite bodies. Magmatic activity of basites was associated with formation of paleorift systems, including the largest one, Viluyi paleorift (Fig. 1). In the Middle Paleozoic, the geodynamic setting for magmatism and rifting was determined by the plume-lithosphere interaction. The rise of the plume's matter underneath the thinned lithosphere was accompanied by decompression melting and formation of basaltic magmas in large volumes. We have studied basalts of the Appainskaya suite which were sampled from the Ygyatta and Markha river valleys (Fig. 2). In the coastal outcrops at the Ygyatta river, two nappes are observed, a (stratigraphically) lower outcrop 17÷23/10 containing plagiophyre palagonite basalts (upper five meters are outcropped), and an upper outcrop 16/10 containing olivinophyric palagonite basalts (upper three meters are outcropped). In the coastal outcrops of the Markha river, from the Enerdek loop to the M. Dyukteli river (outcrop 16÷20/14), only plagiophyric basalts of the lower nappe are developed. At this location, the total capacity of the basalts can reach 35-40 m. In view of the fact that the basalts lie subhorizontally at angles up to 5° (outcrop 17/14, Fig. 3), oriented samples were taken in the modern system of coordinates. Formational features of the chemical composition typical of the Middle Paleozoic intrusive basites (higher contents of Ti, Fe and K) are less clear in derivatives of the effusive facies. By their chemical composition, the basalts are normal alkalinity rocks (the sum of alkali not higher than 3.05 %; SiO2=48.1-49.7 %; rather moderate content of TiO2=1.9-2.5 %) (Fig. 4 A, B). The amount of magnesia (Mg#) ranges from 46 to 56. The main carriers of natural remanent magnetization (NRM, In) are titanomagnetites that belong to titanomagnetite and hemo-ilmenite series (Fig. 4). Research. Our research was conducted in specialized laboratories using modern equipment and facilities of Geo- Scientific Research Enterprise (NIGP) PJSC ALROSA (Mirny), Institute of the Earth's Crust SB RAS (Irkutsk), Kazan Federal University (Kazan) and Institute of Geology of Diamond and Precious Metals SB RAS (Yakutsk). Research results. By magnetic (scalar and vector) parameters, basalts of the

Appainskaya suite are characterized by the bimodal distribution of magnetic susceptibility values, NRM and æ: geometric means are 810·10-5 Si-units and 225·10-3 A/m, respectively, at the Ygyatta river, and 1470·10-5 SI-units and 490·10-3 A/m, respectively, at the Markha river (Table 1, Fig. 5). Factor Q is below 1. Results of the petrophysical observations are consistent with the geological materials and suggest that the basalts at the Ygyatta river occupy the upper stratigraphic horizon. The studied outcrops of basalts of the Appainskaya suite have the following characteristic components of Inch: 1. Component A - negative vectors of the characteristic NRM are clustered in the fourth sector of the stereogram (sample Igy179m1, Fig. 10, Fig. 14 A, Table 2). Found in outcrop 16/10. Component A is metachronic Inm that formed due to heating of basalts by dolerites of the Ygyatta sill, which suggests the dyke-type of the anisotropy of magnetic susceptibility (AMS) (Fig. 6 C) and a high oxidation level of titanomagnetites (sample 179, Fig. 8). 2. Component B - steep positive vectors of the characteristic Inch (samples Igy224m2, Mrh142m2 and Mrh176t2, Fig. 10, Fig. 14 A, Table. 2). Found in outcrops 20/10 and 16÷18/14. Component B is typical of the outcrops with significant deviations of the axes of the AMS ellipse (Fig. 6 D, E), which suggests epigenetic changes in the basalts. New occurrences of titanomaghemites are observed in the studied outcrops (sample 228, Fig. 8), which leads to an almost complete destruction of vector In0 and formation of viscous NRM - Inv, which are oriented in the direction similar to the geomagnetic field. This conclusion is supported by the 'artificial magnetization reversal' tests (Fig. 11 A). 3. Component C - negative vectors of the characteristic NRM are clustered in the first sector of the stereogram at angles varying from -50 to -40° (Fig. 12, Fig. 14, Table 2). Found in four outcrops at the Ygyatta river (outcrops 17/10, and 21÷23/10). 4. Component D - positive vectors of the characteristic NRM are clustered in the third sector of the stereogram at angles varying from 40 to 50° (Fig. 13, Fig. 14, Table 2). Found in four outcrops at the Markha river (outcrops 20A, 20B, and 20C/14). The primary origin of characteristic components C and D of the basalts is determined as follows: - The 'sedimentary' type of AMS (Fig. 6 E, and Fig. 6 F); - According to the differential thermomagnetic analysis (DTMA), the mineral carrier of magnetization is virtually unaltered titanomagnetite with the Curie point of ≈550°C (samples 254 and 204, Fig. 8); - The presence of samples with negative NRM vectors (Table 1); - The magnetically stable state of the components is confirmed by high values of hysteresis parameters (Fig. 7) and the 'artificial magnetization reversal' experiment (Fig. 11 B). - The positive inversion test (Table 3, Fig. 14 B, and Fig. 14 C): γ/γc=5.1/6.2 at the sample level, and γ/γc=8.7/16.2 at the site level. Discussion. Data on 12 sites and previously published values were used to calculate the reference paleomagnetic pole (PMP) (Fran) (Table 5, Fig. 15, A). The PMP coordinates are as follows: latitude φ=1.7°, longitude λ=92.8°, and confidence intervals dp/dm=3.7/5.9°. The PMP's paleomagnetic reliability index is high enough, and the PMP can be thus considered as a reference for the Frasnian period (370±5 Ma). On this basis, taking into account the previous paleomagnetic data, paleomagnetic reconstructions of the Siberian platform, ranging from 420 up to 325 Ma, are obtained in our study (Fig. 15, B). In the above-mentioned period of time, the Siberian platform gradually moved in one direction, mostly latitudinal, from 11° to 25° N. After the Appainskaya time, the latitudinal movement was replaced by motions in the predominantly meridional eastward direction, and the average displacement velocity in these segments increased from 4.4 to 6.7 cm/year. It is possible that after the formation of the Appainskaya suite (Fran), the Siberian platform could pass the three hot spots representing the modern Atlantic islands near the northwestern coast of Africa (Canary, Madeira and Azores, i.e. The northern flank of the African superplume). These hotspots might have formed the tracks (Fig. 15) that controlled the intrusion of alkaline ultrabasic melts and formation of kimberlites in the Late Devon - Early Carbon. Conclusion. In the lower stream composed of the palagonite plagiophyre basalts of the Appainskaya suite, the paleomagnetic studies reveal two primary

components of the NRM vectors, from bottom to top, D and C, respectively, with the direct and reverse polarity. Their presence in the basalts is marked by the 'sedimentary' type of AMS, practically un-oxidized titanomagnetites, and the positive inversion test. The reference PMP for the basalts of the Appainskaya suite, which is determined in our studies, provides for a more precise definition of the paleogeographic position and reconstruction of the drift of the Siberian platform in the Middle Paleozoic (from 420 to 325 Ma) and makes it possible to associate this drift with probable energy sources (i.e. hot spots), which might have been related to the intrusion of kimberlites.

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Keywords

Appainskaya suite, Basalts, Fran, Middle Paleozoic, Paleomagnetism, Siberian platform, Vilyui paleorift system, Ygyatta depression