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ScienceDirect
Russian Geology and Geophysics 59 (2018) 1161–1181
RUSSIAN GEOLOGY AND GEOPHYSICS
www.elsevier.com/locate/rgg

Paleomagnetism of traps of the Franz Josef Land Archipelago

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Received 25 March 2018; accepted 25 April 2018

Abstract

The paper presents results of paleomagnetic studies of traps of the Franz Josef Land (FJL) Archipelago. This area is considered to be part of the Barents Sea Large Igneous Province (LIP) and is usually associated with the Early Cretaceous stage of plume activity, by analogy with other manifestations of late Mesozoic trap magmatism in the High Arctic. Recent isotope-geochemical studies, however, suggest a much longer history of basaltoid magmatism in the FJL area, from Early Jurassic through Early Cretaceous, with three pulses at 190, 155, and ≈125 Ma. Given a significant difference in age, paleomagnetic directions and corresponding virtual geomagnetic poles are supposed to form discrete groups near the Jurassic–Early Cretaceous paleomagnetic poles of Eastern Europe. However, the calculated virtual geomagnetic poles, on the contrary, show a single “cloud” distribution, with its center being shifted to the Early Cretaceous paleomagnetic poles of Siberia. The performed analysis demonstrates that the significant variance is caused mostly by the high-latitude position of the FJL and secular variations of the geomagnetic field during the formation of the traps. Products of the Early Cretaceous magmatism evidently prevail in the data sample. The coincidence of the average paleomagnetic pole of the FJL traps with the Early Cretaceous (145–125 Ma) interval of the apparent polar wander path of Siberia rather than Eastern Europe confirms the hypothesis of the Mesozoic strike-slip activity within the Eurasian continent. This activity might be a natural result of the evolution of the Arctic Ocean.

Keywords: paleomagnetism; Large Igneous Provinces; FJL Archipelago; Arctic

Introduction

Franz Josef Land (FJL) is one of the northernmost Arctic archipelagos consisting of almost two hundred relatively small islands composed mainly of products of intraplate basaltoid magmatism. A thick subhorizontal sequence of lava flow represents a raised fragment of a large igneous province (LIP) formed supposedly in the Late Jurassic–Early Cretaceous. The major part of this LIP covers the entire northern part of the Barents Sea floor up to and including the Svalbard Archipelago, as well as extensive areas lying to the south of Franz Josef Land along Severny Island of Novaya Zemlya in the direction of the Kanin Nos Peninsula (Karyakin and Shipilov, 2009; Shipilov, 2016) and occupies, accordingly, more than a third of the Svalbard plate area, which forms the region’s continental shelf structure (Fig. 1), which, apart from the lava flow facies, is strongly represented by sizeable dikes and sills cutting across the Triassic–Jurassic terrigenous complex composed by sandstones, siltstones, and their weakly-cemented analogues (Fig. 1). Thus, the significant amount of effusive rocks and their geochemical signatures leave no doubt about the plume nature of magmatism and the typical trap formation mechanism of the geological structure of the FJL and the adjacent territories (Dobretsov et al., 2013; Ernst, 2014; Karyakin and Shipilov, 2009). Besides the Barents Sea LIP, other manifestations of late Mesozoic basaltoid magmatism are known within the Arctic region including isolated areas, such as: the Sverdrup area (Canadian Arctic Archipelago and adjacent continental shelf) (Evenchick et al., 2015; Jowitt et al., 2014), the East Siberian Sea (the De Long Archipelago and the adjacent continental shelf) (Dobretsov et al., 2013; Filatova and Khain, 2009; Shipilov, 2011) and, finally, the Central Arctic province. Maps of the latter were generated based on the results of marine geophysical studies in combination with dredging and drilling, with the data c covering a vast area comprising the underwater Alpha-Mendeleev Ridge and the adjacent Makarov and Podvodnikov basins up to and including the Chukotka uplift (Kremenetsky et al., 2015; Morozov et al., 2013).

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1068-7971/$ - see front matter
http://dx.doi.org/10.1016/j.rgg.2018.08.010

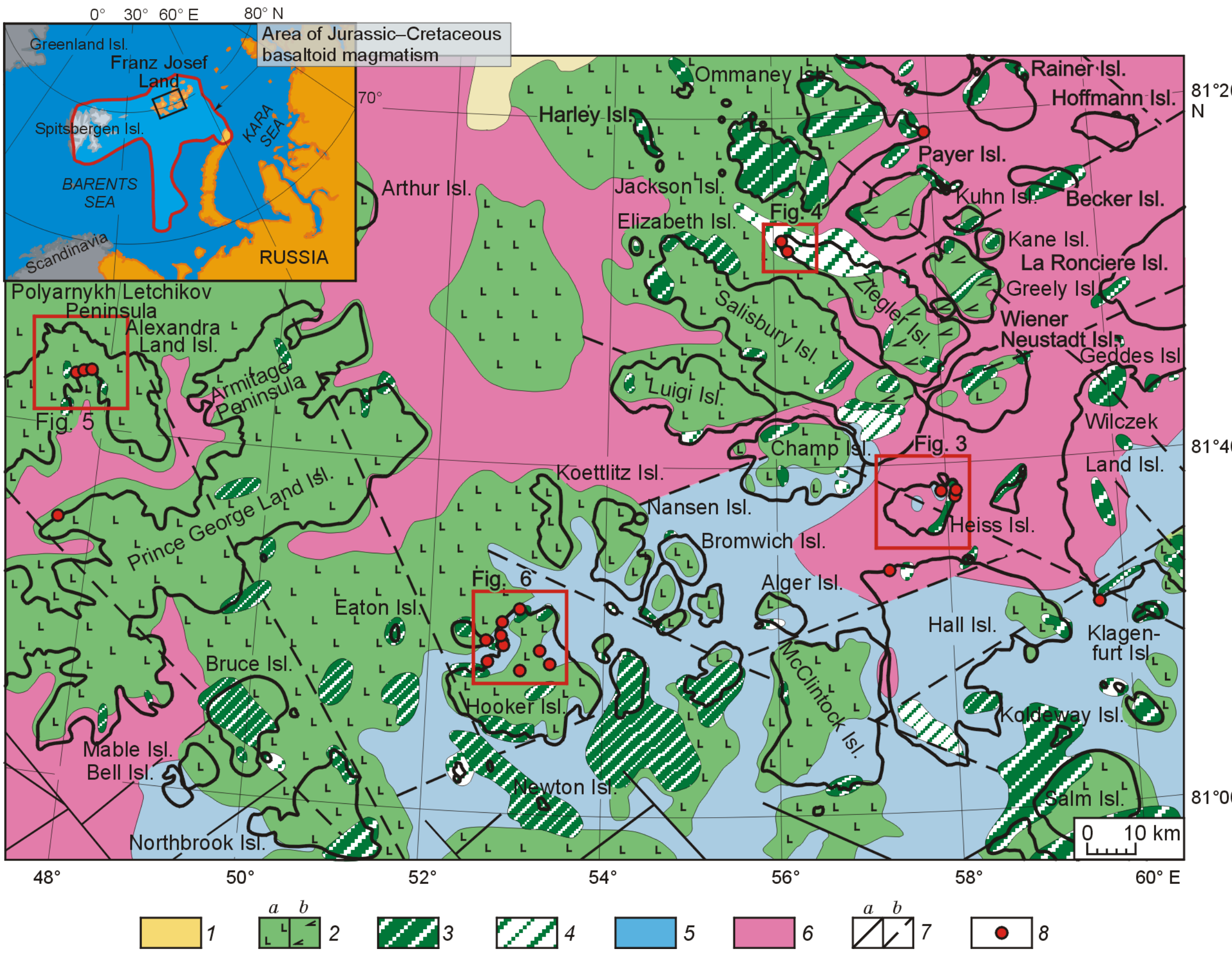

Fig. 1. Schematic geological map of the studied FJL Archipelago area, after (State..., 2006) (revised). The red line in the inset delineates a tentative area of basaltoid magmatism distribution in the Barents Sea LIP, after (Karyakin and Shipilov, 2009). *1*, Oligocene–Pliocene deposits (siltstones, clays); *2–4*, Jurassic (?)–Early Cretaceous trap complex: *2*, tuffs and basalt flows (*a*) and andesibasalts (*b*), *3*, hypabyssal complex (dikes, sills, laccolites) gabbro, gabbro-diorites, gabbro-dolerites, dolerites and monzonites, *4*, vent facies holding extrusive bodies (stocks and nekks) of basalts, andesibasalts; *5*, Jurassic deposits (mudstones, siltstones, sands, sandstones); *6*, Triassic deposits (sands, sandstones, clays, mudstones, siltstones); *7*, faults: established (*a*) and inferred (*b*); *8*, paleomagnetic sampling sites.

The supposed close age of rocks in these areas suggests their association as part of the Jurassic–Cretaceous High Arctic Large Igneous Province (HALIP), formed synchronously with the opening of the Amerasian (Canadian) basin of the Arctic Ocean (Buchan and Ernst, 2006; Dobretsov et al., 2013; Ernst, 2014; Shipilov et al., 2009). Numerous studies have shown that the evolution of this mantle plume is likely associated with the formation of the largest—Siberian—LIP at the turn of the Permian–Triassic, as well as with more ancient manifestations of intraplate magmatism in Northeast Asia (Kuzmin and Yarmolyuk, 2014, 2016; Kuzmin et al., 2010, 2011). The Barents Sea area can thus be regarded as one of the most extensive manifestations of trap magmatism and, given the sufficiently compelling paleomagnetic data, it can be used for absolute plate tectonic reconstructions involving the Arctic terranes in the Mesozoic and for verification of the available geodynamic models of the Arctic basin evolution, primarily the Amerasian (Canadian) basin (Gaina et al., 2014; Koulakov et al., 2013; Laverov et al., 2013; Lawver et al., 2002; Shipilov, 2016; Shipilov and Lobkovskii, 2014; Sokolov et al., 2015; Vernikovsky et al., 2013).

However, reliability of paleomagnetic reconstructions crucially depends on determination of the age of rocks and the time of fixation of the measured magnetization. The episodic behavior, i.e., the formation of a large volume of magmatic rocks in a relatively short period on the geological time scale, is a distinctive feature of LIP magmatism. As is the case with the Siberian LIP, the duration of such pulses is not longer than 15 Ma (Ivanov et al., 2013; Kamo et al., 2003; Reichow et al., 2009), and according to some estimates no more than 1–5 Ma (Kazanskii et al., 2000; Kazansky et al., 2005; Latyshev et al., 2013; Mikhaltsov et al., 2012).

At the same time, a characteristic periodicity of ~ 30 Ma is observed in plume magmatism, which correlates well with large tectonic events in the region, including in the Arctic area, and with global geotectonics (Dobretsov, 2010; Dobretsov et al., 2013). Until recently, the estimated duration of the formation of the FJL traps within the 145–125 Ma interval successfully concorded with the general concept (Corfu et al.,