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Sediments in the Gakkel Ridge rift zone (*Arctic Ocean*): structure and history

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Abstract

The available seismic and magnetic data show the Gakkel Ridge rift zone consisting of the Atlantic and Siberian segments divided by a tectonic suture at 70º E. The two segments have had different histories recorded in their sedimentary cover. Apart from the difference in its morphology, the Siberian segment differs from the Atlantic one in the existence of a series of deposition centers, which might represent a vast Paleogenic basin that formed prior to the Gakkel Ridge. The simple model of North Atlantic spreading fails to explain the long and complex history of the Gakkel Ridge rift and the existence of the depocenters. The particular structure of this zone might have resulted from the growth of rift mountains by accretion of magmatic material during the Paleogene, without significant sea floor spreading.

Keywords: rift zone; sediments; Eurasian Basin; Arctic Ocean; Gakkel Ridge

Introduction

Sediments in geological structures bear record of significant events in their history. The sedimentary structure of the Gakkel Ridge rift zone, studied jointly by geological and geophysical methods, can provide insights into the evolution of the ridge and its surrounding basins.

Early synthesis of the structure and history of the Eurasian Basin of the Arctic Ocean was based mainly on aeromagnetic and gravity surveys with sparse seismic data (Demenitskaya and Kiselev, 1968; Kiselev, 1986; Sweeney et al., 1982; Vogt et al., 1979). A series of linear magnetic anomalies (LMA) identified in the Nansen and Amundsen Basins and correlated with those in North Atlantic (Glebovsky et al., 2006; Karasik, 1968; Vogt et al., 1979) were interpreted in terms of spreading in the Gakkel Ridge and its links with both the global system of midocean ridges and with the Moma rift system (Gramberg et al., 1990). The Gakkel Ridge was hypothesized to be the youngest Cenozoic endmember of the system (Karasik et al., 1983; Naryshkin, 1987; etc.). Its history has been explained by a universally accepted spreading model, which however fails to allow for the very thin crust in the rift zone, ultraslow spreading rates, and a large depth of the rift valley, the features reported soon after which differ it from other mid-ocean ridges.

This study focuses on the Gakkel Ridge rift zone, which comprises the rift valley itself and its flanking mountains up to LMA 5. We discuss features in the regional sedimentary structure revealed by seismic reflection profiling, which call for revision of some essential points in the existing models.

Results

According to the available bathymetric (Jakobsson et al., 2012), magnetic (Gaina et al., 2011), gravity, and seismic data (Glumov, 2012), the Gakkel Ridge can be divided into the Atlantic and Siberian segments (Fig. 1) along ~70° E, the line corresponding to a kink of major regional structures. In this respect, of special interest are two seismic profiles AWI20010300 and AWI20010100 (Jokat and Micksch, 2004) acquired across the Gakkel Ridge rift within its Atlantic and Siberian segments, respectivetely (Fig. 2). The two profiles show, respectively, thin sediments along the ridge axis within Atlantic segment and more than kilometer-thick sedimentary fill of the rift valley in the Siberian one.

The Atlantic segment looks like a spreading Atlantic mid-ocean ridge, with a prominent linear rift valley (Fig. 1) with a relative height in the basement topography of 3500 m (Naryshkin, 1987). The valley has steep sides composed of igneous rocks (Fig. 2*a*), judging by large amounts of basalt,

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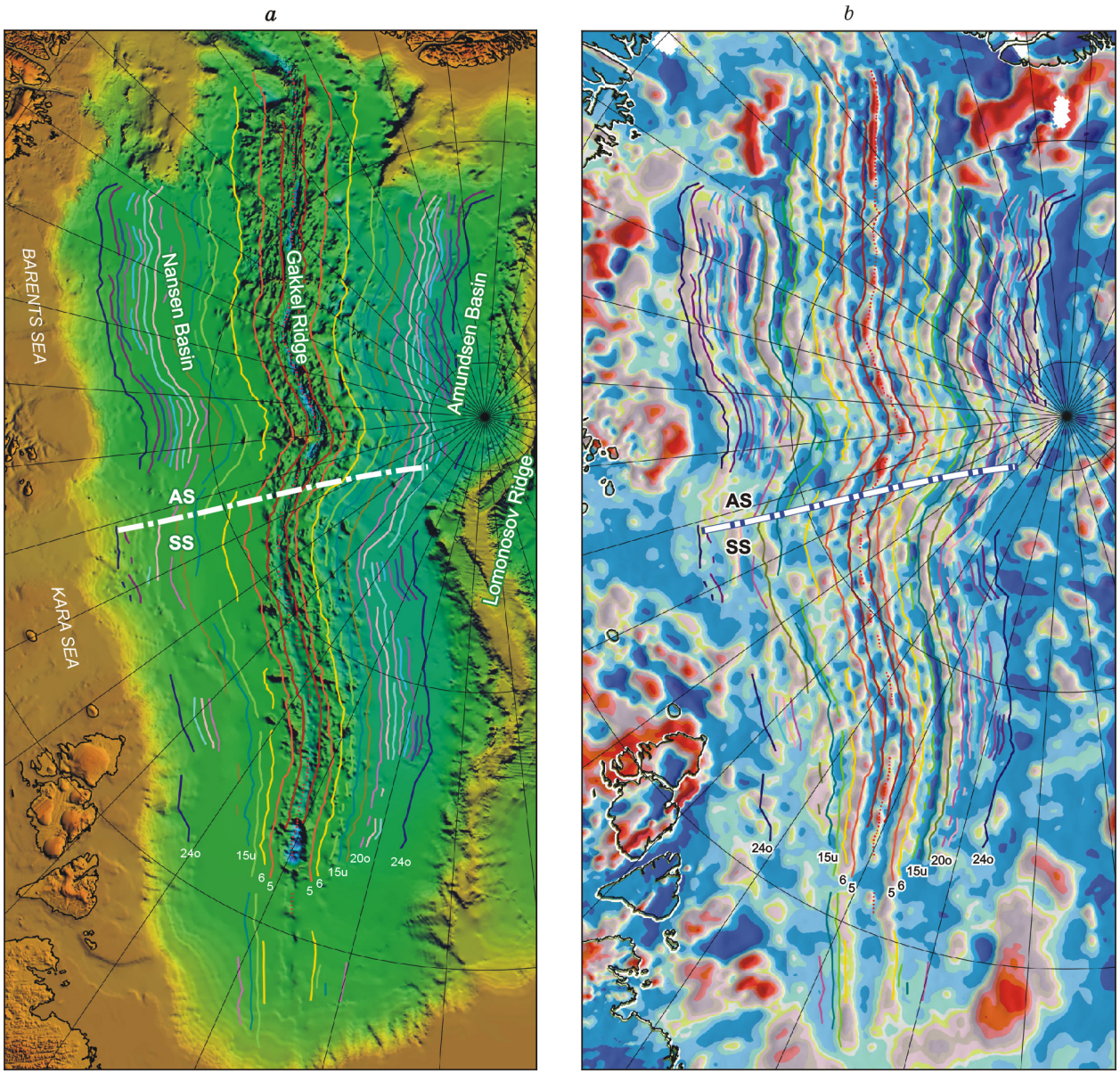

Fig. 1. Bathymetry of the Eurasian Basin in the Arctic Ocean (Jakobsson et al., 2012) (*a*) and a fragment of a magnetic anomaly map (Gaina et al., 2011) (*b*), with LMA locations according to (Chernykh and Krylov, 2011). White dash line divides Gakkel Ridge into the Atlantic (AS) and Siberian (SS) segments.

gabbro-dolerite, and peridotite clasts recovered by dragging (Michael et al., 2003). Magnetic anomalies are distinct lineations (Fig. 1): LMA from 2 to 24 (Chernykh and Krylov, 2011; Vogt et al., 1979).

The Siberian segment differs in rift morphology, magnetic and gravity patterns, as well as in the sedimentary structure. The rift valley has a less prominent expression in seafloor topography (Fig. 1 and 2*b*) due to the presence of thick sediments (see below). The relative height within the rift valley is reduced to 700–900 m on average, rarely reaching 1500 m (Michael et al., 2003), with the greatest contrasts in the mountains flanking the rift valley and smaller difference toward the basin centrocline. It is difficult to trace LMA along the ridge from the Atlantic segment, because of an orthogonal blind zone at the boundary between the two segments. Therefore, many anomalies are fragmentary while reliably identified LMA are fewer in the Siberian segment than in the Atlantic one (Fig. 1).

Finally, there are several local deposition centers with 0.5 to 3–4 km thick sediments (Figs. 2*b*, 3). Depocenters (Fig. 3) were first revealed in seismic profiles near the Laptev Sea continental margin in the centroclinal part of the Eurasian Basin (Gusev et al., 2002; Sekretov, 2002). The large sediment thickness reaching 4 km in the rift valley was explained by ultraslow spreading and voluminous clastic input from the Laptev Sea shelf. However, another depocenter with ~1500 m thick sediments was discovered soon (Jokat and Micksch, 2004) in the Eurasian Basin center (at 86° N; 73° E) far from the existing source areas (Figs. 2*b*, 3).

Similar depocenters with quite a thick sediment fill (Fig. 3) appear in the immediate vicinities of the rift valley in all ten seismic profiles collected across the Amundsen Basin within the Siberian segment during the *Shelf-2011* trip (Glumov,