Tectonophysics 483 (2010) 191–202

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Downsizing the Mjølnir impact structure, Barents Sea, Norway

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ARTICLE INFO

Article history:
Received 2 March 2009
Received in revised form 27 August 2009
Accepted 31 August 2009
Available online 9 September 2009

Keywords:
Impact crater
Potential field interpretation
Density and susceptibility measurements

ABSTRACT

Stratigraphic relationships indicate that the submarine Mjølnir impact structure in the SW Barents Sea is of Cretaceous age (~142 Ma) and the impact palaeolatitude is estimated at 56°N. Though the crater has been intensively studied, its dimensions at depth are uncertain.
Density and magnetic susceptibility measurements of core samples are presented and used to interpret a newly available aeromagnetic survey and gravity data, and to model the potential field anomaly data of the area jointly, so as to constrain better the signature of the crater. Forward modelling suggests that the crater diameter is about 20 km, and thus needs downscaling to about half of the earlier proposed size.

1. Introduction

Gudlaugsson (1993) discovered the Mjølnir impact crater in seismic reflection data, and the crater structure was apparently well established. This submarine impact crater, located in the southwest Barents Sea, was estimated to have a crater diameter of about 40 km and a shallow relief of about 50 m. However, the dimensions other than the relief remain undetermined. The crater is buried beneath several hundred metres thick layer of sediments. Stratigraphic relationships (drill core 7329/03-U-01; 1998; IKU Petroleum Research) suggest a Lower Cretaceous impact age at around 142 Ma (Dypvik et al., 2004). In this account, new density and magnetic susceptibility measurements of core samples from core 7329/03-U-01 are presented and used to integrate a new aeromagnetic survey and the existing gravity data, and to model the potential field data so as to better constrain the signature of the crater. We also present an Early Cretaceous reconstruction at the time of impact.

2. The geological setting

The impact site (73°48′N, 29°40′E) is located on the Bjarmeland Platform (Fig. 1), a shallow shelf characterized by a relatively undisturbed and complete Carboniferous–Quaternary stratigraphic section. The underlying crystalline basement is assumed to be of Palaeozoic age and is at depths of 7 to 9 km (Johansen et al., 1993). Sedimentary strata are almost horizontal, although two prominent seismic reflectors, Top Permian and Base Cretaceous, show a slight dip to the south (Breivik et al., 1995). The current water depth ranges between 350 and 400 m whilst the palaeo-water depth at impact time was suggested to range from 350 to 500 m (Gudlaugsson, 1993; Dypvik et al., 1996; Smelror et al., 2001; Tsikalas et al., 2002). The impact event affected the stratified sediments to a depth of about 4 km, recognized by disturbed strata in seismic profiles.

Indicators for the impact origin of the structure are found in drill cores 7430/10-U-01 and 7329/03-U-01 (1988, 1998 IKU Petroleum Research) and in equivalent layers exposed on Svalbard that are enriched in iridium and shocked quartz — both are found in the ejecta-related layer. The age of the crater is known from biostratigraphy, and indicates that the impact event occurred at the Volgian–Ryazanian boundary (142 ± 6 Ma ago). A new 142 million year plate reconstruction (Fig. 2) shows that the Barents Sea region was centred on the 60°N parallel. The impact palaeolatitude is calculated to 56.4°N, at a time when Greenland also bordered and defined the western margin of the Barents Sea. Thus, and with relevance to tsunami modelling of the impact, the distance to Greenland (ca. 300 km) was approximately the same as to Northern Norway (Finnmark) where waves as high as 100 m have been estimated (Glimsdal et al., 2007). Since then, the Barents Sea area has drifted northward.

3. Magnetic properties and densities from the core 7329/03-U-01

The Mjølnir drill core confirmed the impact origin, revealing disturbed sedimentary layers and an iridium-rich layer just above the disturbed sequence (Dypvik et al., 2004). Even though the drill core gives insight to rock properties and impact-related stratigraphic disturbance, the core never penetrated the uplifted deeper layers seen in seismic sections and reached to only 171 m below the sea floor.

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doi:10.1016/j.tecto.2009.08.036

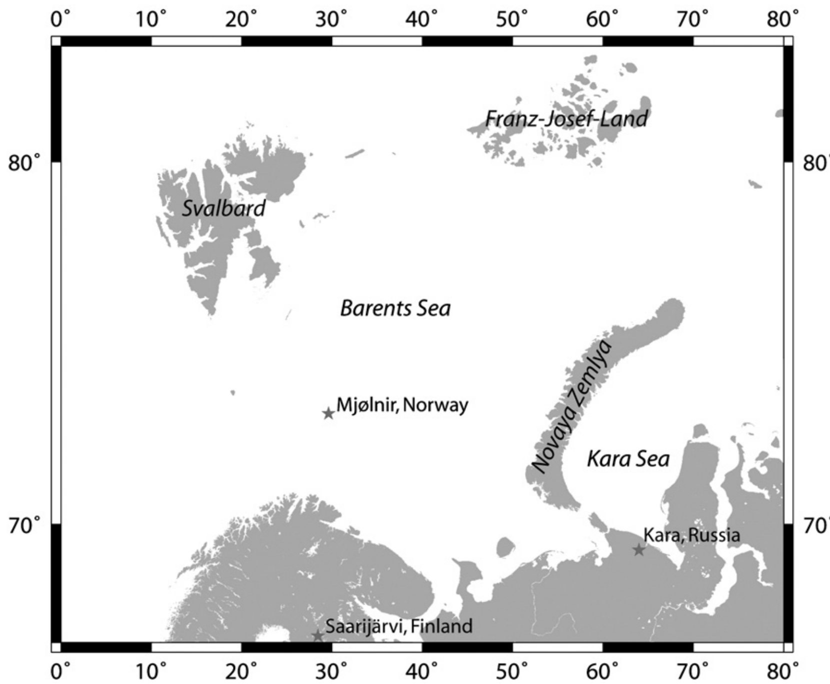

Fig. 1. The location of Mjølnir impact site (73°48′N, 29°40′E) within the southwestern Barents Sea.

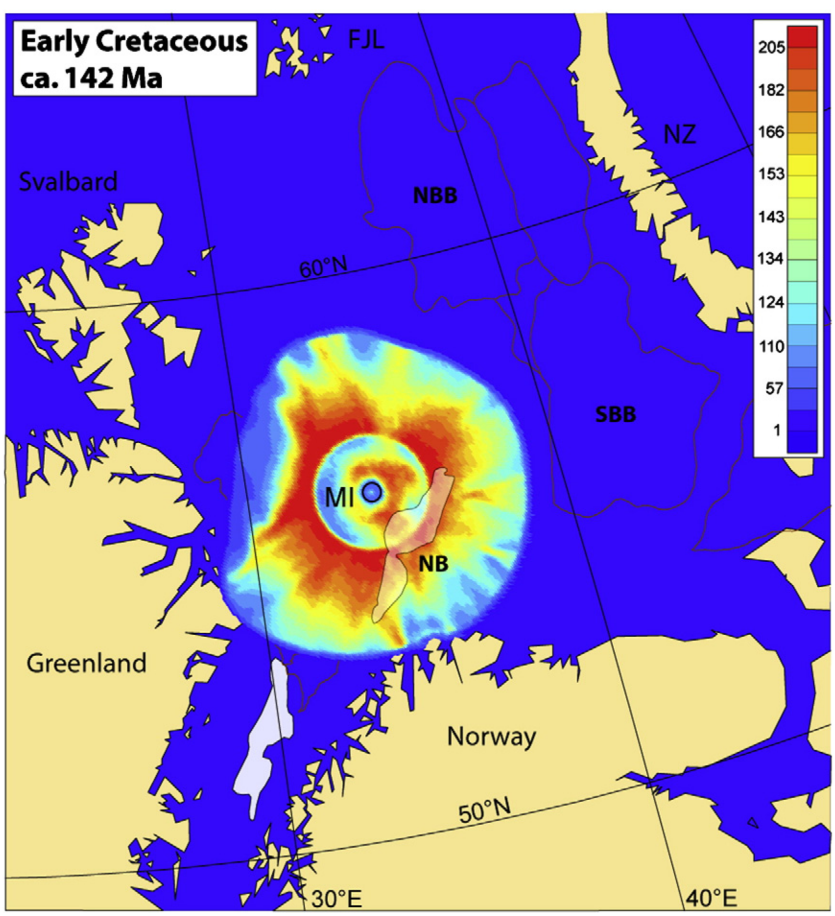

Fig. 2. The palaeogeographic setting of the Mjølnir impact site reconstructed to the Lower Cretaceous, ca.142 Ma (reconstruction parameter according to Torsvik et al., 2008). The main differences with respect to the current setting are the palaeolatitude of 56.4°N and the then young and narrow Atlantic Ocean. The estimated tsunami wave height (after Glimsdal et al., 2007) and sedimentary basin outlines are draped on the reconstruction.