Journal of Geodynamics 47 (2009) 237–245

Contents lists available at ScienceDirect

Journal of Geodynamics

journal homepage: http://www.elsevier.com/locate/jog

Gravity and magnetic data inversion for 3D topography of the Moho discontinuity in the northern Red Sea area, Egypt

Ilya Prutkin[a,*], Ahmed Saleh[b]

[a] Delft University of Technology, Delft Institute of Earth Observation and Space Systems (DEOS), Kluyverweg 1, 2629 Delft, Netherlands
[b] National Research Institute of Astronomy and Geophysics, Helwan, Cairo, Egypt

ARTICLE INFO

Article history:
Received 2 September 2008
Received in revised form
28 November 2008
Accepted 5 December 2008

Keywords:
3D gravity and magnetic data inversion
Moho boundary
Computational methods
Potential fields
Contact surface topography
Northern Red Sea

ABSTRACT

The main goal of our study is to investigate 3D topography of the Moho boundary for the area of the northern Red Sea including Gulf of Suez and Gulf of Aqaba. For potential field data inversion we apply a new method of local corrections. The method is efficient and does not require trial-and-error forward modeling. To separate sources of gravity and magnetic field in depth, a method is suggested, based on upward and downward continuation. Both new methods are applied to isolate the contribution of the Moho interface to the total field and to find its 3D topography. At the first stage, we separate near-surface and deeper sources. According to the obtained field of shallow sources a model of the horizontal layer above the depth of 7 km is suggested, which includes a density interface between light sediments and crystalline basement. Its depressions and uplifts correspond to known geological structures. At the next stage, we isolate the effect of very deep sources (below 100 km) and sources outside the area of investigation. After subtracting this field from the total effect of deeper sources, we obtain the contribution of the Moho interface. We make inversion separately for the area of rifts (Red Sea, Gulf of Suez and Gulf of Aqaba) and for the rest of the area. In the rift area we look for the upper boundary of low-density, heated anomalous upper mantle. In the rest of the area the field is satisfied by means of topography for the interface between lower crust and normal upper mantle. Both algorithms are applied also to the magnetic field. The magnetic model of the Moho boundary is in agreement with the gravitational one.

1. Introduction

The Red Sea is considered to be a typical example of a newly formed ocean. Therefore, since the discovery of plate tectonics, a great number of studies discussed its evolution as a key to the understanding of continental rifting and the initiation of sea floor spreading (Drake and Girdler, 1964; Tramontini and Davies, 1969; Makris et al., 1983; Gaulier et al., 1988; Meshref, 1990). The northern part of the Red Sea appears to be characterized by oceanic type crust, lying at a mean depth of 7–8 km, whereas the Moho is at a mean depth of 10–13 km, and at 32 km closest to the coastline (Gaulier et al., 1988; Makris et al., 1991; Rihm et al., 1991). In the Gulf of Suez, the top of the crust is at a depth of 5 km. The Moho is found at a relatively shallow depth of 18–20 km and at a mean depth of 30–35 km both under southern Sinai and Eastern Desert plateaus (Gaulier et al., 1988; Saleh et al., 2006). Refraction data indicate the Moho depth of 35–40 km in the areas not affected by the rifting event (Ginzburg et al., 1981; Makris et al., 1983; Gettings et al., 1986; El-Isa et al., 1987). The anomalous nature of the upper mantle (8.0 km/s) and the thinning of the crust beneath the northern Red Sea rift are well known from the results of seismic and gravity studies. The density values of the different geological sedimentary units and the megastructures (the crust and the upper mantle) of the present study are based on the P-wave velocity distribution in the northern Red Sea and the Gulf of Suez (Gaulier et al., 1988).

Our goal is to retrieve the 3D geometry of the Moho interface for the northern Red Sea area by means of two new algorithms for gravity and magnetic data inversion and for separating sources in depth. Till now the usual approach to find 3D topography of a contact surface is forward gravity modeling. One changes an initial model in interactive way to diminish gravity residuals. Recently this approach has been applied, for instance, to study a geological structure of the northern Red Sea area in Saleh et al. (2006) using the package IGMAS (Götze and Lahmeyer, 1988) for interactive gravity modeling. The disadvantages of the forward modeling approach are following. One changes the model of the geological section from one profile to another, but changes in one vertical section influence the gravity field along other profiles. Each section takes into account a lot of geological and seismic a priori information, but the number of parameters, per section, is much larger, than the number of profile observations, it is not reasonable from the viewpoint of sta-

* Corresponding author. Tel.: +31 1527 87394; fax: +31 1527 82348.
E-mail address: I.Prutkin@tudelft.nl (I. Prutkin).

0264-3707/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jog.2008.12.001