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Review Article

The distribution of Moho depths beneath the Arabian plate and margins

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ABSTRACT

In this study three new maps of Moho depths beneath the Arabian plate and margins are presented. The first map is based on the combined gravity model, EIGEN 06C, which includes data from satellite missions and ground-based studies, and thus covers the whole region between 31°E and 60°E and between 12°N and 36°N. The second map is based on seismological and ground-based gravity data while the third map is based only on seismological data. Both these maps show gaps due to lack of data coverage especially in the interior of the Arabian plate. Beneath the interior of the Arabian plate the Moho lies between 32 and 45 km depth below sea level. There is a tendency for higher *Pn* and *Sn* velocities beneath the northeastern parts of the plate interior with respect to the southwestern parts of the plate interior. Across the northern, destructive margin with the Eurasian plate, the Moho depths increase to over 50 km beneath the Zagros mountains. Across the conservative western margin, the Dead Sea Transform (DST), Moho depths decrease from almost 40 km beneath the highlands east of the DST to about 21–23 km under the southeastern Mediterranean Sea. This decrease seems to be modulated by a slight depression in the Moho beneath the southern DST. The constructive southwestern and southeastern margins of the Arabian plate also show the Moho shallowing from the plate interior towards the plate boundaries. A comparison of the abruptness of the Moho shallowing between the margins of the Arabian plate, the conjugate African margin at 26°N and several Atlantic margins shows a complex picture and suggests that the abruptness of the Moho shallowing may reflect fundamental differences in the original structure of the margins.

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1. Introduction

The Arabian plate, with an area of 0.12 steradian or about 4,800,000 km^2, is one of the 14 large plates whose motion was described by the NUVEL-1A poles (Bird, 2003). The plate is notable in that it is bounded on its various sides by major representatives of all three types of plate boundaries, namely constructive, conservative and destructive. For example, on its southwestern and southeastern sides it is bounded by the constructive margins of the Red Sea and the Gulf of Aden, which are two of the youngest examples of sea-floor spreading (Fig. 1). On its western side it is bounded by the

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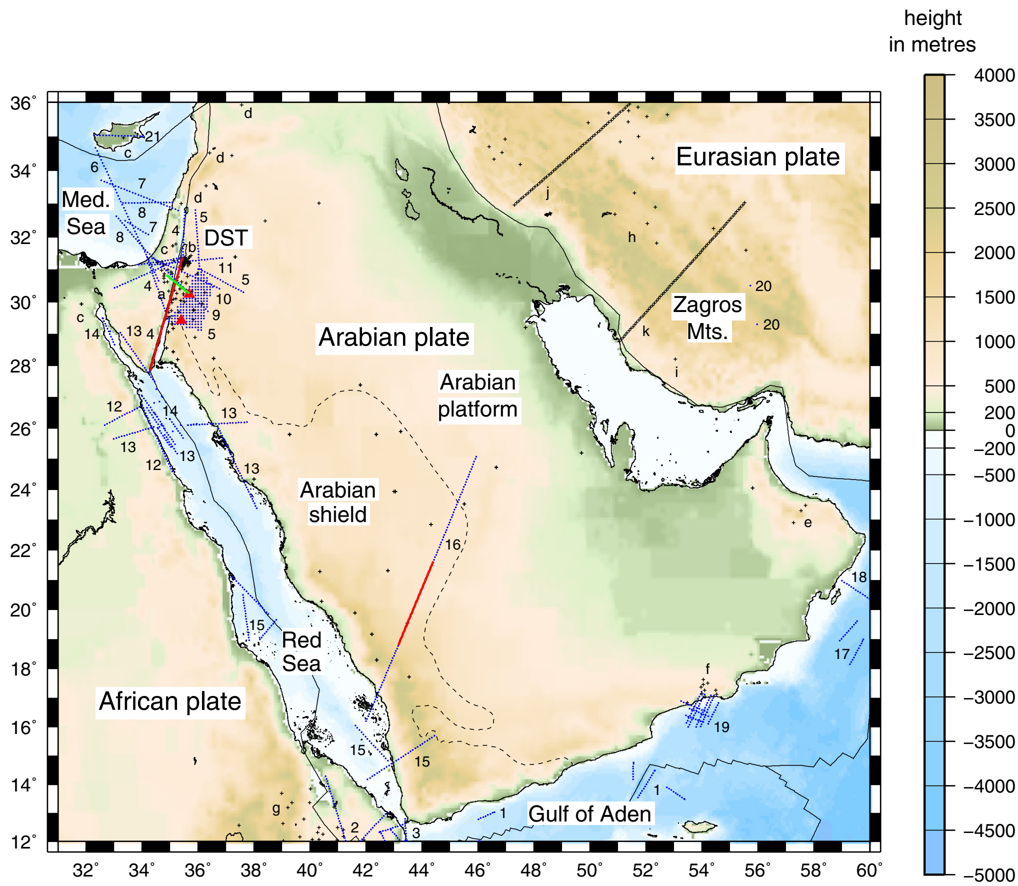

Fig. 1. Location map of the Arabian plate and margins. Blue dots, with numbers tied to locations and references in Table 1, show points for which Moho depths have been obtained from seismic wide-angle reflection/refraction and near-vertical incidence reflection profiles. Black crosses, with letters tied to locations and references in Table 1, show points for which Moho depths have been obtained from receiver functions. Red lines show the locations of the wide-angle reflection/refraction profiles for which data are shown in Fig. 2. Green line across the Dead Sea Transform (DST) shows the location of the near-vertical incidence reflection profile for which a migrated section is shown in Fig. 3. Red triangles show the locations of two seismic stations for which receiver functions are shown in Fig. 4. Plate boundaries (black lines) are from model PB2002 (Bird, 2003). Boundary between Arabian shield and Arabian platform (black dashed line) is from Al-Amri and Gharib (2000).

Dead Sea Transform (DST), which is one of the classical examples of a conservative, transform plate boundary. Finally, its northern side forms part of the destructive Alpine–Himalayan collisional belt, represented in the study region by the Zagros mountains (Fig. 1).

Whereas the DST and the recent constructive margins of the Red Sea and the Gulf of Aden have attracted quite a lot of attention in terms of crustal structure studies, this has not been the case for the interior of the Arabian plate and its northern margin. Lazar et al. (2012) and Stern and Johnson (2010) present recent overviews of geophysical and geological data and studies in the region of the Arabian plate. The lack of attention for large regions of the plate interior can be exemplified by the ground-based gravity studies (see Fig. 2 in Lazar et al., 2012). This lack is perhaps due to a large extent to the relative inaccessibility of the interior of the plate due to its being mainly a desert environment and to the fact that the northern margin is on the one hand not as spectacular as the Himalaya–Tibet system and on the other hand not as accessible as the European Alps. The aim of this study is to collate and describe information on Moho depths, the single best known crustal parameter (Molinari and Morelli, 2011), from controlled-source seismic profiles and receiver function studies throughout the region (Fig. 1), a regional earthquake tomography study in the northwest part of the region and ground-based gravity studies mainly towards the edges of the study region and, as a result of this collation, construct two maps of Moho depths for the region. One of these maps includes the ground-based gravity studies and the other does not. As these maps do not unfortunately cover the entire region, a map of Moho depths derived from the combined gravity field model, EIGEN 6C (Förste et al., 2011), which includes data from satellite missions will also be presented. Additionally, cross-sections of Moho depths along profiles crossing the whole region where data exist more often than not or the plate margins where Moho depths change rapidly over short lateral distances will be presented. In the discussion, a comparison will be made between the maps and cross-sections derived in this study on the one hand and, on the other hand, the CRUST2.0 global model (Bassin et al., 2000) and previous crustal thickness maps for the region (Baranov, 2010; Molinari and Morelli, 2011; Pasyanos and Nyblade, 2007; Seber et al., 1997, 2000; Segev et al., 2006).

2. Data sources

2.1. Controlled-source seismic profiles

The first controlled-source seismic profiles in the region were offshore refraction profiles carried out in the 1950s and 1960s in the Gulf of Aden and the Red Sea. Whereas Laughton and Tramontini (1969) were able to determine Moho depths and upper mantle velocities from some of the lines in the Gulf of Aden, neither Drake and Girdler (1964) nor Tramontini and Davies (1969) were able to determine either Moho depths or upper mantle velocities with any certainty from the lines in the Red Sea. The earliest profiles with an onshore component were actually carried out on the African side of the Red Sea in the southernmost corner of the Arabian plate in 1971 and 1972 (Fig. 1, Table 1 and Berckhemer et al., 1975; Ruegg, 1975). The