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GRAVITY MODELLING AND ITS IMPLICATIONS TO THE TECTONICS OF THE SOUTH CASPIAN BASIN

Granath, J. W.[1]; Soofi, K. A[2]; Baganz, O. W.[2]; and Bagirov, E[2]
[1] Independent Consultant
[2] Conoco, Inc., Houston, Texas

Summary

The large isostatic anomaly dominating the northwestern part of the South Caspian Basin is best modeled as a root of South Caspian crust that has displaced the normal lithospheric mantle. In the eastern South Caspian gravity modelling suggest that continental crust does not extend seaward as far as previously presumed and that the Turkmen platform is composed of thickened sedimentary section overlying Caspian Sea type crust.

Introduction

Satellite-derived free air gravity data (Sandwell et al., v. 7) for the South Caspian Basin, combined with ow-order onshore free air gravity, show a steep 120-mgal decrease from the Albroz Mountains along the south coast of the Caspian Sea (Fig. 1). The negative gravity gradient continues to-150 mgal at the Apsheron Sill, on the northern margin of the basin. This negative anomaly is not surprising in the light of the 900 m water depth for most of the southern Caspian Sea, the 20 km thick sedimentary section, and the "anomalous" oceanic character of the crust. However, the negative gravity anomaly persists under the Apsheron, and northward into the southwestern part of the central Caspian Sea, in an area of low topography and shallow sea bottom. It adjoins the negative Bouguer anomaly of the Greater Caucasus Mountains, but in the Caspian Basin it constitutes a pronounced isostatic anomaly.

In contrast to the western Apsheron area, the eastern South Caspian Basin contains a 40-mgal gravity high that extends 200 km seaward from the coast of Turkmenistan. It is separated fromthe onshore by a small gravity low. Seismic data show no significant change in thickness of the Tertiary section between onshore and offshore Turkmenistan.

Satellite-Derived Free Air Gravity

The free air gravity Anomaly data used were generated by Sandwell et al. (1997) using altimetry data from Saesat, Geosat and ERS-1 and ERS-2. The altimeter data from these different satellites are converted to grids of vertical gravity gradient and gravity anomalies using the following procedure.

The long-wavelength orbital errors are appropriately filtered to reduce the noise. Ascending and descending slope profiles are then interpolated into separate grids, which are combined to form a grid set representing east and north vertical deflection. The vertical gravity is calculated directly from the vertical deflection grid by taking a simple derivative. The derivation of Free Air Gravity Anomaly, on the other hand is more complicated, as it needs Faurier analysis and subsequent marging of dense orbital grids of Geosat and ERS as well as low density grids of their exact repeat missions (ERM).

Comparison of these data with ship borne data show that satellite derived gravity is within 4-7 mgals of random ship tracks. The accuracy improves to 3 mgal when the ship track is right on top of the ERM.

Modelling Methods

Gravity profiles derived from the Sandwell data set were matched using the LCT 2-D software. Geological sections were scanned and attributed with the following denity values: Cenozoic sediments 2.3.g/cc, Mesozoic sedimentary fill 2.5, continental crust 2.7, Caspian Sea Crust 2.9 and lithospheric mantle 3.35. Initial Moho depths were taken from Rodriguez (1969). Interfaces between the various model elements were interactively adjusted to obtain a satisfactory visual fit.

Model Results

2-D lithospheric-scale gravity models that best match the free air gravity profile show an 80 km wide root of South Caspian crust under the Apsheron Peninsular area (Fig. 2). Alternative models, which presume a strike –slip relationship along the Apsheron Sill, fail to produce the same negative gravity anomaly.

The east-west oriented model (Fig. 3) in the eastern South Caspian suggests that this anomaly is caused by thickened sedimentary section overlying “anomalous” South Caspian type crust, which continues under the Turkmen shelf. Models assuming continental underpinning to the Turkmen Shelf produce a gravity low.

Conclusions

The models suggest that the Caspian crust is sinking beneath and underthrusting Eurasian continental crust in the nortwestern part of the South Caspian Basin, geometrically resembling subduction. The deformed sedimentary wedge in the western Caspian, and regional seismicity are consistent with an interpretation that subduction has been initiated in the northwestern part of the South Caspian Basin.

The model in the eastern Caspian indicates that the sedimentary column is thickened by reason of comprenssive deformation in the Mesozoic section (similarly to that onshore in Turkmeniztan) and the overlapping ancestral Amu Derya Delta. Continental crust does not seem to underlie any part of the southern Caspian Sea.

References

Rodriguez, R.G. (1969) Atlas of Asia and Eastern Europe to support detection of underground nuclear testing, v. V. Crust and Mantle conditions. Dept. Of Interior, USGS FOR Advanced Research Projects Agency.

Sandwell, D. T., and Smith, W.H.F., 1997. Marine gravity anomaly derived from Geosat and ERS-1 satellite altimetry, Jour. Geophysical Research 102. No. B5: 10,039-10,054.

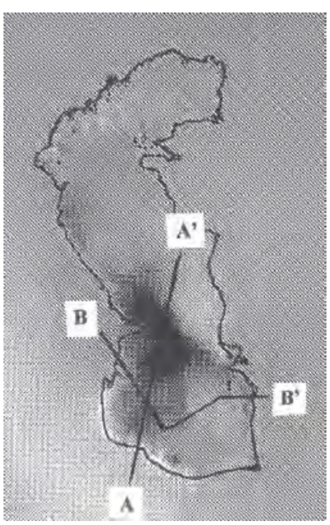

Figure 1. Satellite-derived free air gravity of the South Caspian Sea, after Sandwell et al. (1997). Lines of profile in Figs. 2 and 3 are shown.

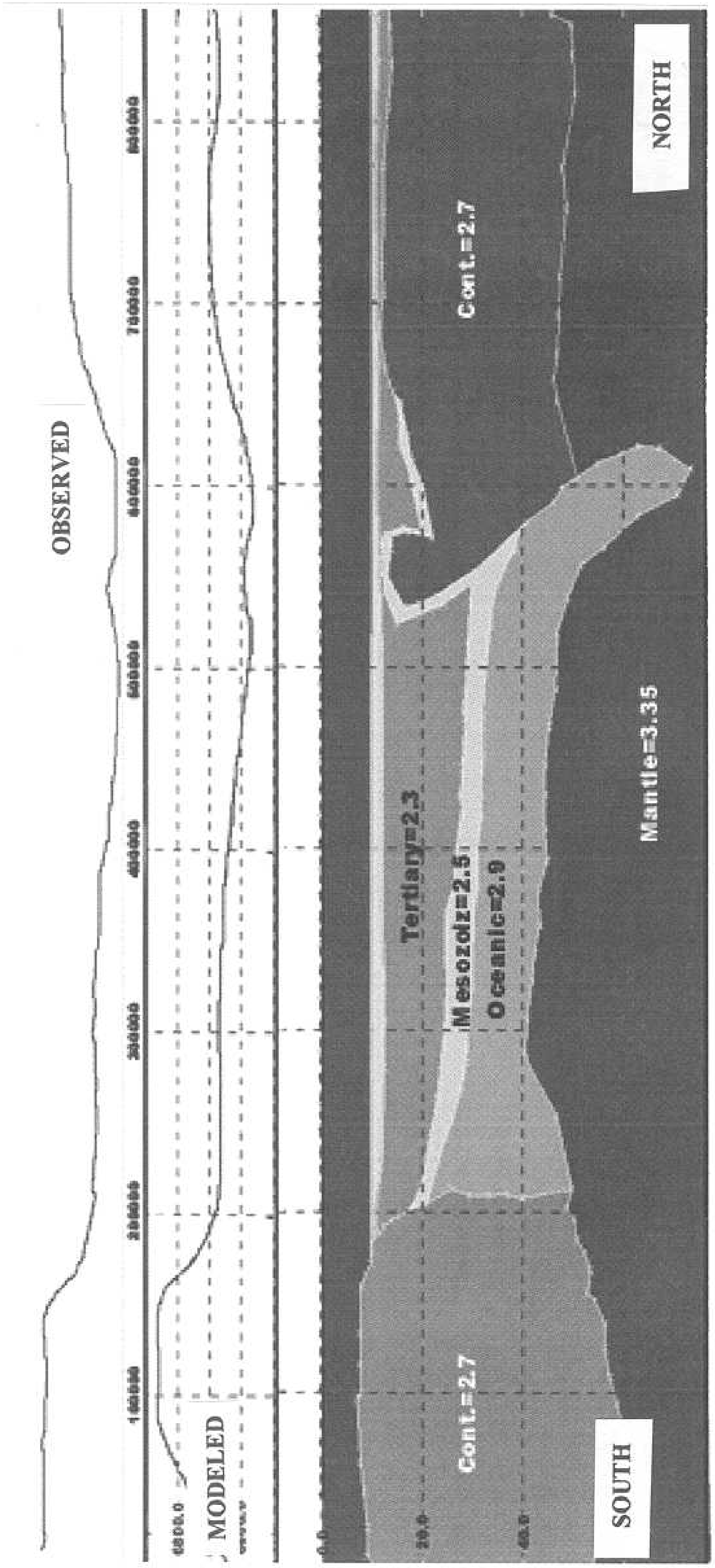

Figure 2. North-south cross section A-A’, and its modeled and satellite-derived gravity profiles. Location shown in Figure 1.

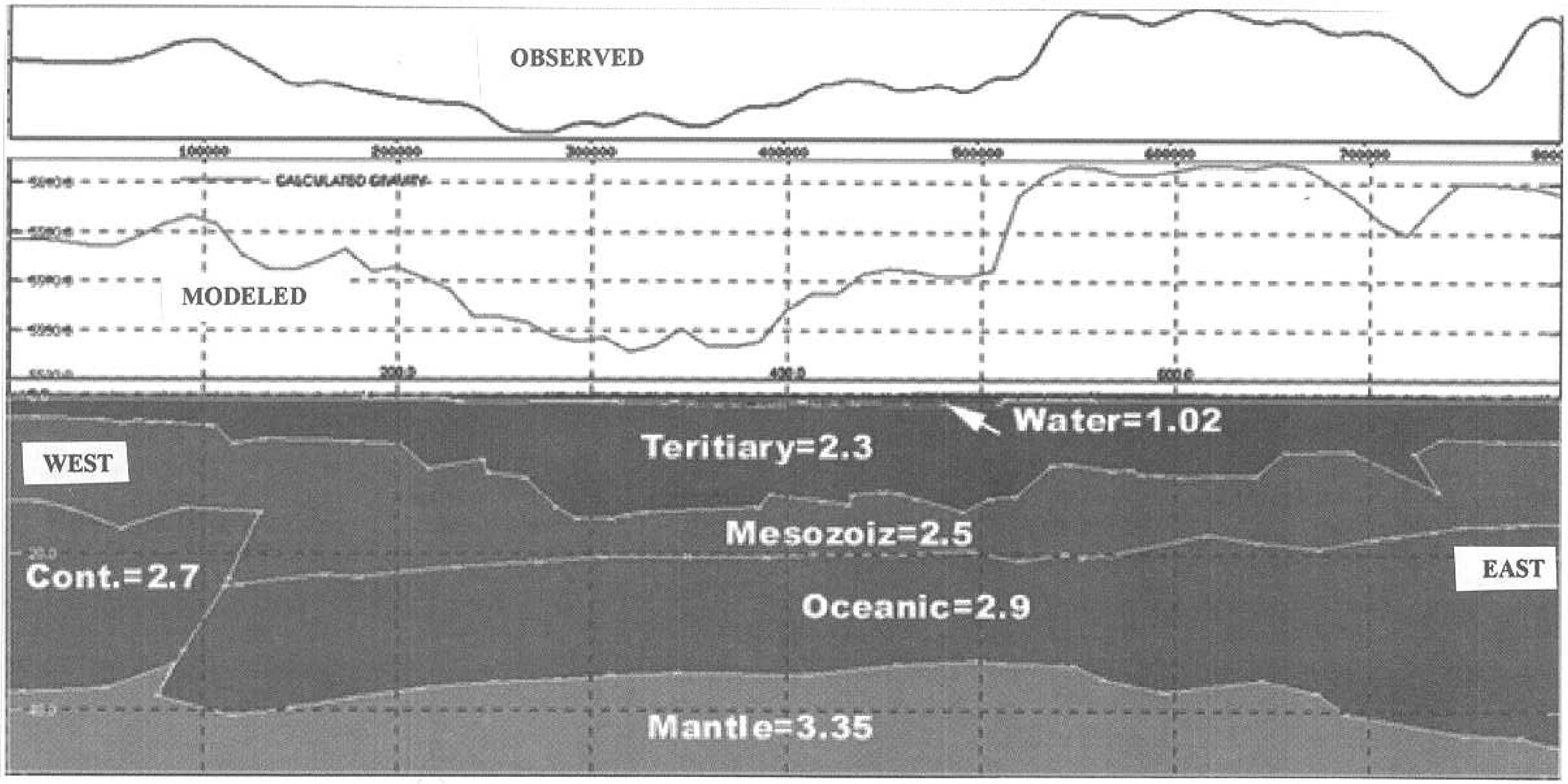

Figure 3. East-west cross section B-B', and its modeled and stellite-derived gravity profiles. Location shown in Figure 1. This is a preliminary model in that the match between some details in the match between some detail in the gravity profiles can be improved.