What lies beneath the anamolous geoid low in the Indian Ocean?

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The geoid is a hypothetical surface on the Earth which would approximate the mean sea level in absence of winds and tides[1]. It is an equipotential surface computed by taking Earth's gravity and rotation alone into effect, if oceans and the atmosphere were in equilibrium. Unlike the reference ellipsoid, geoid is an irregular surface which varies from place to place in terms of highs (positive) or lows (negative). This undulating surface provides a great tool for understanding the Earth's interior because geoid anomalies can be attributed to the uneven mass distribution inside the Earth.

One of the most intriguing geoid anomalies on Earth[1] – the Indian Ocean Geoid Low (IOGL) – is observed south of the Indian Peninsula, where the geoid deficit is over to ~100 m (Figure 1). This anomalous observation has remained a mystery that has baffled geoscientists for many decades with still no convincing answers. Besides, this part of the Indian Ocean has also experienced very high lithospheric deformation apparently due to a diffused plate boundary between India and Australia[2,3]. Another significant point to note is that adjoining this region also experienced the world's largest intraplate strike–slip earthquake of *M* 8.6 in 2012, followed by equally strong aftershocks. Therefore, it is extremely important to know the source behind this geodynamic enigma in the Indian Ocean.

With the advent of improved global seismological images in recent years[3] as well as robust numerical modelling, several competing hypotheses have been advanced to explain the largest geoid low on the Earth. Some researchers[4,5] argue that it is caused by a remanent of cold, dense oceanic plate which subducted in the Mesozoic period[6] and sank deep into the lower mantle. However, others argue that the largest geoid low could be due to low-velocity anomalies in the upper mantle[7]. Recently, Ghosh *et al.*[8] through numerical modelling of mantle convection inferred that the source of IOGL stems from a low-density anomaly between upper and mid mantle (~300–900 km depth). They also proposed that hot buoyant material rising from the deep mantle beneath Africa migrates northeast in sync with movement of the Indian

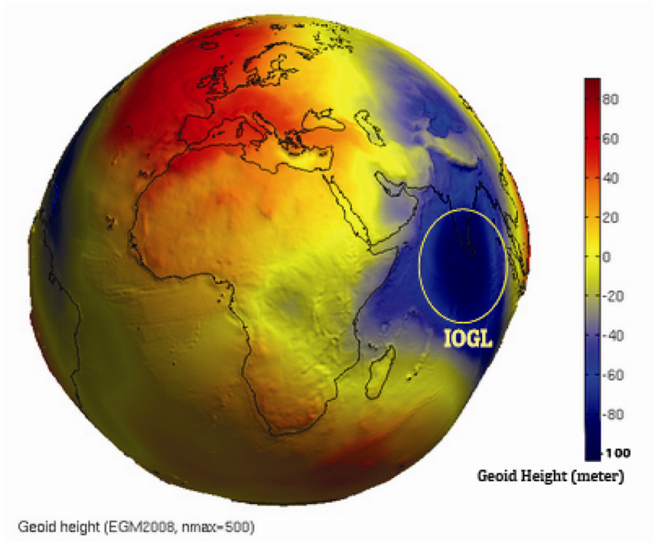

Figure 1. The global geoid with Indian Ocean Geoid Low highlighted (image source: http://www.asu.cas.cz/~bezdek/vyzkum/rotating_3d_globe/).

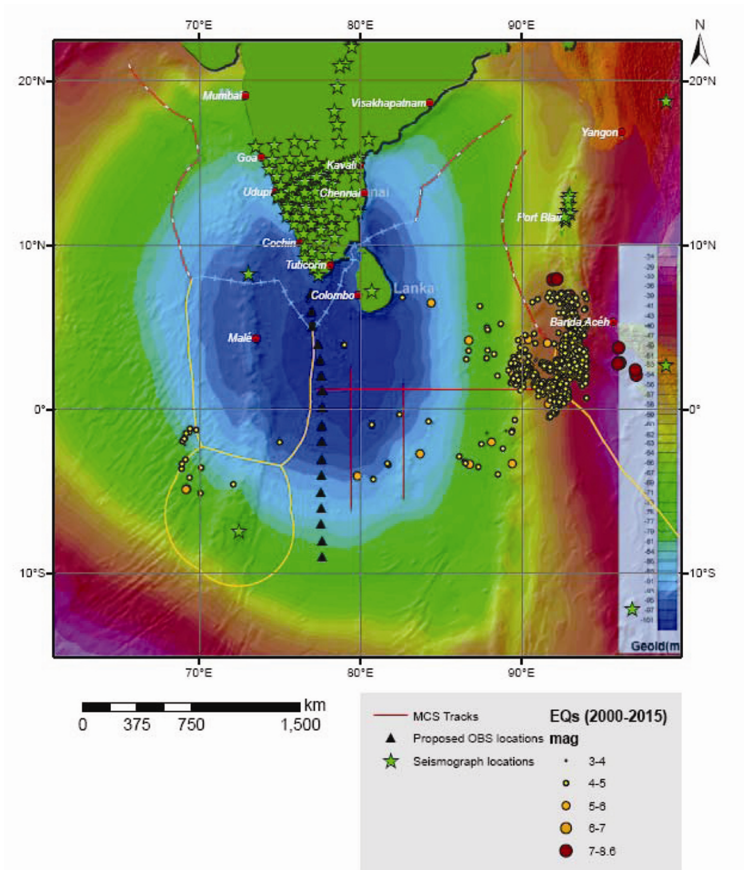

Figure 2. Ocean bottom seismometers (OBS) deployment map for the Indian Ocean overlain on IOGL anomalies. Earthquakes of variable magnitudes are superposed along with proposed OBS deployment locations. Other symbols are self-explanatory.

plate, causing huge deficiency in the geoid in this region. While being a novel approach, like other models their best-fit model for IOGL is based on available global seismological data of much lower resolution. Therefore, it is imperative to obtain high-resolution images of the lithosphere as well as mantle in the IOGL region using fine grid of broadband seismological stations over the long term. The enhanced subsurface images on regional to local scales would enable validation of existing hypotheses and to clearly understand possible causes behind this most intriguing problem from the deep.

The National Centre for Antarctic and Ocean Research, Goa has embarked upon an ambitious Deep Ocean Mission Programme under the aegis of the Ministry of Earth Sciences (MoES), Government of India (GoI), to image deep Earth structure in the Indian Ocean. Long-term deployment of an extensive network of ocean bottom seismometers (OBS) is envisaged starting early 2018 (Figure 2). These stations would provide complementary seismological data to the existing on-land seismological network in India and adjoining regions to render high-resolution tomographic images on local to regional scale. Through the pilot phase of N–S passive OBS deployments under this unique experiment, an enhanced imaging of the lithosphere and mid-lower mantle in the Indian Ocean in IOGL region is aimed. In order to decipher this bewildering phenomenon in the Indian Ocean, collaborative efforts from geosciences fraternity is welcome towards this endeavour.

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