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Research Advances

An Anomalous Seamount on the Southwestern Mid-Ridge of the South China Sea

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Objective

The development of continental rifting and seafloor spreading can be predominated by magmatic upwelling (magma-rich) or tectonic stretching (magma-poor). Located in the terminal portion of propagating seafloor spreading of the South China Sea (SCS), the southwestern mid-ridge of the southwest sub-basin (SWSB) of the SCS was found with much thin crust and numerous faulted blocks coupling with magma-poor continental margins along its flanks. Therefore, the southwestern part of the SWSB is most likely to be a tectonic-dominated basin. To justify the hypothesis with further evidence, we investigated the nature of seamounts on the southwestern mid-ridge of the SWSB which may inherit seafloor spreading.

Methods

In a Chinese-France cooperative project, a geophysical survey transverse (CFCST) was run across the southwestern mid-ridge of the SWSB via the Longmen Seamount in 2011 and 2013. The data sets include gravity, bathymetry, ocean bottom seismic, and long-streamer multi-channel seismic and magnetic data. The raw ship-born gravity data were processed in routine procedures, e.g., smoothing, Eotvos correction and 2D density model-based inversion. The gravity data together with the seismic profile and the bathymetric map compiled with the newest multi-beam data were analyzed.

Results

The seismic reflection profile (Fig. 1a) and bathymetry map (Fig. 1d) show that the Longmen Seamount is ca. 1400 m above the surrounding seafloor and 20 km wide, far larger than other seamounts on the survey line. It stands prominently on the bathymetric map (Fig. 1d), however almost invisible on the free-air gravity map (Fig. 1e). It is even characterized by the deepest trough (negative peak) on the free-air gravity (FG) profile, whereas those small seamounts show visible positive peaks as usually expected on FG profile. Thus, the free-air gravity variation does not correlate positively with the topographically evident Longmen Seamount, but in anti-phase. Moreover, another one, the Longxi Seamount displays a similar relationship between topographic and gravity features (Figs. 1d and 1e).

With 2D sediment-crust-mantle reference model simplified from the reflection and refraction images, numerous inversion trials were made with various density values for the CFCST profile. The fitted density seems always low for the Longmen Seamount. The bulk density of 2.7 to 2.75 g/cm^3, typically for igneous body and the crust, will result in a “root” deeper into the mantle 10 km, a hyper-deep end-member model. To keep the root of the Longmen Seamount at the same level as the neighboring area (Fig. 2c), a best-fit bulk density is 2.33 g/cm^3, slightly higher than the unconsolidated abyssal sediments, which shows a low-density end-member. If the effect of a 3D distribution of the seamount is considered, the seamount will be even deeper with even smaller density. The resultant end-members imply that the seamount is either made of sediments-equivalent materials which stack from a deep (~5 km) crustal rift valley, or basaltic buildup embedding deep (~10 km and more) into the mantle. In fact, a fault-bounded mid-valley, ca. 40 km wide, is clearly visible in the sub-basin on the bathymetric map (Fig. 1d) and attested by reflection and refraction images which show that the crust is usually thin, ~5 km at most, and occasionally less to 1 km. In this case, mantle shoaling is rather spontaneous than deepening, thus ruling out the possibility of deep-rooted volcanism. In accordance with

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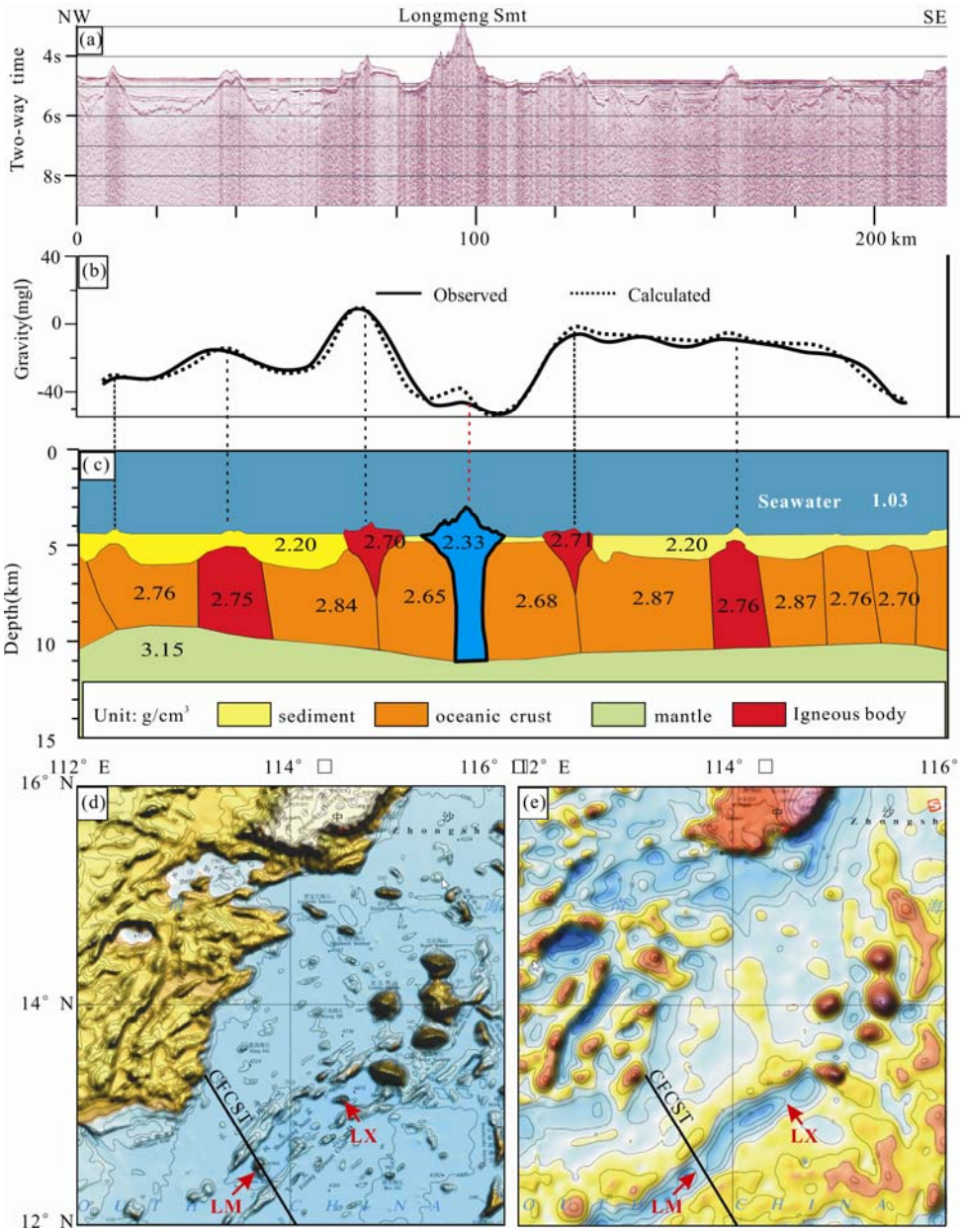

Fig. 1. Correlation of gravity with seismic and bathymetry data.
(a), Seismic profile of CFCST; (b), Observed (solid line) and modeled (dashed line) free-air gravity anomaly along CFCST; (c), Blocked density model; (d), Bathymetric map with location of the CFST line; (e), Free-air gravity anomaly. The CFCST line is incompletely plot on the map. LM, Longmen seamount; LX, Longxi seamount.

the thin crust and deep crustal rift valley, it is inferred that the Longmen Seamount alike was formed by tectonism rather than volcanism. Nevertheless, the true nature of the seamounts with anomalous low-density awaits further study.

Conclusion

It is recognized from gravity inversion together with alternate geophysical measurements that the Longmen Seamount is composed of low-density materials, rather than igneous rocks as usual belief. It stands within a deep mid-ridge valley formed reasonably by high tectonic extension, poor of magmatism.

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