Geophysical analysis of the Yonaguni, Irabu and Tarama knolls

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This research aims at understanding the subseafloor structure of the Yonaguni, Irabu, and Tarama Knolls, which are volcanos located in the southern Okinawa Trough backarc basin, where the Philippine Sea Plate subducts below the Eurasia Plate. The Okinawa Trough is now in the rifting stage. Through the state of the Yonaguni, Irabu, and Tarama Knolls, we can also infer the dynamics of the southern Okinawa Trough.

We collected bathymetry, gravity, and magnetism data of the Yonaguni Knolls and the adjacent area during the YK11-10 cruise in 2011, in the YK14-16 cruise, collecting the data for the Irabu and Tarama Knolls. The Yonaguni Knolls are located at the western end of the Okinawa Trough (Yaeyama graben), where the water depth is 1700 meters, 200 meters deeper than the area west part of the knolls. The Yonaguni Knolls consists of dozens of knolls, that align in E-W trending three rows parallel to the rift axis. These rows show a right-stepping en-echelon pattern, forming general NE-SW trend, oblique to the rift. The heights of the knolls are among 300-500 meters. Irabu and Tarama knolls at the east of Yonaguni knolls. The water depth surrounding the Irabu and Tarama knolls is about 2000 meters. The heights of the knolls are up to 600 meters. The Tarama Knolls locate in an EW trending rifting zone, and they are at the south of the rifting axis. The Irabu knolls locate in the intersect of the East-West trending rifting zone where Tarama Knolls are and a Northeast-Southwest rifting zone of the Okinawa Trough.

We calculated the Bouguer anomaly to remove the effect of topographic relief, assuming the density contrast between water and crust is 1720kg/m3. In the Yonaguni survey area, the Bouguer anomaly generally decreases from east to west, from 30 mGal to 5 mGal. The eastern part of the survey area showing a high Bouger anomaly (BA) corresponds to the active rifting zone of the Okinawa Trough. The high BA likely indicates the thinner, extended crust by backarc extension. The mantle material has a higher density than the crust, uplifting, causing the higher gravity of the rifting area. The rift axis is segmented and trends NE-SW direction east of the Irabu Knoll. The EW trending Yaeyama Graben is accompanied by positive gravity anomaly, whereas the NE-SW trending rift shows a negative gravity anomaly. It may suggest the difference of the rifting stage.

The influence on the gravity of the knolls seems to be negative. Yonaguni Knolls corresponds to a lower BA approximately 5 mGal than that in the surrounding area. It may be interpreted that volcanoes are active; hot magma has a low density. Gravity analysis on the Tarama knolls shows a similar result to the Yonaguni knolls. Low gravity anomaly beneath the knolls indicates low-density structure beneath the knolls. It is likely due to the active volcanism, where melting occurs. The other possibilities are thinner crust or different material density. There is no distinct gravity anomaly above the Irabu Knolls.

Magnetic anomaly distribution shows that three knolls are accompanied by typical dipole anomalies, and the rift axis shows a positive anomaly larger than 100nT. A positive magnetic anomaly along the rift axis likely indicates the existence of intrusive rocks.
Assuming the magnetization of knolls having the same direction to the ambient field (taken from IGRF), we did the calculation of reduction to pole. The knolls are positively magnetized, suggesting the recent eruption.

The positively magnetized body is located beneath the southern peak of the Tarama Knolls, and it seems that no magnetized body under the northern peak of the Tarama knolls. Magnetized body beneath the Yonaguni and Irabu knolls are well-distributed beneath the knolls. Magnetic anomaly of

Tarama is less than 500nT, whereas Irabu knolls have an up to 1000nT anomaly, which suggests more igneous rocks formed in the Irabu knolls area.

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