琉球諸島南西部の隆起について
Uplift of southwestern islands of the Ryukyu Arc

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The determination accuracy of the vertical position by GNSS (Global Navigation Satellite System Global Navigation Satellite System) is worse than the horizontal component. However, we already have 20 years of crustal movement data from the Japanese dense GNSS array GEONET (GNSS Earth Observation Network), and much more accurate vertical velocity data are available. In this study, we focus on the southwestern Ryukyu Arc (Yonagunijima, Iriomotejima, Ishigakijima and so on) and explored the cause of the prominent uplift shown by the GNSS points deployed on those islands. In the Okinawa trough, to the northwest of the Ryukyu Arc, active back-arc spreading goes on, and the spreading velocity is faster in the western part, reaching the maximum of about 5 cm/yr. As a result, the southward horizontal velocity also becomes maximum in Yonaguni, and decreases as it goes to the east. The uplift velocity is about 5 mm/yr at the Yonaguni, the westernmost island, which gradually decreases as we go eastward (Iriomotejima, Ishigakijima), and it becomes almost zero in Miyakojima. They are roughly proportional to the southward velocity of the islands due to the spreading of the Okinawa trough, suggesting a link between uplift and back-arc spreading.

As the divergent boundary on land, Iceland and the East African Rift are known, but the GNSS observation in the vicinity has found horizontal movement due to spreading, but the long-term uplift like the southwestern Ryukyu Arc has not been reported. At the plate boundary immediately below Iriomotejima, a slow earthquake (SSE) of about Mw 6.6 occurs once every six months (Heki & Kataoka, 2008 JGR). Tu & Heki (2017 GRL) found that the cumulative amount of slip of these SSEs fluctuates about 10 years from GNSS data of the Ryukyu Arc in the past 20 years. In addition, remarkable earthquake swarms occurred in the Okinawa trough when the slip accumulation accelerated. This suggests that back-arc rifting episodes recur with the period of about ten years in the Okinawa Trough, and subsequent stress diffusion by viscous relaxation of the upper mantle may cause the accelerated southward movement of the block including these islands. In this study, we assume that the uplift in the southwestern Ryukyu Arc was caused by repeating rifting episodes in the Okinawa trough.

The basic processes of the back-arc spreading is the intrusion of the dike, and they bring both horizontal and vertical displacement in Yonaguni about 60 km south of the trough axis as the elastic response to it. However, the velocities far exceed those by simple elastic responses, and we have to consider viscosity relaxation (stress diffusion) after intrusions of the dikes. We stacked viscoelastic responses by numerous past repeating rifting episodes (decadal occurrence of 5 m thick dikes) and investigated whether uplift can also be explained as a part of it. In this study, we used software developed by Dr. Y. Fukahata, Disaster Prevention Research Institute, Kyoto University, to calculate viscoelastic responses at various distances and its time evolution assuming two layers composed of elastic upper layer and viscoelastic lower layer. We compared the calculated and observed velocities and examined the combination of depth and dimension of dikes and viscoelastic structure.

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