Secular variations in helium isotope ratios in Izu Oshima volcano

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Helium isotope ratios (3He/4He) differ significantly in geochemical reservoirs such as air, the crust, and the mantle. Therefore, helium in volcanic gases can be used as a sensitive tracer of magma activity. In Izu-Oshima volcano, 3He/4He of a steam well increased immediately after the 1986 eruption from a low value of 1.7 Ra, peaked in 1988 at 5.5 Ra, and has been decreasing until now (Sano et al., EPSL 1991). The 3He/4He corrected for atmospheric contamination using 4He/20Ne was about 6.2 Ra throughout the last 1986-1990 eruptive activity. On the other hand, air-corrected 3He/4He of hot spring gases collected from other wells have been constant at 6.2 Ra since 2001. These results suggest that the supply of magma-derived helium to the steam well has been decreasing, while the 3He/4He of magmatic gas itself has been constant over the past 30 years.

The lower 3He/4He of the present magma than the mantle value of 8 Ra suggests the significant contribution of crustal helium in the magma reservoir. On the other hand, 3He/4He of olivines in 19-40 ka volcanic rocks are around 7 Ra, suggesting that 3He/4He of the magma at these stages were more similar to that of the mantle. However, 3He/4He of olivines in 1.3 ka scoria is 4.6 Ra, indicating that crustal helium significantly contaminated the magma.

Based on these observations, two scenarios can be expected for the next eruption: first, if the old magma reservoir is reactivated, the 3He/4He of hot spring gases will remain unchanged at about 6 Ra, and only the contribution of magma-derived helium in the steam well will increase, similarly to the previous eruptive activity. In the second scenario, in which the reactivation of the magma is caused by a supply of primitive magma with a high 3He/4He, not only the contribution of magmatic helium in the steam well increases, but also the air-corrected 3He/4He of the steam and hot-spring gases will be higher than 6 Ra. Namely, whether the next eruption results from new magma supply from greater depths or just reactivation of the old magma can be constrained by 3He/4He.