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He and C isotope geochemistry of dissolved gases in groundwater of Jeju Volcanic Island, Republic of Korea

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Jeju Island, a volcanic field in Northeast Asia, was formed through intraplate volcanic activity during the late Cenozoic. Although there is no evident volcanism at present, the existence of a low-velocity zone (LVZ) in the subcontinental region has been suggested. Moreover, it has been reported from previous studies that groundwater in some areas of Jeju Island contains mantle-derived helium and carbon dioxide. To understand the potential volcanic activity in Jeju Island and trace its origin, we report the results of geochemical analysis of dissolved gases in carbonic springs, natural springs, and groundwater wells.

In most groundwater and natural spring samples in Jeju Island, N_2 is the dominant dissolved gas (65 to 95 vol.%). For the carbonic springs, however, CO_2 is the main dissolved gas constituting more than 97 vol.%. The relative abundances of N_2-Ar-He in the dissolved gases indicate a two-component mixing trend between mantle-derived gases and atmospheric gases, which is more evident in carbonic springs and some groundwater samples with high He concentrations. This trend is also shown through the correlation between $^{3}He/^{4}He$ and $^{20}Ne/^{4}He$ ratios.

The $\delta^{13}C$-CO_2 (vs. VPDB) values in carbonic springs ranged between -5.5 and -9.3‰, indicating a mantle origin, while other samples exhibited lower values ranging from -13.4 to -22.7‰. In addition, $^{3}He/^{4}He$ (1Ra = 1.38 x10^{-6}) ratios in the dissolved gases of carbonic springs, ranging from 5.6 to 6.3 Ra, along with some groundwater samples ranging from 5.6 to 6.8 Ra, also suggest a mantle origin. This tendency indicates that mantle-derived helium is more extensively emitted than carbon dioxide across Jeju Island, particularly suggesting the presence of a specific path for mantle-derived carbon dioxide in the southwestern region where carbonic springs are concentrated.

In conclusion, we propose that there is an ongoing emission of helium and carbon dioxide from the mantle in Jeju Island, coupled with the existence of a low-velocity zone (LVZ) implying potential magmatism.