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Geophysical and geochemical constraints on the heat source in non-volcanic regions, Japan

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It has been recognized that the Iide Mountains, consisting of Mesozoic sedimentary rocks and Late Cretaceous to Paleogene granitic rocks, Northeast Japan, are unique. Although they occur in a non-volcanic region, hot springs in the Iide Mountains have anomalously high heat discharge values similar to those from hot springs in volcanic regions. In order to provide geophysical and geochemical constraints on the heat source for the hydrothermal activity, we carried out wide-band MT soundings on a profile across the Iide Mountains and determined the chemical and isotopic compositions of gas and water samples from hot springs around the mountains. A two-dimensional model shows that an anomalous conductive body (~10 ohm-m) is clearly visible beneath the Iide Mountains. The conductor widens with increasing depth, and extends from the near-surface down to the base of the crust and perhaps into the upper mantle. The 3He/4He ratios determined range from 0.22 to 7.9 RA, and the highest ratio is similar to MORB-type helium, indicating a significant contribution of primordial mantle helium. The hot springs with high 3He/4He ratios are distributed around the Kitamata-dake, which is one of the peak of the Iide Mountains. It is apparent that there is a good correlation between the occurrence of hot springs with high 3He/4He ratios and the position of anomalous conductive body. These high helium ratios are considered to indicate the likelihood of mantle-derived materials supplying MORB-type helium beneath the Kitamata-dake, and the possibility that mantle derived helium has been diluted by atmospheric and/or crustal components with lower helium ratios away from the peak. In order to examine whether or not ancient magma of Middle Miocene age is a possible source of the high 3He/4He ratios of the hot spring gases, we calculated the evolution in 3He/4He ratios of the ancient magma with time. As a result, it is concluded that the anomaly beneath the Iide Mountains is due to newly ascending magmas in the present-day subduction system rather than hydrothermal fluids related to late remnant magmatism of Middle Miocene age.