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He isotope systematics of the Northwest Geysers geothermal field, California

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The Geysers, a steam-dominated reservoir that is hosted by Mesozoic metagraywackes, is the largest operating geothermal field in the world. It is associated with bimodal Quaternary volcanism and plutonism of the Clear Lake volcanic field, ranging in age from 2.1 Ma to 10 ka [1]. Felsic intrusions underlying the geothermal reservoir are interpreted to represent the heat source. Recent geophysical surveys and heat flow studies both suggest that young intrusions provide the heat necessary to sustain the elevated temperatures in the northwestern portion of the field, and that there may be some residual magma still present at depth [2, 3]. The Prati 32 well (part of the NW Geysers EGS field demonstration project) encountered a temperature of 400°C at a depth of 3.4 km [4]. Sampling of gas conducted periodically between 2010 and 2017 from production wells near the EGS demonstration site in the NW Geysers revealed that while there is a fairly wide amount of variability in He isotopic compositions (4.56 up to 9.35), most samples had He R/Ra values > 7, indicating that helium is primarily sourced from degassing magma. The observed He isotopic variability does not appear to correlate with well temperature or differences in non-condensable gases (NCG), nor does it vary systematically with time. One possibility is that the contributions of the two main sources of helium into the NW Geysers geothermal reservoir, via magmatic degassing and diffusion of radiogenic He from the crustal rock matrix, vary spatially and temporally as new fracture pathways are opened due to thermal stresses resulting from cold water injection, thus resulting in the observed complex He isotopic variations. The injection of cold water also serves to abate the concentration of NCG in the high temperature zone reservoir fluids.

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