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$^{20}Ne/^{36}Ar$ in geothermal fluids of Theistareykir: a possible thermometer of water-rock interactions?

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The Theistareykir geothermal field is located in north-eastern Iceland, ca. 30 km north of the Krafla volcano. In this area, between 10 and 2.5 ka ago, the intersection of the mid-ocean ridge with the Tjörnes Transform Zone led to a fissure swarm with associated basaltic volcanism. The geothermal reservoir is hosted in tholeiitic basalt lavas and hyaloclastites, with occasional occurrence of silicic volcanic rocks that are moderately to highly altered. The field is recharged by local precipitation, and possibly older glacial water originating in the southern highlands. A thorough fluid geochemical survey, which included noble gases and $^{87}Sr/^{86}Sr$, was carried out between 2017 and 2019 to identify fluid sources and to improve our understanding of fluid circulation in the system. Water was collected from 10 wells using a gas/water separator. The $^{87}Sr/^{86}Sr$ ratios vary significantly from 0.70358 ± 0.00003 to 0.70671 ± 0.00004. The lowest value is close to that of N-MORBs, the reservoir rocks. A linear positive correlation between δ18O and the $^{87}Sr/^{86}Sr$ ratios in water suggests either that radiogenic $^{87}Sr/^{86}Sr$ values up to 0.70671 are derived from seawater infiltration - a hypothesis rejected on the basis of the Cl and B content - or be acquired from hyaloclastites or silicic rocks. The $^{87}Sr/^{86}Sr$ ratios vs. $^{20}Ne/^{36}Ar$ ratios discriminate the sampled wells into two distinct linear direct trends, which can be explained by mixing of different fluid generations. The first common fluid is the original high-temperature geothermal water acquiring $^{87}Sr/^{86}Sr$ of 0.7030 from tholeiitic basalts and a 20Ne/36Ar ratio of 0.15 from dissolution of atmospheric gases in the meteoric water recharging the reservoir. The other fluids show $^{87}Sr/^{86}Sr$ up to 0.70671 and variable $^{20}Ne/^{36}Ar$ ratios close to that of the atmosphere (0.5). These fluids might represent meteoric water re-equilibrating at reservoir temperatures of 95 to 195˚C and possibly participating in alteration of rocks, acquiring radiogenic Sr from silicic rocks and hyaloclastites. This suggests that $^{20}Ne/^{36}Ar$ ratios may have the potential to be used as a geothermometer of secondary processes of rock alteration in geothermal reservoirs.