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Helium isotope studies on mud gas samples from the SAFOD Main Hole

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We present data from noble gas isotope studies performed on 14 gas samples extracted from returning drill mud during drilling of SAFOD (San Andreas Fault Observatory at Depth) Main Hole near the town Parkfield (California). The samples were taken when significant amounts of helium were detected in the drill mud by real-time mud gas monitoring.

All air-corrected ^{3}He/^{4}He ratios are lower than the atmospheric ratio, but higher than the mean crustal values of $\leq$0.1Ra; therefore helium is a mixture of crustal helium with a small portion of mantle-derived helium. Down to a depth of 3051 m, ^{3}He/^{4}He ratios of $>$0.45Ra show that the contribution of mantle-derived helium is very small on the Pacific Plate, which composes the SW of the SAF. The ^{3}He/^{4}He ratios become significantly higher at depths below 3781 m on the North American Plate, were ^{3}He/^{4}He ratios of $\sim$0.9Ra were found. Two samples collected at 3196 m and 3433 m indicate some mixing between both reservoirs with Ra of $\sim$0.6, however, both contain only a very small portion of non-atmospheric helium.

Based on our observations, we conclude that the contribution of mantle-derived fluids to the total fluid inventory at the SAF is small. Higher ^{3}He/^{4}He ratios found in two nearby wells imply that the fluid migration from depth directly through the SAF is, at least to some extend, hampered. The distinct helium isotopic compositions down to 3051m and below 3781m depths, with only little evidence for mixing between both hydrologic systems, demonstrate that the SAF in some way acts as a seal for fluid migration.