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The Origin and Post Processes of Mud Volcano Fluids in Taiwan: Evidence from Hydrogen, Oxygen, and Strontium Isotopic Compositions (δD, δ18O, 87Sr/86Sr, 87Sr/86Sr*, and δ88/86Sr)

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Mud volcanoes are important passageways for deep fluids to migrate upward, providing important window to study fluid/sediment interaction at depth. Combining usage traditional stable isotopes (H and O) and non-traditional stable strontium isotope provides a robust tool for tracing the fluid sources. Fluids emitted from mud volcanoes were collected in Southern and Eastern Taiwan, their chemical compositions, and H, O, Sr isotopes were analyzed to delineate the sources and migration processes. A modified EEN (Empirical External Normalization) technique was applied to analyze the 87Sr/86Sr, 87Sr/86Sr* and δ88/86Sr ratios. These fluids show lower major elements (i.e. Cl, Na, K, Ca, Mg, and SO42-) than seawater, an exception of high Ca mud volcanoes in eastern Taiwan. The B, Ba, Li, and Si enrichment in these fluids are consistent with high degree sediment alteration and clay dehydration. The Sr distributions in mud volcano fluids show grouping pattern and relate with their geological backgrounds. Most mud volcano fluids have positive δ18O (up to 7.1‰ and negative δD values related to V-SMOW, and higher 87Sr/86Sr* (up to 0.71161) than seawater except the mud volcanoes in eastern Taiwan, indicating fluid-rock interaction at depth. On the other hand, most mud volcano fluids have higher Sr/Cl and lower δ88/86Sr than seawater except mud volcanoes in Chiayi County; the extremely low Sr/Cl ratio and high δ88/86Sr (up to 0.81‰ indicates possible co-precipitation of carbonates from high alkalinity fluids during migration. It is implied that mud volcano fluids in Taiwan were originated from 2 to 5 km and were chemically controlled by tectonic, water-rock interaction and clay dehydration, but was masked by retrograde co-precipitation during migration.