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Linking hydrothermal He-CO_2 degassing to regional seismicity in volcanically and tectonically active regions, southeastern Tibetan Plateau

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Degassing of deeply-derived fluids (e.g., He and CO_2) is widely observed in seismically active regions associated with volcanic unrests and tectonic movements, providing potential insights into the seismogenic processes from a perspective of deep fluids. Here, we present geochemical studies on He-CO_2 degassing from the Tengchong volcanic field (TVF) and the Xianshuihe fault (XSF) in the southeastern Tibetan Plateau, aiming to reveal the role of deep fluids in triggering regional seismicity. Higher fluxes of mantle He [$(1.08 \pm 0.84) \times 10^{10}$ atoms m^{-2} s^{-1}] and CO_2 [$(1.29 \pm 1.00) \times 10^4$ mol km^{-2} yr^{-1}] are observed near active volcanoes in the TVF, which are ~4 times the background values [mantle He and CO_2 flux = $(0.26 \pm 0.16) \times 10^{10}$ atoms m^{-2} s^{-1} and $(0.32 \pm 0.19) \times 10^4$ mol km^{-2} yr^{-1}]. Spatially, the high He-CO_2 fluxes of magmatic origins correspond well with several earthquake swarms and deep low-frequency earthquakes that are likely driven by magmatic fluids [1]. On the other hand, vigorous release of deeply-derived CO_2-rich fluids ($^3He/^4He$ = 0.94−2.73 Ra; $\delta^{13}C_{CO2}$ = −8.9 to −2.6‰) dominates bend section of the XSF, where localized mantle melting and metamorphic decarbonization may have produced the CO_2-rich fluids and fed the hot spot of high CO_2 flux (9.66×10^9 mol/yr) along the XSF. The high CO_2 flux hot spot could explain the high risk of earthquake hazard in the XSF bend section, such as the 2022 *M*s 6.8 Luding earthquake [2]. Taking the results of fluid origin and transport, CO_2 fluxes, and regional seismicity together, we suggest that the deep CO_2-rich fluids may have played a crucial role in generating overpressure conditions involved in seismogenic processes beneath the TVF and XSF. The spatial relationships between hydrothermal He-CO_2 degassing and regional seismicity could present a snapshot for how deep fluids of various origins may contribute to seismic dynamics and thus should be considered in earthquake prediction based on gas/fluid geochemistry.

References:

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[2] Liu, *et al*. (2023), *Journal of Hydrology* 620, 129482.