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Continental Subduction and the Distribution Regime of Deep Volatiles in Tibetan Plateau

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Subducting slab plays an essential role in distributing the volatile geochemistry in oceanic subduction zones; however, its role in continental subduction zones remains poorly constrained. We present helium and stable carbon isotope data, as well as the chemical compositions of hydrothermal volatiles from the Tibetan Plateau, one of the most significant continental convergence areas on Earth. Our aim is to explore the role of the subducting continental slab beneath the plateau through geochemical mapping of deeply-sourced volatiles.

From a west to east perspective, the boundary between crustal and mantle helium domains exhibits a rough NW-SE orientation, which is not parallel to the suture zone, so as the carbon isotopes in hydrothermal volatiles. The Indian continental slab is underthrusting with an eastward increase in dip angle beneath Lhasa terrane. Such a slab geometry of the Indian lithosphere with different subduction angles can alter the thermal structure of the mantle wedge by impeding deep upwelling heat from the asthenosphere, thus playing a crucial role in deep volatiles recycling in southern Tibet.

From a south to north perspective, hydrothermal volatiles in Himalayas and southern Lhasa terrane are geochemically characterized by crustal helium and relatively light carbon isotopes. Systematic increase in $^{3}He/^{4}He$ values and $\delta^{13}C$ ratios are observed in volatiles from south to central Tibet, and decrease towards the Songpan-Ganzi terrane and its north. Hydrothermal volatiles in central and northern Tibet exhibit a minor but detectable contribution of mantle-derived components (>10%), with a higher proportion of carbonate involved in their source. When excluding samples that may have been potentially influenced by significant strike-slip faulting or air contamination, these observations are consistent with a warm thermal structure resulting from asthenosphere upwelling beneath central and northern Tibet, as imaged by high electrical conductivity anomalies, and the coexistence of opposing Indian and Asian subduction systems beneath the Tibetan Plateau.

Our study therefore highlights the critical role of the subducting slab in shaping the recycling processes of volcanic volatiles within the context of continental subduction.