Carbon dioxide in the Nepal Himalayas: Segmentation of the crustal source?

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Beyond the carbon dioxide (CO_2) sink mainly related to silicates weathering, the Himalayas produce and release a significant amount of CO_2, likely of metamorphic origin. In addition to dissolved carbon in rivers, direct CO_2 emissions have been indeed evidenced at several locations in Nepal, in particular in the Main Central Thrust zone, the main shear zone separating rocks of the Lesser Himalaya from rocks of the Higher Himalaya, and connected at depth to the décollement ramp – the Main Himalayan Thrust. These manifestations are most of the time observed at hydrothermal geosystems located in valleys oriented north-south, and encompass a variety of CO_2 emissions: dissolved CO_2 in hot springs (maximum dissolved inorganic carbon concentration of 55 mmol·L^{-1}), bubbling of CO_2, CO_2 flow from aquifer degassing, and direct gaseous CO_2 discharges observed at the ground surface (dry mofettes and diffuse degassing structures with CO_2 fluxes larger than 10 kg·m^{-2}·day^{-1} in many places).

Here, we present an up-to-date overview of carbon isotopic data ($\delta^{13}C$) of the CO_2 emissions observed at all the currently known Nepalese hydrothermal systems, over more than 400 km along the Nepalese Himalayan arc, from Far-Western Nepal (Jumla district) to the east of Central Nepal (Kodari). This extended region includes the rupture zone of the 2015 M_w7.8 Gorkha earthquake. $\delta^{13}C$ values of dissolved and gaseous CO_2 (n>200) range from –14 ‰ to +13 ‰ and from –12 ‰ to +0.1 ‰, respectively, with most of values for gaseous CO_2 above –3 ‰, thus compatible with a metamorphic origin of CO_2. Interestingly, $\delta^{13}C$ data appear spatially organized, with a >100-km-long segment along the Himalayan arc showing higher $\delta^{13}C$ values, and with 10-km-wide regions characterized by similar $\delta^{13}C$, hence indicating similar CO_2 sources, respectively. This study opens the way towards a better understanding of the metamorphic CO_2 source and production processes in active orogens.