Isotopic, Aquatic Geochemistry of Geothermal Springs of Northwest Himalaya, India: Implications for their Source of Origin and Orogenic CO₂ Degassing – Sameer K. Tiwari, Wadia Institute of Himalayan Geology (WIHG), 33, General Maha Dev Singh Road Dehradun (E: sameer@wihg.res.in*; stiwariisr@gmail.com)

The internal heat of the Earth has been emanating since its formation which is manifested in forms of volcanism and its subsurface outgassing of volatiles from its surface. Towards this, the evaluation of geogenic carbon fluxes between solid Earth and its atmosphere provides a better tool to understand the global geological carbon cycle. There are major geogenic CO₂ suppliers, which include the magmatic mantle and metamorphic degassing from active and quiescent volcanoes, fault zones, geothermal systems, and CO₂-rich groundwater. The major emphasis of the research is aimed at understanding the nature of the degassing process in the northwest Himalayan geothermal belt using isotopic and geochemical proxies of the geothermal springs.

Indian Himalayan geothermal field hosts about 340 geothermal springs in natural as well as an artesian condition that ejects hot waters and volatiles with varied temperature and chemical compositions. The occurrences of geothermal fields are common in the north-western part of the Himalaya encompassing Uttarakhand, Himachal Pradesh, and Ladakh region, thus probably to their link to the northward migration of the Indian plate and due to underplating. Hence, these sites provide an opportunity to analyze tectonically driven gas emissions and their impact on regional and global climate.

In the present realm of research, sixty geothermal springs along the Indus and Nubra valleys of the Ladakh, Sutlej, Beas, and Parbati valleys of the Himachal, Alaknanda, Bhagirathi, Goriganga, and Kali river valleys of the Uttarakhand regions have been investigated. The major & trace element characteristics and stable isotopic composition ($\delta^{13}\text{C}_{\text{DIC}}$, $\delta^{18}\text{O}$ & δA) of these springs were employed to trace their origin and the process of metamorphic CO₂ degassing. Such information was also used to infer about the altitude effect of stable isotopes in the arid Himalaya. The surface temperature of these springs varies from 21 to 95° C, whereas pH ranges from slightly acidic to alkaline 6.2 to 8.9.

Major ions data indicate that these springs fall under the hydrochemical categories of HCO₃⁻: Cl⁻: SO₄²⁻ and Na+K: Mg: Ca types. The abundance of trace elements in these spring waters, such as Fe, B, Li, Sr, Mn, Al, Mo, Zn, and As, were found in a considerable amount, possibly due to the enhanced rock-water interaction at elevated temperatures.

These springs contain high ratios of dissolved inorganic carbon (DIC) with concentrations of HCO₃⁻ ranging from 1300 to 13400 μM (micro moles). The $\delta^{13}\text{C}_{\text{DIC}}$ ratios of these springs vary from -8.4‰ to +1.7‰ VPDB, which points towards the deeper source of their origin.

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Fig.1. Schematic model of recharge source of geothermal springs and CO₂ degassing in Northwest Himalaya.

Stable isotopes of Oxygen ($\delta^{18}\text{O}$) and Hydrogen (δA) composition of these springs indicate mixing of thermal water with a meteoric dominated reservoir as most of these samples fall on the line defined by Global Meteoric Water Line (GMWL) (Fig.1). Here we adopt a method for direct measurement of Dissolved Inorganic Carbon (DIC) concentration in the geothermal springs to estimate geogenic CO₂ flux from an active region based on water discharge and area of the geothermal system between the tectonic boundaries of the Northwest Himalaya.

In this study, we have estimated the metamorphic CO₂ flux using the geochemical composition of forty geothermal springs covering the Ladakh, Himachal, and Garhwal regions (Tiwari et al., 2016; 2020). It has yielded a value of 2×10^8 moles of CO₂/year. This indicates that the degassing of CO₂ from Himalayan orogen is a significant contributor to the global carbon budget of the atmosphere on a longer time scale.

References

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