Integrated Isotope-geochemical Investigation in the Selected Geothermal Areas of India

The term 'Geothermal' originates from two words: 'geo', means earth whereas 'therme', means temperature/heat. Therefore, the geothermal heat is basically the thermal heat stored beneath the earth surface which serves as an energy source in diverse applications, ranging from large-scale power stations to smaller heat pumping systems. Integrated isotope (both stable and radioactive) and geochemical characterization of the thermal waters are extremely valuable in providing information about the origin of thermal fluid, identification of their possible recharge area, geochemical evolution, source of dissolved solutes, estimation of subsurface reservoir temperature etc. Among various stable isotopes, the variations in the $^{18}O/^{16}O$, $^{2}H/^{1}H$, $^{13}C/^{12}C$, $^{34}S/^{32}S$ and $^{87}Sr/^{86}Sr$ isotopic ratio have been widely used in accessing different hydrological characteristics of thermal fluids. On the other hand, radioactive environmental isotopes like tritium (^{3}H) and ^{14}C are mainly used for estimating the residence time of the thermal waters.

The thesis enumerates the in-depth isotope-geochemical assessment of three promising geothermal areas (Tural-Rajwadi area, Godavari valley area and Tapoban-Badrinath area) situated in the three distinct geological settings. It was observed that all the thermal springs found in the Tural-Rajwadi (Deccan Trap region, Maharashtra), Godavari Valley (Sedimentary formation, Manuguru region) and Uttarakhand region (Himalayan belt) are meteoric in origin. Based on the isotopic evidence, the probability of magmatic water was found to be negligible even in the Uttarakhand geothermal region which is a part of tectonically active Himalayan geothermal system (Fig.1). Tural-Rajwadi geothermal area located near the seashore exhibited enriched stable isotopic value than the Godavari valley geothermal area which was situated deep inside the island (continental effect). The Badrinath thermal water (BTHS-1) of Uttarakhand area showed most depleted isotopic signature due to its highest altitude of recharge. Geochemically, thermal waters in the Tural-Rajwadi region were more mature (Na-Cl type) compared to the thermal waters in Godavari valley and Uttarakhand region (bicarbonate type). Application of the lumped parameter models (LPM) along with the tritium time series data in precipitation was found to be very useful in constraining the mean transit time (MTT) of the thermal water. Tritium dating also allowed in quantifying the extent of mixing of the thermal water with the non-thermal water. The highest extent of mixing (up to 70%) was observed in the Tapoban thermal spring (THS-1) of Uttarakhand area. Carbon-14 dating technique helped to estimate the transit time of the very old thermal water present in the Tural-Rajwadi and the Godavari valley geothermal area. Among the three geothermal areas, the thermal waters from the Uttarakhand area were found to be the youngest one (age ranged from 40 to 112 years). The geothermal systems from the peninsular India i.e. Tural-Rajwadi (age varies from 6000 to 15000 years) and Godavari valley (age varies from 9900 to 18600 years) contained much older fraction of thermal waters. Chemical geothermometers, mixing models as well as multicomponent geothermometry techniques were simultaneously applied to better constrain the reservoir temperature. The subsurface reservoir temperature was found to be highest in the Tural-Rajwadi geothermal area ($160^{\circ} \pm 10^{\circ}C$) whereas the estimated reservoir temperature in Uttarakhand and Godavari valley geothermal area was found to be similar ($\sim 130 \pm 10^{\circ}C$) (Fig.2).

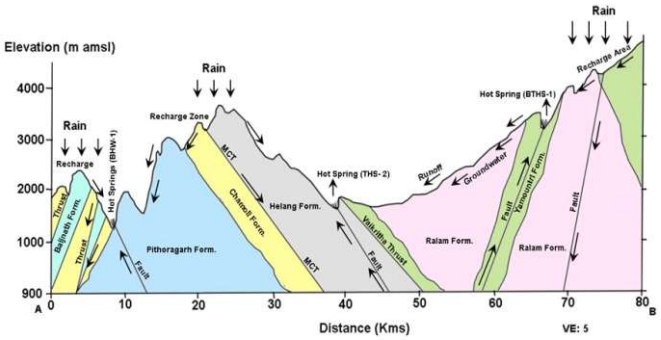

Fig.1: Conceptual diagram showing origin and evolution of Uttarakhand geothermal area

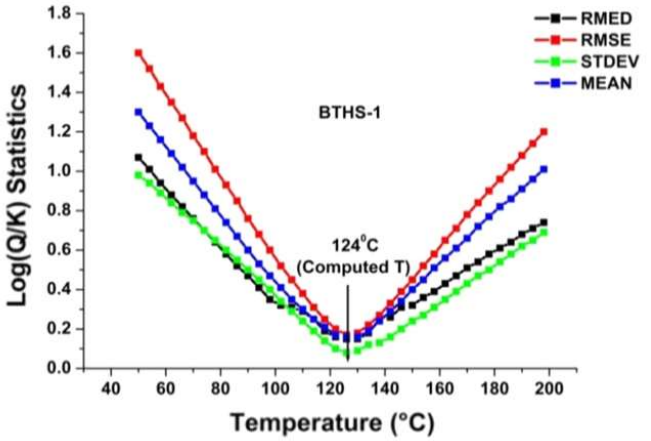

Fig.2: Reservoir temperature estimation in Uttarakhand geothermal area using multicomponent geothermometry method

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