P - 425

Perspectives for Development of Geothermal Energy Resources In India

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Introduction

Geothermal energy is an abundant resource of energy, which has been successfully catering to both industrial as well as domestic energy requirements in many parts of the world over the past few decades. Geothermal energy uses the Earth's internal heat. Being a relatively clean and renewable resource, it has been a preferred choice for an alternative energy resource.

The Indian Scenario

In the context of Precambrian terrains in general, and India in particular, the moderate-to-low temperature hot spring systems represent potential geothermal energy resources. In India, some of the major groups of hot springs occur in the west coast region, the Son-Narmada-Tapti lineament zone in central India, Rajgir-Monghyr, Surajkund and Bakreshwar in eastern India, Manikaran and Puga-Chhumathang valley springs in northern India (GSI, 1991; 2002). Of these, the Tattapani hot springs located in Chattisgarh region of the Indian shield and the Puga-Chhumathang valley springs located in the Ladakh Himalaya hold promise for development as geothermal fields for power production using the binary-cycle method. In the case of the former, the temperatures of the issuing waters is ~110 ^{o}C, the highest recorded so far in the shield. The spring waters are meteoric in origin as indicated by oxygen and helium isotopic data, and the age of these waters indicated by tritium dating is ~40 years (Thussu et al., 1987; Sharma et al., 1996; Minnisale et al., 2000). Lack of evidence for Quaternary magmatism in the region and the meteoric nature of the hot spring waters point to forced convection enabled by peizometric gradient prevalent between the recharge area and the hot springs as responsible for maintaining the spring discharges. These springs basically "*mine*" the Earth's normal heat flow. However, no heat flow measurements outside the localized hot springs zone have been made. There is therefore a clear need to establish the regional thermal conditions by systematic geothermal measurements because they would contain information about subsurface flow and location of recharge area (Lachenbruch et al., 1976).

In the case of Puga valley springs, geothermal evidence gathered so far and the occurrence of cesium deposits around the springs have indicated the possibility of high temperature hydrothermal circulation in the subsurface (Absar et al., 1996). Magnetotelluric studies carried out recently indicate the presence of an anomalous conductive feature (~5 Ohm m) below a depth of ~2 km in the area of the thermal manifestations (Harinarayana et al., 2006; Azeez and Harinarayana, 2007). Although there are geochemical indicators pointing to a magmatic heat component in the thermal waters, further efforts are necessary to fill existing gaps in knowledge and verify the hypothesis regarding the existence of subsurface magma chambers or young intrusive granites in the region. Such heat sources alone can sustain power generation on a reasonable scale (Rao et al., 2003). Determination of background heat flow outside the hot springs zone, helium-isotopic measurements on the thermal waters, detailed petrographic and geochronological studies on young granite intrusives, and tritium dating of the waters would be useful for testing a magmatic heat source. A pilot-scale binary power plant, utilizing the thermal waters from the shallow reservoir (<500 m), could be established on an experimental basis to assess the potential of the geothermal field for sustainable power production. The heat extracted from warm-to-hot waters emerging from other hot spring systems can be gainfully employed for a number of *direct uses* such as development of tourist spas for bathing, swimming and balneology, greenhouse heating in cold climates, and agricultural product processing. Further, the significant economic and environmental benefits of using moderate-to-low enthalpy geothermal waters to replace even small

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quantities of conventional fuels for direct uses cannot be ignored today.

A second category of geothermal resource called “*hot dry rock*” has not yet been explored in India. In such resources, heat is stored in hot and poorly permeable rocks at shallow depths within the Earth’s crust without any fluid availability to store or transport the heat. Very localized, highly radiometric heat sources such as high heat producing granites and other young and highly silicic igneous intrusives having a depth extent of a few kilometers, could be possible targets of future exploration efforts in the country. Such efforts reinforce the need for carrying out systematic heat flow as well as radiogenic heat production investigations on a country-wide scale.

Conclusions

Broadly, two scenarios exist for the development of geothermal energy resources in India. The hot springs distributed in a number of geological provinces in India constitute low-enthalpy geothermal resources. In contrast to producing geothermal fields that are located in Quarternary volcanic / magmatic settings, the majority of hot springs in India are located in Precambrian provinces. Two promising areas, suitable for further testing and pilot-scale power production using binary cycle, are Tattapani hot springs in Chattisgarh and Puga-Chhumathang group of hot springs in Ladakh. The former in case of the former has not been determined conclusively, while that in the case of the latter to be the normal heat flow in the region. A second category of geothermal resource called “*hot dry rock*” has not yet been explored in India. In such resources, heat is stored in hot and poorly permeable rocks at shallow depths within the Earth’s crust without any fluid availability to store or transport the heat. Localized, radiogenic heat sources such as high heat producing granites and other young and highly silicic igneous intrusives having a depth extent of a few kilometers, could be possible targets of future exploration efforts in the country. Such efforts reinforce the need for carrying out systematic radiogenic heat production and heat flow investigations on a country-wide scale.

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