Origin of groundwater helium and temperature anomalies in the Cambay region of Gujarat, India

S.K. Gupta*, R.D. Deshpande

Earth Science Division, Physical Research Laboratory, Post Box No. 4218, Navrangpura, Ahmedabad 380 009, India

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Abstract

A survey of natural helium in soil-gas and groundwater was undertaken in the Cambay region of Gujarat, India. The Cambay basin, known for high heat flow, is a graben characterised by NNW–SSE trending major fault system and successive down faulting along sympathetic faults parallel to major trendline and orthogonal faults cutting across. Several wells indicated higher than atmospheric equilibration concentration of helium, referred to as anomalous helium concentration. These wells generally had high groundwater temperature and appear to be located along basement faults in the study area, particularly on both eastern and western flanks of the Cambay basin.

Groundwater helium anomalies are explained through a conceptual model as originating largely from within the crystalline basement, through radioactive decay in the form of plumes localised by the major faults and fractures. Groundwater temperature anomalies originate due to setting up of a shallow (~ 1–2 km) depth convective circulation, again along major faults and fractures, which facilitate both upward and downward migration of groundwater. The sedimentary cover acts as a dispersive medium. Therefore, no significant helium anomalies are seen within the Cambay graben that has more than 3-km-thick sedimentary cover. It is thus seen that even though helium and groundwater have different origins, the faults and fractures in the crust can associate anomalous concentrations of helium and groundwater temperatures along themselves in a longitudinally distributed manner by providing preferred pathways for migration of helium and by facilitating establishment of convective hydrothermal circulation of groundwater.

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1. Introduction

Following the Bhuj earthquake of January 26, 2001, there has been a renewed interest in identifying active faults in western India. Most of the recent work in this direction is based on re-evaluation of seismic data combined with remote sensing and geomorphological investigations of a few selected localities. These studies in the state of Gujarat have delineated four major linear tectonic structures (Fig. 1) that converge in this region: the ‘Kachchh rift zone’, the ‘Cambay tectonic zone’, the ‘Narmada Tapti tectonic zone’ and the ‘Kukdi–Ghod lineament zone’ (Misra, 2001). Earlier, Burke and Dewey (1973) had identified the region of this convergence as a ‘triple junction’ comprising of the ‘Cambay graben’ (CG),