Geophys. J. Int. (2001) **147,** 677–687

Magnetotelluric images of deep crustal structure of the Rehai geothermal field near Tengchong, southern China

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Accepted 2001 July 25. Received 2001 July 23; in original form 1999 November 3

ABSTRACT

Broadband (0.004–4096 s) magnetotelluric (MT) soundings have been applied to the determination of the deep structure across the Rehai geothermal field in a Quaternary volcanic area near the Indo-Eurasian collisional margin. Tensorial analysis of the data show evidence of weak to strong 3-D effects but for approximate 2-D imaging, we obtained dual-mode MT responses for an assumed strike direction coincident with the trend of the regional-scale faults and with the principal impedance azimuth at long periods. The data were subsequently inverted using different approaches. The rapid relaxation inversion models are comparable to the sections constructed from depth-converted invariant impedance phase data. The results from full-domain 2-D conjugate-gradient inversion with different initial models are concordant and evoke a picture of a dome-like structure consisting of a conductive (<10 Ωm) core zone, *c.* 2 km wide, and a resistive (>50–1000 Ωm) cap which is about 5–6 km thick in the central part of the known geothermal field and thickens outwards to about 15–20 km. The anomalous structure rests on a mid-crustal zone of 20–30 Ωm resistivity extending down to about 25 km depth where there appears to be a moderately resistive (>30 Ωm) substratum. The MT images are shown to be in accord with published geological, isotopic and geochemical results that suggested the presence of a magma body underneath the area of study.

Key words: geothermal field, magma chamber, magnetotelluric imaging, volcanism.

1 INTRODUCTION

The Tengchong area (Fig. 1) is geologically unique. It is the only part of the Himalayan geothermal belt—extending from south-west Tibet to the western part of Yunnan in China along the Indo-Eurasian suture zone—that is affected by Quaternary volcanism. Volcanism started at Tengchong during the Pliocene or Miocene and continued throughout the Pleistocene period, reaching its peak in Early Pleistocene (Liao & Guo 1986). Granite and gneiss are the basement rocks in the area. The crustal thickness in the Tengchong area is about 40–50 km (Xu *et al.* 1994), and the structure is dominated by roughly north–south trending, regional-scale, strike-slip faults (Fig. 1). Important geothermal fields are located within a circular topographic feature (see Fig. 1) south-west of Tengchong. The Rehai (Hot Sea) and Reshuitang (Hot Pool) fields (Fig. 2) are part of these geothermal fields and are, respectively, situated about 13 and 20 km south-west of Tengchong. The Rehai field is structurally controlled with the main faults running roughly NNE–SSW (*c.* N20°E) locally and the cross-cutting faults trending NW–SE as shown in Fig. 2. There are surface manifestations of geothermal activity (in the form of hot springs and fumaroles) in the area. The reservoir rock in the Rehai field is a 69 Myr granite in the north and Precambrian gneiss in the south which are overlain by Miocene sandstone and conglomerates (Liao *et al.* 1991; Bai *et al.* 1994). A Lower Pleistocene andesite cover sequence occurs in the northern and western parts of the Rehai field while Middle Pleistocene basalt abounds in the eastern part (Fig. 2).

There is a recent effort to re-evaluate the thermal resources in this volcanic area. Previous geophysical, geological, isotopic and geochemical studies suggest the presence of a magma body underneath the area (Liao & Guo 1986; Liu *et al.* 1989; Bai *et al.* 1994; Xu *et al.* 1994). In the early 1980s, Liu *et al.* (1989) carried out microseismic measurements around the Rehai field. They inferred the presence of a thin (7 km thick) upper crustal layer over the central portion of this field and which thickens gradually away from the centre forming an umbrella-shaped cap for the geothermal system. Preliminary magnetotelluric (MT) soundings were performed in the mid 1980s at Tengchong by the

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