GEOLOGY OF THE PICO ALTO GEOTHERMAL PROSPECT, TERCEIRA ISLAND, AZORES

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ABSTRACT

A geothermal prospect has been located within the large (25 km²) Quaternary caldera of Guilherme Moniz volcano on the island of Terceira. Pico Alto Volcanic Centre occupies the northern part of the caldera, where concentrated post-collapse silicic volcanism demonstrates the likely presence of a magmatic heat source at shallow depth in the crust. Surface hydrothermal activity is confined to a small area (Furnas do Enxofre) on the west bounding fault to Guilherme Moniz caldera. The area is characterised by hot ground (6500 m²) and weak fumarolic activity. Temperatures of 150°C at 150 m depth have been encountered by thermal gradient holes. No active springs exist, but fossil siliceous sinters occur 5 km north of the area. Although relatively little hydrothermal activity is evident at the surface, a deep geothermal system is postulated to exist beneath Pico Alto Volcanic Centre in the northern part of Guilherme Moniz caldera.

INTRODUCTION

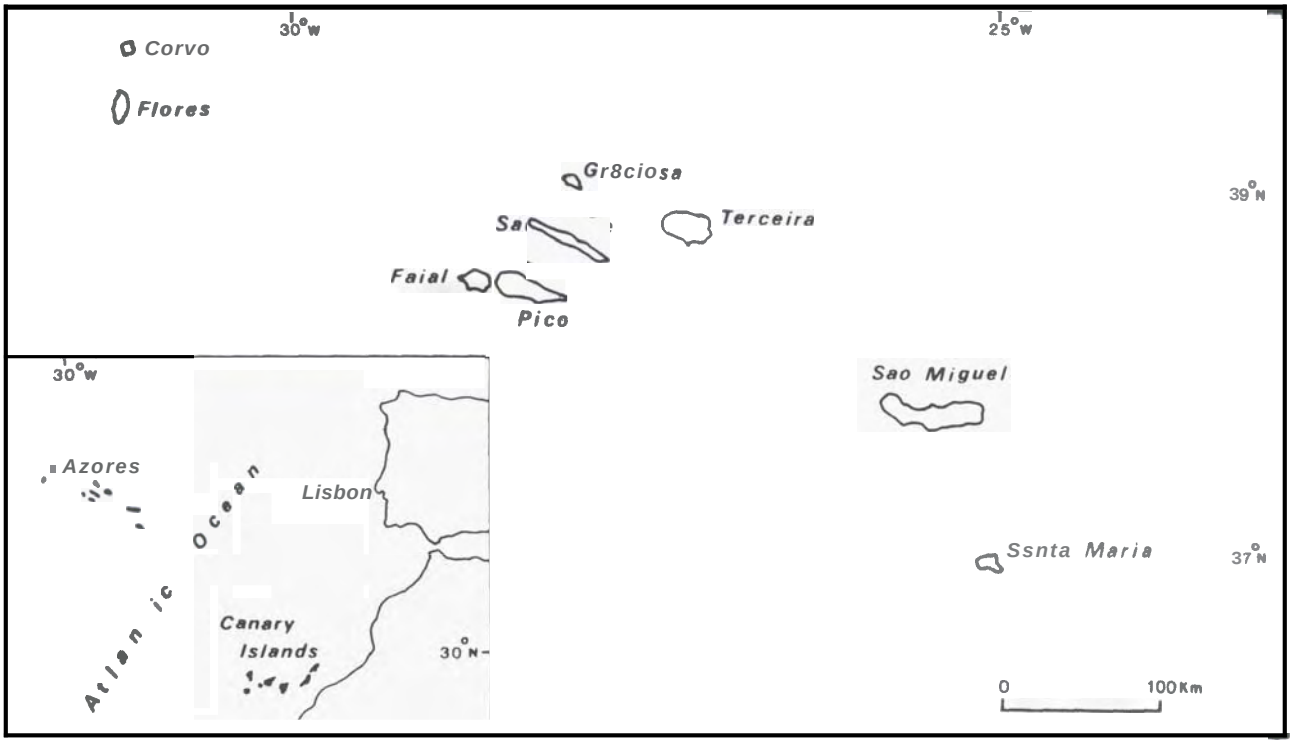
Terceira is one of nine volcanic islands of the Azores archipelago, which trend almost linearly across a broad plateau in the Central North Atlantic (Fig. 1). The region is the site of the triple junction between the North American, Eurasian and African plates (Searle 1980).

Investigation of the island's geothermal resources commenced in early 1981. This paper summaries the geology of the geothermal prospect located in the central part of the island.

GEOLOGICAL SETTING AND VOLCANIC HISTORY

Pico Alto Volcanic Centre (PAVC) is a complex pile of young silicic eruptives (lava flows, coulees, domes and pyroclastics), occupying the northern part of the large (25 km²) caldera of

Fig. 1 Location of Terceira and other islands of the Azores.



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Guilherme Moniz (Fig. 2). A residual gravity anomaly of -16 mgal is centred at Guilherme Moniz (Anderson et al 1982). The anomaly, as interpreted by Anderson, largely reflects low-density volcanics infilling the caldera to an average depth of about 1 km below sealevel. A prominent rift zone transects the caldera just south of PAVC. The rift is characterised by basaltic volcanism contemporaneous with activity at PAVC.

The multi-stage collapse of Guilherme Moniz caldera probably commenced late in the Pleistocene, and was accompanied by the eruption of several voluminous ignimbrites. PAYC has been the focus of the two youngest ignimbrites, the Lajes and Angra Ignimbrites, carbon dated at about 21,000 and 23,000 years B.P. respectively. Since caldera collapse at Guilherme Moniz, volcanism has been concentrated at PAVC where exclusively silicic eruptions have produced at least 8 km^3 of lava over the past 50,000 - 60,000 years.

MAGMATIC HEAT SOURCE

The history of repeated silicic eruptions at PAVC is strong evidence for the continued existence of a large silicic magma chamber beneath the northern part of Guilherme Moniz caldera. Blocks of plutonic rock (quartz syenite) ejected by the more violent ignimbrite-producing eruptions provide supporting evidence for the existence of a cooling (or cooled) magma body at comparatively shallow depth.

Smith and Shaw (1979) have shown that thermal anomalies of economic interest are frequently associated with young silicic volcanic systems. Accordingly, bodies of silicic magma have been considered the most effective cause of near-surface thermal anomalies, because they commonly reside in long-lived magma chambers at shallow crustal levels.

HYDROTHERMAL ACTIVITY

Surface hydrothermal activity is currently confined to the vicinity of Galhardo coulee (Furnas do Enxofre), extruded some 12,000 years ago on the west bounding fault to Guilherme Moniz caldera. Hot ground (6500 m^2) and several weak fumaroles occur within and just outside the crater of Galhardo. The thermal activity is closely associated with intersecting faults that trend NW - SE, W - E and NNE - SSW. The first two trends lie parallel to major structural elements of the island and the third to a prominent fault displacing post-collapse lavas inside Guilherme Moniz caldera.

The surface hydrothermal alteration at Furnas do Enxofre is typical of perched acid-sulphate conditions, indicating that thermal waters have never discharged at the surface there. However, the presence of amorphous silica in cuttings from thermal gradient holes implies the infiltration of near-surface rocks by silica-bearing fluids in the past. In addition, the diagenesis of some of the silica to chalcedonic quartz suggests that thermal activity at Furnas do Enxofre has

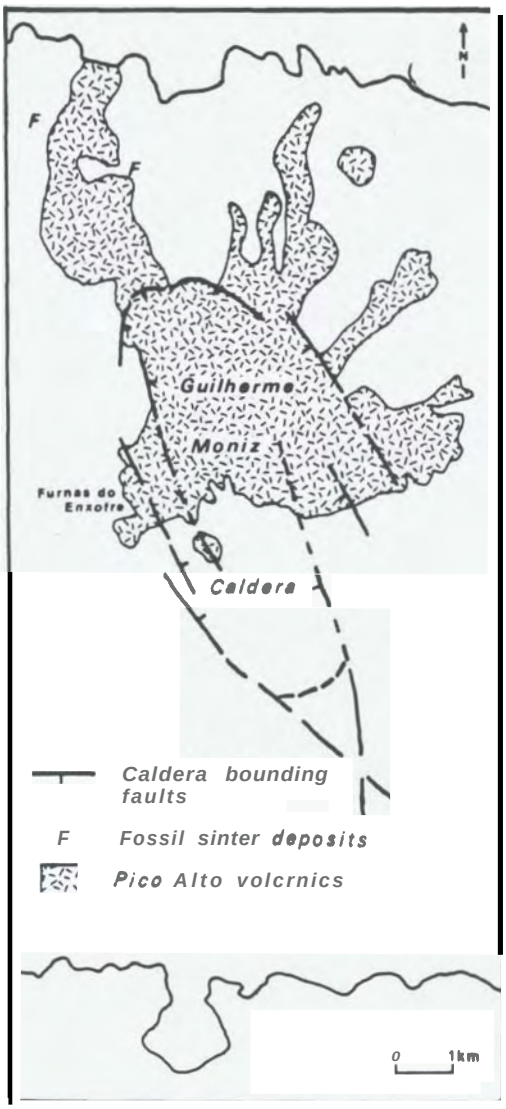

Fig. 2 The Pico Alto Geothermal Prospect Area, showing Guilherme Moniz caldera, Pico Alto Volcanic Centre, Furnas do Enxofre, and fossil sinter localities (adapted from Lloyd and Collis 1981).

persisted for a long period of time (ten or more thousand years). Four temperature gradient holes drilled at Furnas do Enxofre have encountered temperatures of 150°C at 150 m depth.

Fossil siliceous sinters have been found at two localities, near Biscoitos and Rego de Agua on the northern slopes of PAVC. These sinters provide the only material evidence for the existence of fossil thermal springs on the island. The most likely source of the hot water which fed the springs is a reservoir beneath PAVC. Extinction of the springs may be related to the reservoir receding below sea-level and/or to sealing of the fractures by which the hot water found egress to the surface. Any present outflow emerges undetected through the sea-floor

CONCLUSION

Although relatively little hydrothermal activity occurs at the surface, a deep geothermal system is postulated to exist beneath PAVC in the northern part of Guilherme Moniz caldera. In the past, this geothermal system was the most likely source of hot mineralised water discharging near Biscoitos and Rego de Agua, and also infiltrating near-surface rocks at Furnas do Enxofre. Extinction of these thermal features may be related to the geothermal system receding below sealevel and/or to sealing of the fractures by which the hot water found egress to the surface. Present-day surface hydrothermal activity is confined to Furnas do Enxofre where low pressure fumaroles occur in a setting of high thermal gradients and prominent cross faulting. Localised boiling may be taking place as groundwaters come into contact with steam rising along faults from the deep geothermal system postulated to exist beneath PAVC.

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