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Investigations into gas of possible geothermal origin at Smithton

by P. W. Baillie

Abstract

Isotopic analysis suggests that gas seeping near Smithton may be of geothermal origin. However, a geothermal gradient of 26.4°C/km indicates that the gas emanates from depths greater than 10 km, and so is unlikely to be economically usable as an energy source.

INTRODUCTION

Naturally-occurring gas was originally reported seeping in an open paddock near Smithton about 1.5 km northeast of Briant Hill (Baillie, 1992). The gas discharge, only observable into standing water, consists of numerous strongly-discharging bubble trains over an area of at least 50 square metres. The landowner (Mr A. House) reported that the seep has been active for over 50 years.

Subsequent investigations revealed that gas seeps occur along a nothwesterly-trending linear feature at least 1.5 km in length. The known gas seep locations were accurately surveyed using a Magellan GPS device and are shown in Figure 1. The strongest discharges occur into Deep Creek, where many litres of gas are discharged every hour (fig. 2).

This report details investigations carried out to determine the source and depth of origin of the gas.

GAS CHEMISTRY

A sample of gas from the originally-reported seep was collected by water displacement into a glass bottle which was then stored upside-down and forwarded to CSIRO, North Ryde (NSW), for analysis.

The results of that analysis are –

		Chemical analyses, %v/v
Methane*		0.07
Carbon dioxide		59.8
Oxygen+		8.7
Nitrogen		31.5
		Isotopic analyses, ‰ PDB#
Methane	^{13}C	-32.3
Carbon dioxide	^{13}C	-4.0
Carbon dioxide	^{18}O	-4.9

* FID detector
\+ Includes argon
\# International Standard Peedee Belemnite

The chemical and isotopic compositions of the gas are remarkably similar to those reported from geothermal areas in New Zealand and the United States (*cf.* Hoefs, 1973). Isotope differences ($^{13}CO_2$-$^{13}CH_4$) of +28.3 indicate a final gas equilibration temperature of approximately 260°C (Bottinga, 1969). It was therefore decided to undertake a drilling program to determine:

(a) the geothermal gradient, and

(b) whether the gas could be exploited as an energy source (Baillie, 1992).

It should be noted that the composition of the gas (predominantly carbon dioxide and nitrogen) precludes use of the gas itself as an energy source. The region may be a source of carbon dioxide if sufficient quantities of gas exist in underground reservoirs.

REGIONAL GEOLOGY

The gas seeps occur within the Smithton Basin, a gently folded 4 km thick mixed succession of Upper Proterozoic to Upper Cambrian sedimentary and volcanic rocks resting with angular unconformity on folded basement rocks of the Upper Proterozoic Rocky Cape Group (Lennox *et al.*, 1982; Baillie and Crawford, 1984). Tertiary volcanic rocks are present throughout the region and have a minimum age of 8.5 Ma some 12 km to the east on the Stanley Peninsula (Baillie, 1986).

The regional geology indicates that bedrock in the immediate environs of the seep is likely to be the Late Proterozoic Black River Dolomite, although at the surface the gas is seeping through coastal sands of probable Last Interglacial age (Lennox *et al.*, 1982; Baillie *in* Brown, 1989).

DRILLING RESULTS

To determine the geothermal gradient and bedrock characteristics, a drill hole was sited near the original seep. The hole was pre-collared to 180.0 m by down-hole hammer and then drilled to a total depth of 493.27 m by conventional diamond drilling. A subsequent survey

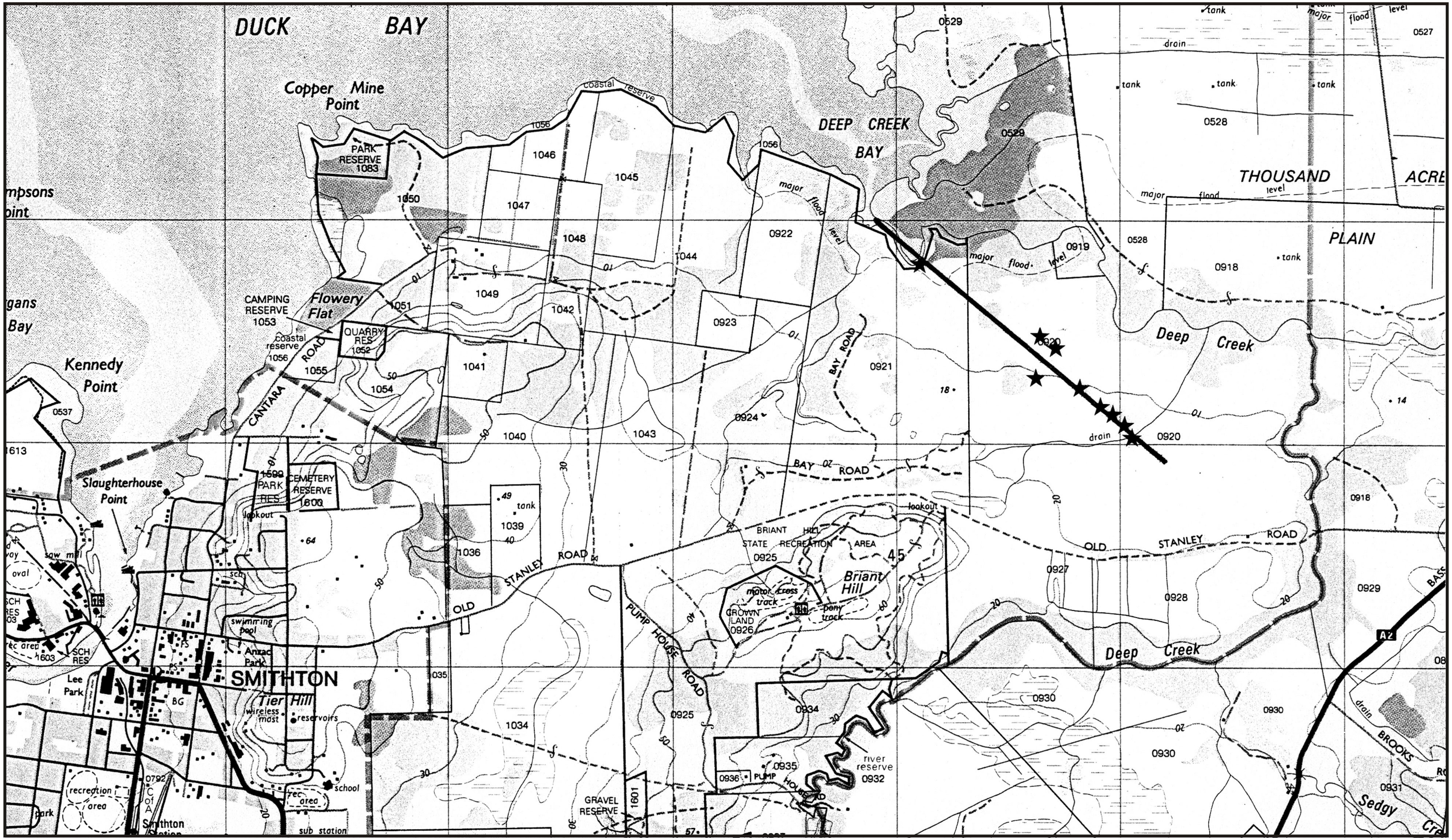


Figure 1

Locality map of Smithton area showing location of known gas seeps.

Figure 2

Photograph showing gas discharge into Deep Creek.

(fig. 3) showed that significant deviation occurred during drilling, and that a true vertical depth of approximately 400 m had been penetrated.

The hole is located north of the Old Stanley Road at:–

Easting	346 045 mE
Northing	5 478 030 mN

The drilling confirmed that bedrock is within the Black River Dolomite formation. The following is a log of the hole:–

0 – 180.0 m — No core.

180.0 – 493.3 m — Predominantly dark grey, but may be light or very dark grey, often well-bedded in beds 500 mm, occasionally finely laminated and cherty, very fine-grained sandstone (10%), siltstone (~ 10%) and mudstone (80%).

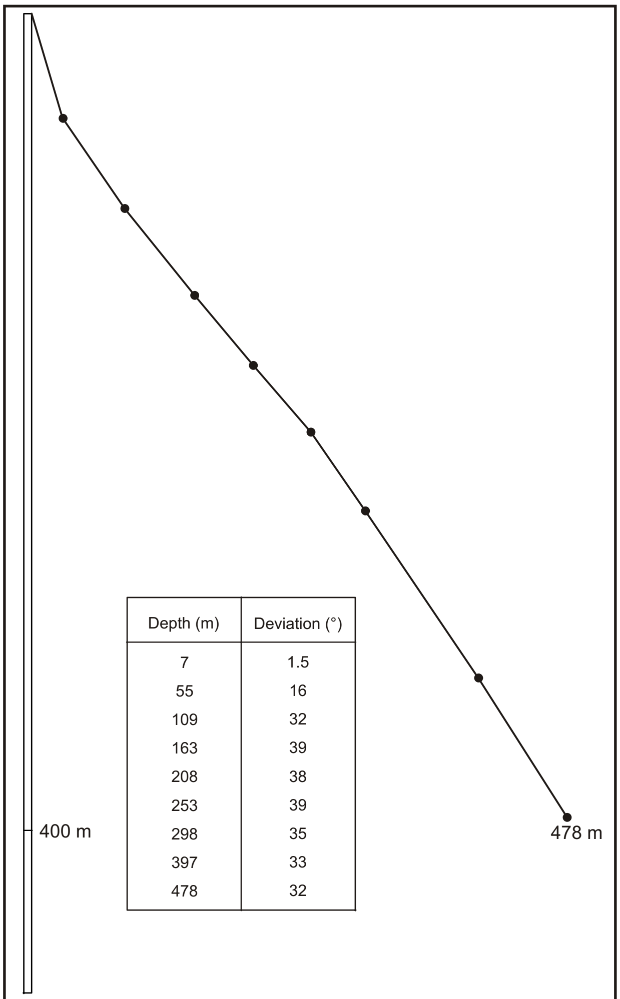
Occasional medium-scale trough cross bedding present and bedding sometimes disrupted by ?diagenetic brecciation.

Core often broken.

Beds dip 30–45°; no tectonic cleavage.

184.1 – 187.1 — Light green/brown, highly weathered and altered porphyritic basalt.

Thin section examination of representative samples showed that the succession encountered consists of very fine-grained/muddy, carbonate-bearing sedimentary rocks. XRD analysis indicated that the samples contained



Depth (m)	Deviation (°)
7	1.5
55	16
109	32
163	39
208	38
253	39
298	35
397	33
478	32

Figure 3

Downhole survey of Deep Creek drillhole.

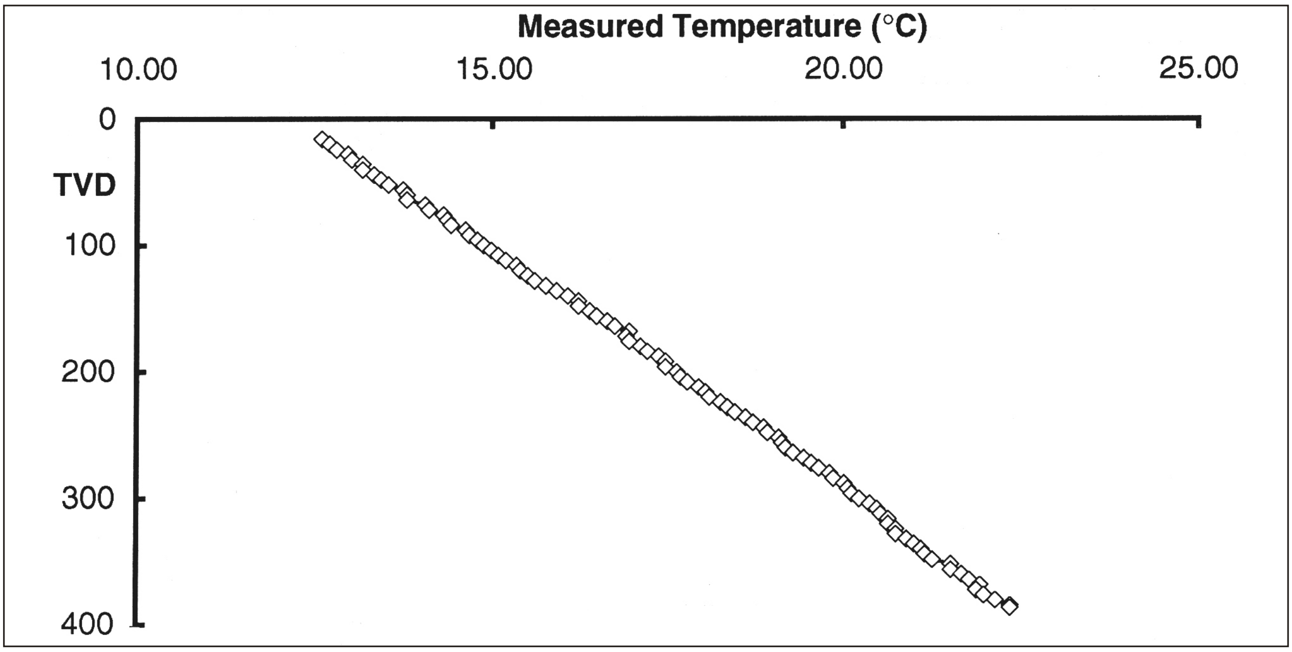


Figure 4

Plot of temperature against true vertical depth, Deep Creek drillhole; single reading taken every five metres drilled.

up to 15% carbonate, comprising ankerite dolomite or siderite.

WIRELINE LOGGING

Following completion of drilling, a suite of wireline logs was run (casing had been set to 180 m). Natural gamma, neutron porosity and density logs, together with resistivity and a down-hole flowmeter, yielded little information as the hole was blocked at 290 m.

GEOTHERMAL GRADIENT

Following logging, the hole was cased and sealed and allowed to thermally equilabrate for a period of about four months. The hole was then logged with a temperature tool. Figure 4 is a plot of temperature against true vertical depth–regression analysis indicates a geothermal gradient of 26.4°C/km at the drill site.

Figure 5 is a reduced temperature plot of the temperature data. Values plotting above zero indicate areas of higher than expected temperature, due either to local heat production (unlikely in this situation) or a decrease in thermal conductivity. The plot indicates that several minor lithological changes are present (as indicated by changes in thermal conductivity) with a more significant change of lithology at about 310 m. As full core recovery was not carried out, the nature of the changes could not be determined.

The result is similar to the geothermal gradient of 27.8°C/km determined from a borehole near Forest, approximately 7 km to the east (Green, 1989). Both results are significantly less than the average gradient of 36°C/km from the onshore Otway Basin of Victoria and the world average of around 30–33°C/km (King *et al.*, 1985).

It should be noted that there are few temperature data from basement rocks in either Victoria or Tasmania for meaningful comparison with the Smithton data. From the point of view of this study, however, it can be confidently concluded that there is no indication of an elevated geothermal gradient in the Deep Creek area suggestive of a hot source at a relatively shallow depth.

DISCUSSION AND CONCLUSIONS

Significant volumes of gas are emanating along a probable fault in the Deep Creek area and have been doing so for at least 50 years; there is no evidence that any liquids are reaching the surface at the present time. Liquids associated with the gas are probably lost within the broken and possibly karstic aquifer system within the Black River Dolomite.

Geochemical analysis of the gas unequivocally indicates a geothermal origin, yet there are no obvious recent volcanics in the area. If the gas is of geothermal origin, it must be related to a relatively recent or active intrusive source at a depth of at least 10 km. The area does not appear to be any more seismically active than other Tasmanian regions (the nearest permanent seismic station was at Savage River until January 1992), but any current intrusive activity should be detected by installation of a small seismic net in the Deep Creek/Smithton area.

Numerous spring mounds (both calcareous and siliceous) have long been known from the Smithton area and are apparently related to the distribution of Palaeozoic/Proterozoic carbonate rocks. It is significant, however, that the Smithton 1:50 000 geological map (Lennox *et al.*, 1982) indicates both siliceous and calcareous spring mound deposits occurring near Deep Creek on, and on trend with, the northern end of the probable fault. It thus appears possible that all of the

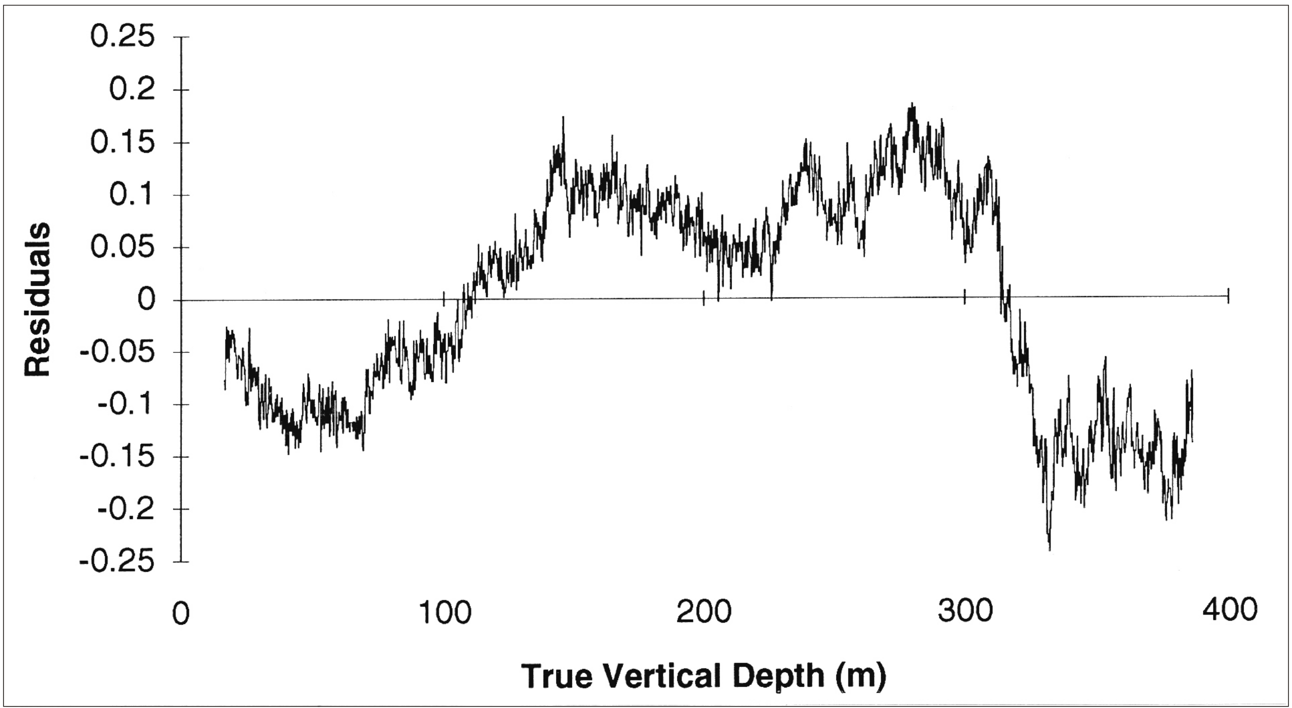


Figure 5

Reduced temperature profile, Deep Creek drillhole; data smoothed by calculation of moving point average over length of 600 mm and then every 4th point resampled (200 mm).

Smithton spring deposits are related to the process currently producing gas in the Deep Creek area.

Green (1982) noted that CO_2 discharges are known from Daylesford, Victoria, together with Smithton, Luina and Kimberley in northern Tasmania, and suggested a deep, ?mantle source for CO_2 discharge in South East Australia coinciding with an area of high heat flow. A mantle source may be possible, although Baillie (1992) has demonstrated a biogenic origin for the Kimberley gas and it appears unlikely that the Smithton region is one of high heat flow.

The source of the Deep Creek gas remains problematical.

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