Overview of Geothermal Resources and Exploration Activity in Victoria

David H Taylor, Ben C Harrison
GeoScience Victoria, GPO BOX 4440, Melbourne, VIC, 3001
Corresponding author: david.taylor@dpi.vic.gov.au

Victoria currently derives most of its electricity generation from brown coal but is keen to diverse towards lower emission energy sources. Geothermal energy offers the possibility of base load power generation plus direct use thermal applications. Legislation for geothermal resource security was passed in 2005. In 2006 and 2008 two rounds of competitive tendering resulting in about two thirds of the State being placed under exploration by seven different companies. They have pledged to spend close to $370 million over the next five years in the quest to find and develop geothermal resources. Legacy data from petroleum exploration suggests potential for Hot Sedimentary Aquifer (HSA) plays in basins along the onshore margin of Victoria. Elsewhere the geology may support Engineered Geothermal Systems (EGS) plays in the abundant Palaeozoic granites. Magmatic plays may also exist in association with a major episode of recent basaltic volcanism. Governments, Universities and exploration companies are currently collecting basic geothermal data such as heatflow measurements and thermal conductivities to better characterise the potential of geothermal systems in Victoria. A number of Inferred Resources have been declared but deep drilling to appraise these is awaiting funding opportunities.

Keywords: Geothermal, Hot Sedimentary Aquifer, Energy generation,

Background History

The oil shocks of the 1970s piqued interest into alternate energy sources. Town water supplies drawn from thick Cretaceous-Tertiary basins along the Victorian coast showed temperatures of about 50-90C at 1-2km depth. The potential of direct use of this hot water was investigated (King et al. 1987). Petroleum exploration in the same area also occasionally intersected a deeper basal aquifer with temperatures of about 130-150C at 3.5-4km depth (Woollands & Wong 2001). Low oil prices throughout the 1990s suppressed interest in alternate sources but the return of higher prices and concerns around green house gas emissions have again sparked interest in the potential of geothermal energy. Legislation was put in place in 2005 and exploration companies were invited to tender for large permit blocks established across the State in 2006 and again in 2008. To support tender bids, a preliminary review of the geothermal prospectivity was published by the State government geology organisation (Driscoll 2006). This report included a quality-controlled compilation of temperature data from pre-existing groundwater and petroleum bores.

Geological Framework for potential geothermal systems

Geothermal potential depends on the interaction of a number of geological factors. The best resources are likely to exist in regions where high heat flow passes through rocks of low conductivity (good insulation) to create high temperature at shallow depth (Duffield & Sass, 2003).

Unfortunately there is insufficient published heat flow data and hardly any published thermal conductivities to allow a quantitative assessment via these criteria. Instead, the geothermal potential can only be assessed indirectly, in a more qualitative manner, by looking at geological factors which control the geothermal factors. The recent publication of a geothermal systems assessment framework (Cooper & Beardsmore 2008) outlines the four factors that need consideration: (1) a heat producing basement (2) an insulating blanket (3) a fluid to move the heat around with and (4) a reservoir to accommodate the fluid.

Applying this four factor analysis to the major geological provinces of Victoria gives some idea of their relative geothermal prospectivity (Figure 1). The broad diversity in the age and types of rocks across Victoria gives some potential for all three types of geothermal systems: Engineered Geothermal Systems in Hot Rocks; Hot Sedimentary Aquifer; and Magmatic.

Three broad geological/geothermal provinces can be delineated across Victoria: (1) The Palaeozoic bedrock (2) the onshore Otway and Gippsland Basins and (3) the Murray Basin.

The Palaeozoic bedrock consists predominantly of Cambrian to Devonian deep marine siliclastics that have been tightly folded and cleaved at various times in the Palaeozoic (blues, browns and purples of figure 1). These rocks underlie the other provinces. This exposed bedrock gives good insight into the heat producing basement factor. Numerous granites intrude this bedrock (red blobs on figure 1). In west and central Victoria some of them have felsic, fractionated geochemistry with mild enrichment in heat producing elements so the Engineered Geothermal System plays may be possible where

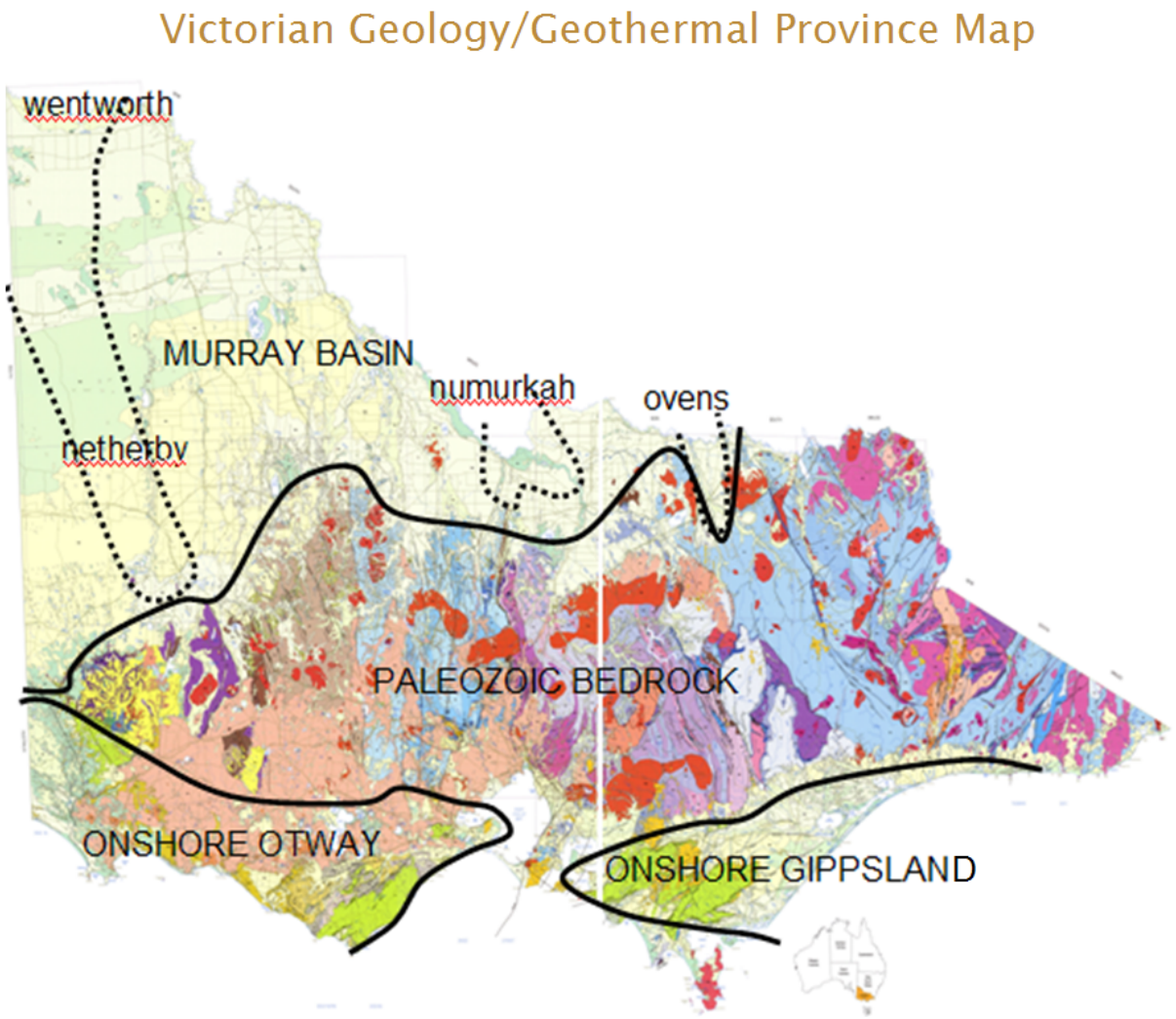

Figure 1: Geological/Geothermal Province map of Victoria based on underlying geological controls. Three broad geothermal provinces of Palaeozoic bedrock, onshore basins, and Murray basin each have a number of potential geothermal play types where factors favourably align.

some granites still lie buried within the bedrock or beneath the adjacent basins? In the southwest, an extensive province of young basalts has erupted onto the bedrock in the last few million to tens of thousands of years (the light pink in figure 1). Thus there is the possibility of Magmatic plays related to residual transient heat anomalies in the upper crust that may exist because of the recent magmatism.

The Onshore Otway and Gippsland Basins are Cretaceous rift basins associated Gondwana break-up (greens and yellow along coast in Figure 1). These basins are well characterised thanks to a long history of petroleum exploration. They contain several kilometres of muddy sediments overlying a coarser grained basal unit. This provides a natural reservoir already charged with hot water beneath an insulating blanket to create an attractive fairway for Hot Sedimentary Aquifer plays. In the Otways this basal unit has been intersected upon the basin floor but in the Gippsland basin this unit has yet to be tested away from the margins, at the depths necessary for a geothermal play. Beneath these basins there is also potential for Engineered Geothermal System plays in places where it is floored by granites.

The Murray Basin is a Tertiary intracratonic sag basin (light greens and yellow inland in Figure 1). It generally contains only a few hundred metres of sandy marly cover. This is insufficient cover to act as a heat blanket but in some places deeper troughs – such as the Wentworth, Netherby, Numurkah and Ovens - exist and can contain up to a couple of kilometres of sediment that is poorly known since there has been limited petroleum exploration here. Alignment of favourable factors over the deeper troughs may allow Engineered Geothermal System or Hot Sedimentary Aquifer plays but the favourability of the geothermal factors in this province has yet to be validated.

Science Research and Company Exploration

Most activity by everyone – government agencies, university academia and exploration companies –

is focussing on collecting the fundamental geothermal data sets of temperature gradients and thermal conductivities to allow heat flow mapping.

GeoScience Victoria is working with GeoScience Australia on the National Geothermal Energy Project (Budd et al., 2008). In the Murray Basin, 7 deep water bores were recently measured to fill a large gap in the national heat flow database. More bores are planned to be entered as access and the national work program permits. In addition to supporting the Federal program, GeoScience Victoria also has some moderate funding to purchase a thermal logger to accelerate State coverage and also allow opportune access to appropriate mineral exploration drill holes etc. Similar to this government work, many of the exploration companies have also been re-entering bores for temperature logging and measuring cores for thermal conductivity so that heat flow calculations and conductive 1-2-3D modelling of their permit areas can be undertaken. Several Inferred Resources of 'Stored Heat' have already been declared and some of these plays are now ready for further appraisal by deep drilling.

Pathways to Resource Development

In the absence of detailed, dedicated geothermal data, most of Victoria can be viewed as 'blue sky' or perhaps 'green fields' at best, in those areas where some legacy petroleum data exists. Most of the Victorian geothermal explorers are small companies with limited amounts of capital and cash-flow to fund their 5 year exploration programs. Ideally, as these companies collect information and decrease risks and unknowns, they could call for more capital through either debt or equity raisings until it becomes probable that a major backer would farm-in for development. The Global Financial Crisis has badly affected this traditional venture capital pathway through to resource development.

At the national level the Federal government has committed a significant amount of funds into a geoscience investigation program and also put up money for co-funding deep appraisal drilling. If these drilling appraisals lead to early success then perceived risks around geothermal energy may lessen and allow easier funding for the whole industry from more the traditional pathway.

Company announcements around Inferred Resources and/or conceptual targets suggest that several thousand MW of electricity generation may be possible but it is still early days for the geothermal industry in Victoria.

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