Perth Basin's Geothermal Resources

Ghori, K.A.R.
Geological Survey of Western Australia, Department of Industry and Resources, East Perth, Western Australia
Email: ameed.ghori@doir.wa.gov.au

EXTENDED ABSTRACT

New Era—Western Australia commenced a new era in the search for energy from geothermal resources to broaden the State's energy base with the first acreage release for geothermal exploration covering the Perth Basin on 22 January 2008 (Figure 1). The geothermal acreage release followed amendment to the State's Petroleum Act 1967, which was proclaimed in January 2008 as 'Petroleum and Geothermal Resources Act 1967'.

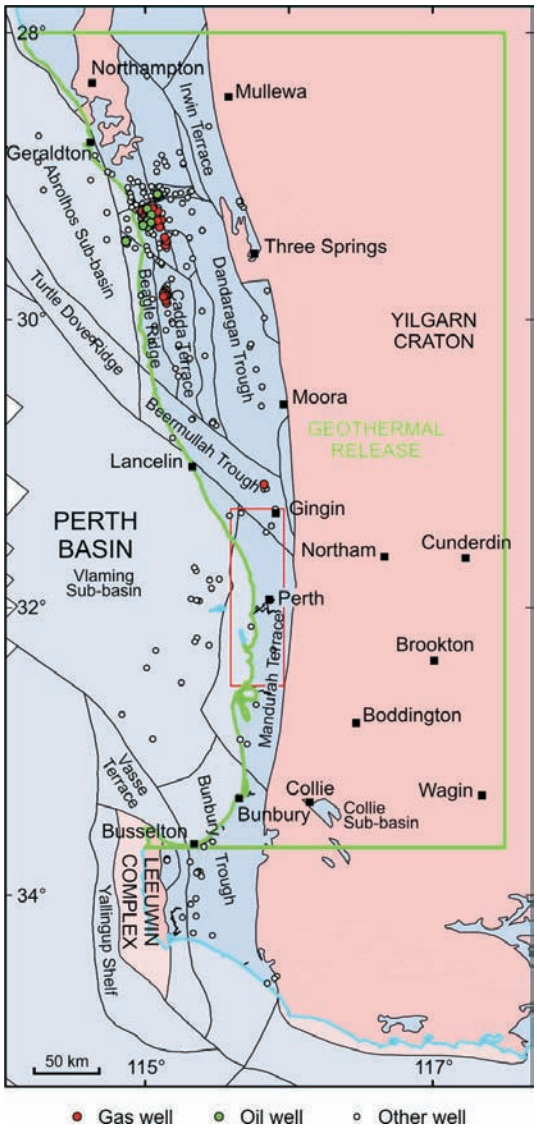

Figure 1. Map showing acreage released area, petroleum wells including current oil and gas producers, and area of water bores (red boundary).

The first study to specifically evaluate geothermal energy resources for Western Australia was initiated in the 1980s for hydrothermal resources. It recognised low temperature reservoirs (65–85 °C) at depths of 2.0–3.5 km, with the best economic potential in the Perth Basin (Bestow, 1982). The next study was initiated in 2006 to evaluate hot rock resources, especially where the depth to 200 °C is less than five kilometres. Petroleum wells in parts of the Canning, Carnarvon, and Perth basins indicate two favourable factors for developing Engineered Geothermal System (EGS); potentially high-heat generating granitic basement and stress environments that are favourable for stimulation, leading to development of horizontal geothermal reservoirs. The Carnarvon Basin has

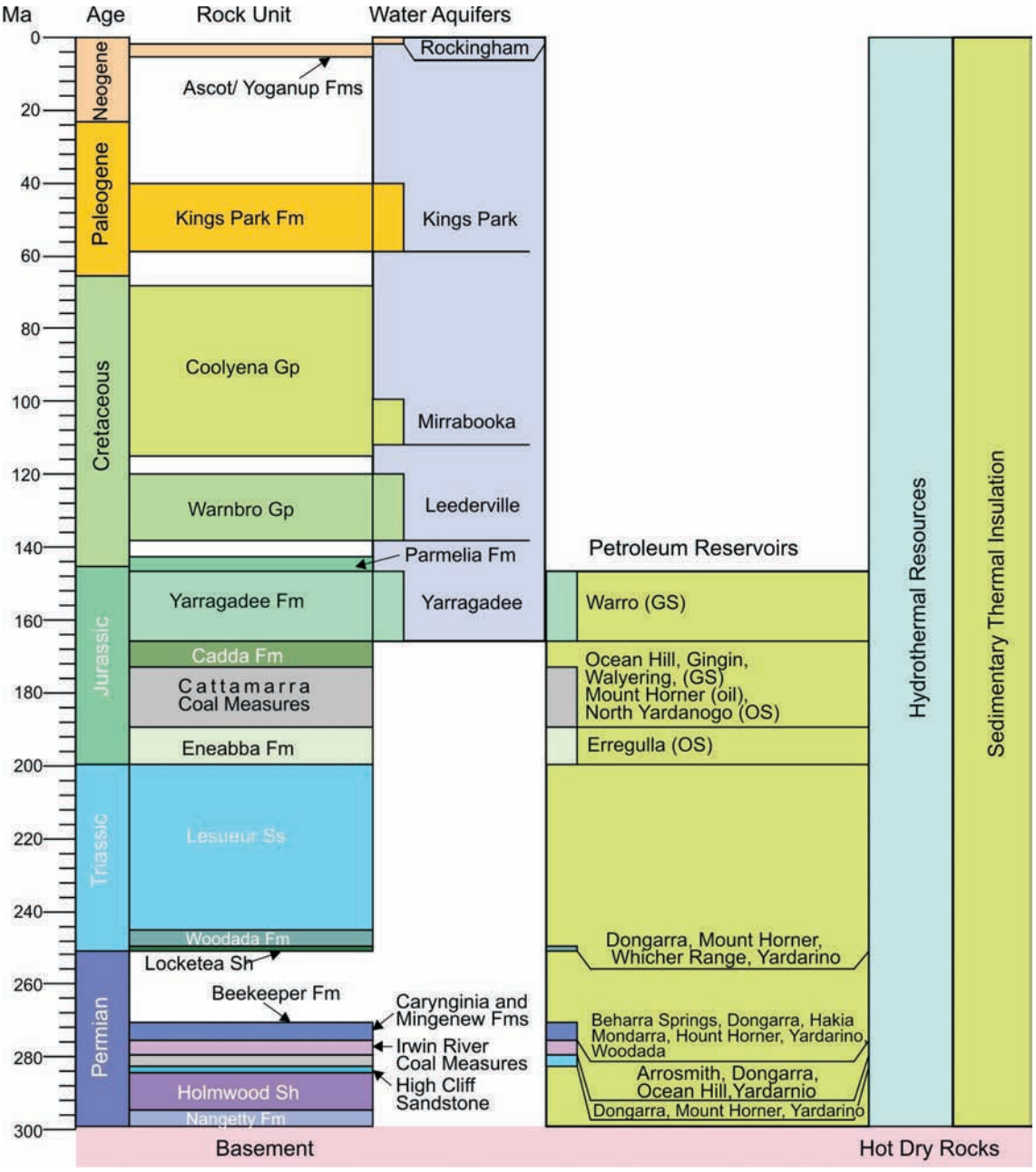

Figure 2. Generalised stratigraphy and distribution of water aquifers, petroleum reservoirs, and potential geothermal resources in the Perth Basin.

the greatest number of wells with high temperature gradients, followed by the Perth and Canning basins (Chopra and Holgate, 2007; Ghori, 2007 and 2008).

This evaluation of the Perth Basin is mainly based on studies archived in the GSWA Library, including GSWA publications:

- for geothermal resources—Bestow (1982), Chopra and Holgate (2007), Ghori (2007 and 2008);
- for hydrogeology—Thorpe and Davidson (1991), Davidson (1995); and
- for petroleum geology—Mory and Iasky (1996), Crostella and Backhouse (2000), Owad-Jones and Ellis (2000) and unpublished companies reports submitted to GSWA.

Perth Basin—is a north–south elongated trough in the southwest of Western Australia (Figure 1), containing mostly a Permian to Lower Cretaceous succession under a thin cover of Tertiary. The eastern boundary is the Darling Fault and the basin extends offshore to the continental–oceanic boundary.

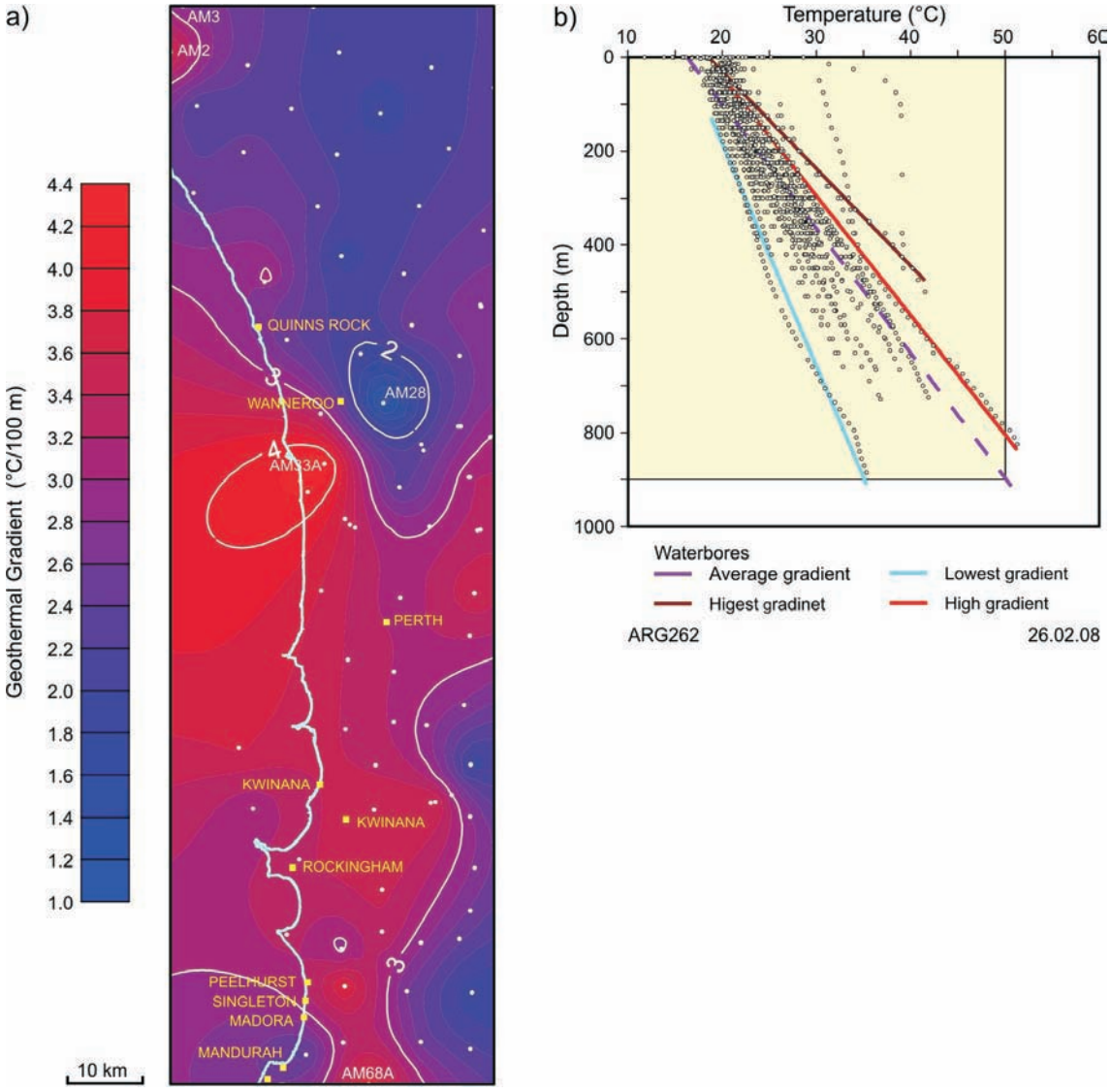

Figure 3. Average subsurface temperature gradient recorded in water bores of the Perth Region: a) geographic distribution of average geothermal gradient; b) subsurface temperature as a function of depth.

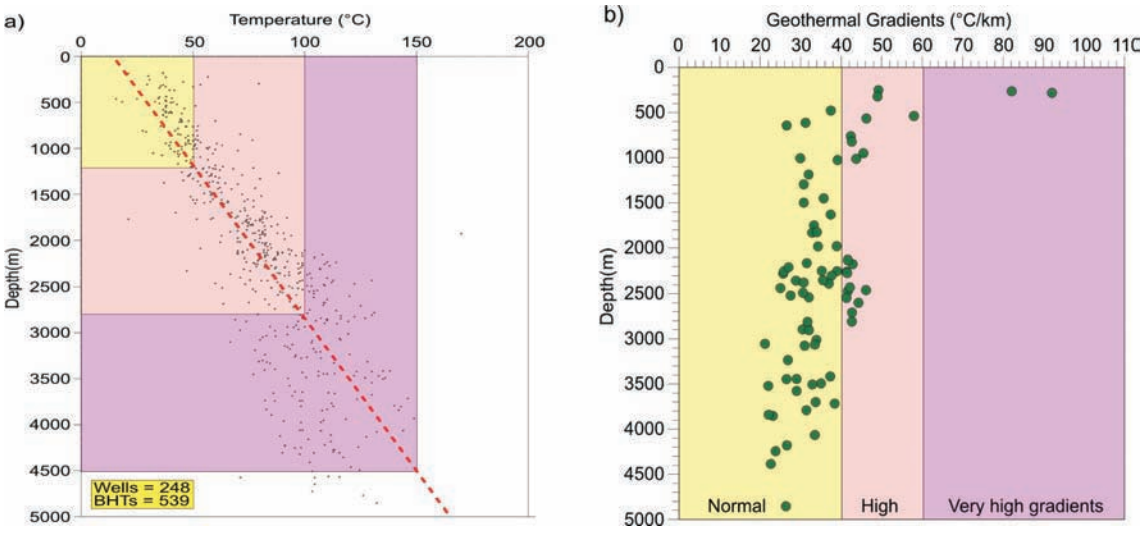

Figure 4. Subsurface temperature recorded in the Perth Basin: a) BHTs as a function of depth; b) equilibrium geothermal gradient as a function of depth from Chopra and Holgate (2007).

The groundwater resources of the Perth region have been systematically investigated by drilling since 1961, and Neogene to Jurassic aquifers down to a depth of 1,100 m are exploited to supplement the industrial and domestic water supply. Petroleum exploration commenced in the 1950s and has resulted in discoveries of at least 13 oil and gas fields. Figure 2 shows the generalised

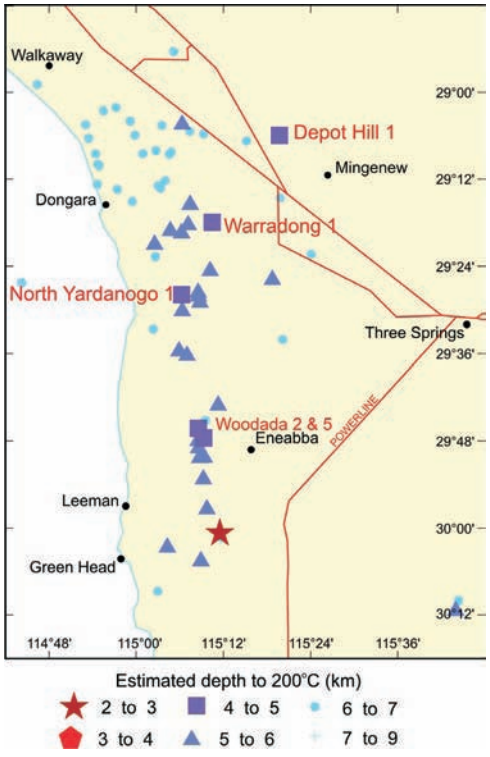

Figure 5. Wells with estimated depth to 200 °C shallower than 5 km in the Perth Basin.

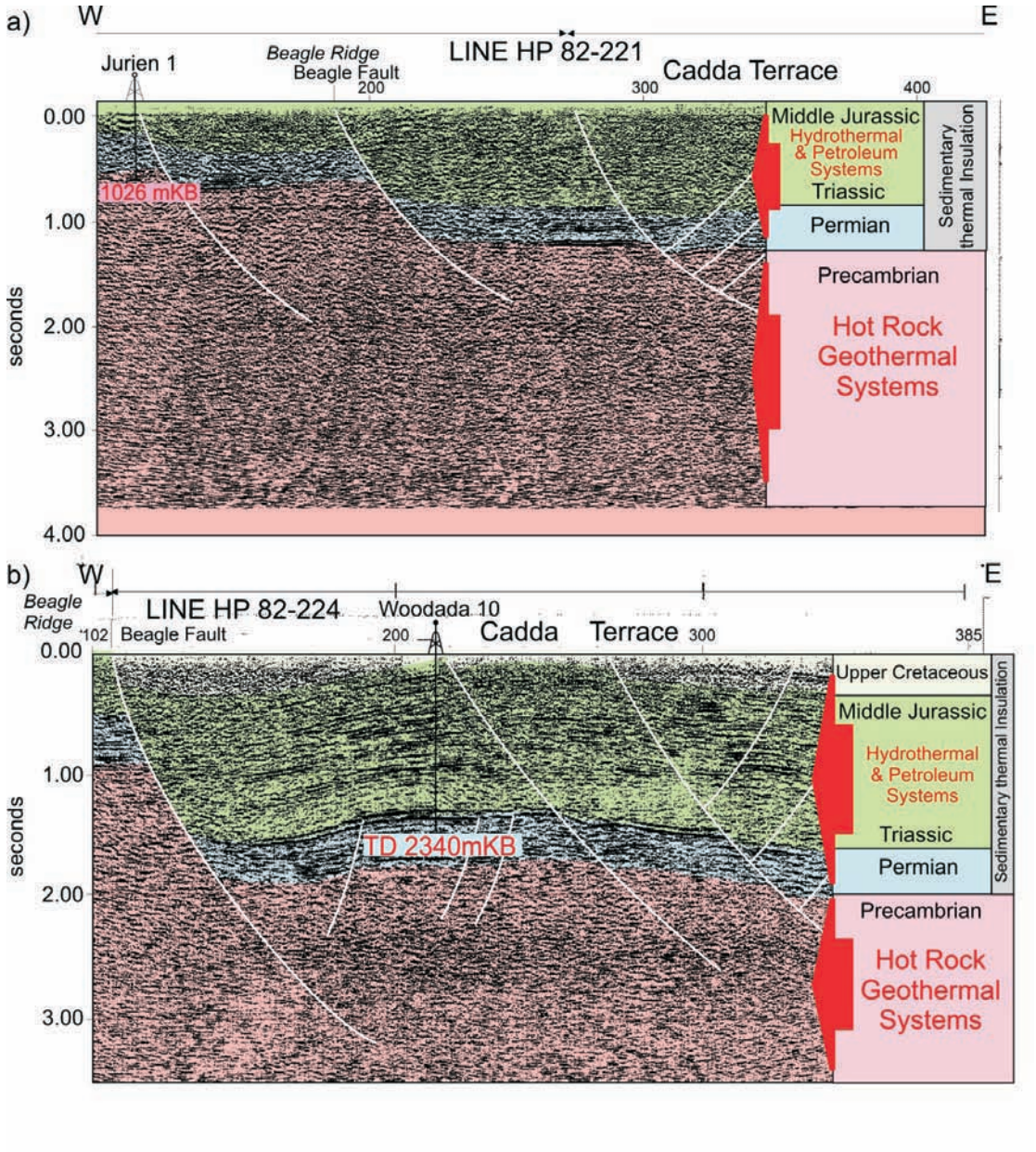

Figure 6. Conceptual model for petroleum and geothermal resources of the Perth Basin: a) Beagle Ridge; b) Cadda Terrace.

stratigraphy of the Perth Basin and distribution of water aquifers, petroleum reservoirs and potential geothermal resources.

The prediction of subsurface temperature distribution in the Perth Basin is based on temperature logs recorded in 47 artesian monitoring water bores, and bottom bole temperatures (BHTs) recorded in about 335 petroleum wells. For each water bore, temperatures at different depths were compiled and geothermal gradients were computed. The recorded gradients range from 1.1 °C/100m to 4.4 °C/100m at depths less than one kilometre. The highest, as well as the lowest, subsurface temperatures are recorded around the Wanneroo area (Figure 3). The lower temperatures extend towards the north and the higher towards the south of the Wanneroo area. These temperatures indicate low temperature resources up to 50 °C at a depth less than one kilometre in areas of high geothermal gradients.

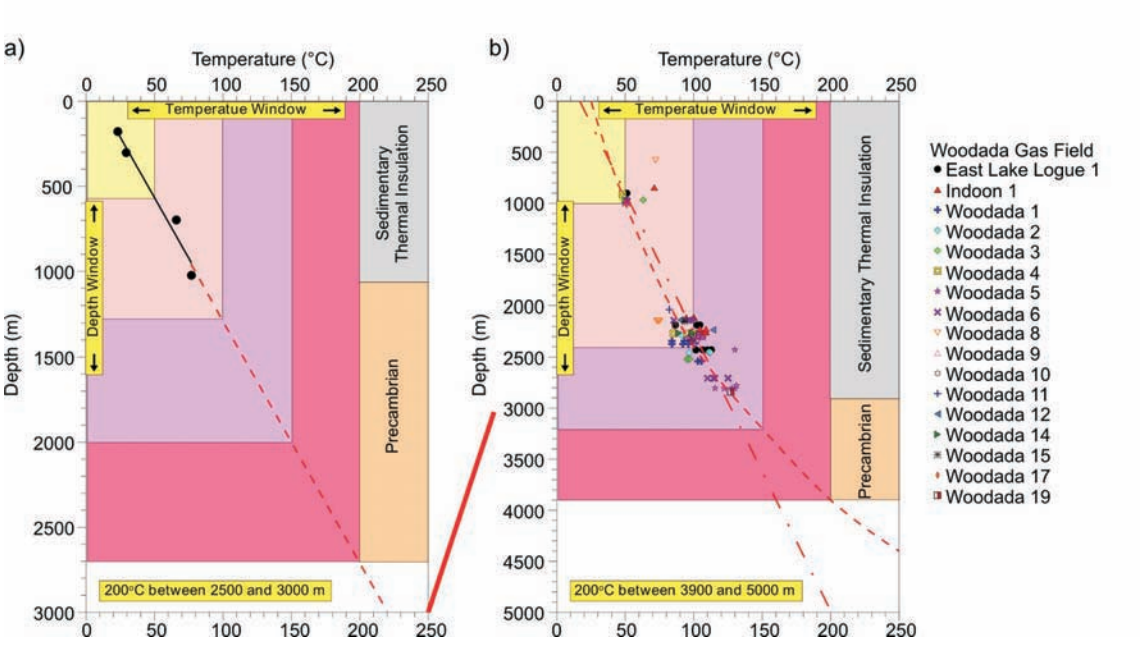

Figure 7. Subsurface temperature as a function of depth of the Perth Basin: a) Jurien 1; b) Woodada Gas Field.

The recorded BHTs in Petroleum wells provide temperature distribution for a larger area and a greater depth (850 m) than the Perth region water bores (Figure 1). Figure 4 shows the Perth Basin subsurface temperatures as a function of depth: a) recorded BHTs (540) in 242 petroleum wells; b) estimated equilibrium geothermal gradient as a function of depth (Chopra and Holgate, 2007). These plots show that the recorded temperatures and depths are up to 150 °C and 4.5 km, respectively. The corrected estimated equilibrium temperatures are expected to be 10% to 20% higher than these recorded temperatures.

For the Perth Basin, the estimated geothermal gradients in 83 wells (Chopra and Holgate, 2007) indicate the presence of wells with very high to normal gradients, ranging from 90 °C/km to 20 °C/km (Figure 4b and 5). Gradients in wells deeper than 2 km are considered more reliable and representative for hot dry rock resources.

Conceptual models for petroleum and geothermal resources have been developed for the Beagle Ridge (Figure 6a) and the Cadda Terrace (Figure 6b) of the Perth Basin, because of the high geothermal gradients in Jurien 1 (55 °C/km) on the Beagle Ridge and Woodada 2 (40 °C/km) within the Cadda Terrace. Jurien 1 was drilled to a total depth of 1,026 m and intersected granitic basement at 967 m. The extrapolated recorded temperatures indicate that 200 °C could be reached between 2.5 km and 3.0 km (Figure 7a). This may be an economical depth for developing geothermal resources, if other factors for developing EGS are found favourable. Figure 7b shows the subsurface temperatures as a function of depth for the 17 wells of the Woodada Gas Field. The extrapolated temperatures indicate 200 °C at depths between 4 and 5 km. The reservoir temperature of the Woodada Gas Field is 120 °C at depth range from 2,125 m to 2,496 m (Owad-Jones and Ellis, 2000).

Whereas an overthrust regional stress regime is ideal to develop horizontal geothermal reservoirs, further studies are required to confirm if such conditions exist within the Perth Basin. Stress data collected *in-situ* exclusively from borehole breakouts in 20 petroleum exploration wells in the Perth

Basin indicate stress E–W orientations (Hillis and Reynolds, 2000). At this stage it is unclear if there are horizontal geothermal reservoirs across the Perth region.

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