

Assessment of Otway Basin Hot Sedimentary Aquifer systems for geothermal and water uses

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The Otway Basin, spanning the southern parts of Victoria and South Australia (Figure 1), is the location of a new regional geological and geothermal study by FrOG Tech Pty Ltd. In partnership with P.I.R.S.A., Geosciences Victoria and Geoscience Australia, the study integrates potential field and seismic data, information from both hydrocarbon exploration and water wells and thermal data to understand the nature of onshore and offshore Otway Basin Hot and Warm Sedimentary Aquifers and their inter-connections. The initial targeted formations within the fault controlled depocentres are Upper Jurassic to Lower Cretaceous synrift and postrift, nonmarine, interbedded sandstones, shales and coals of the Otway Supergroup aquifers.

onshore and offshore sedimentary basins. In both states, small scale geothermal studies have been conducted by government geological surveys and consultants (e.g. Jenkin, 1962; Thompson, 1978, 1979; Nahm & Reid, 1979; Akbarzadeh & Thompson, 1984; King *et al.*, 1987; the Sustainable Energy Authority of Victoria (SEAV), 2005, Driscoll 2006.), but have not been linked into a regional framework.

The project

This ongoing project will integrate Otway Basin geofabric (hydro-thermal and tectono-stratigraphic properties) studies with a detailed geothermal resource calculation.

This study intends to create for the first time, an attributed geological framework for the entire Otway Basin encompassing interpretation of terranes, basement composition/lithology, tectonic event-response, definition and description of deep and shallow potential aquifer/aquitard pairs contained in the economically exploitable geothermal window to the megasequence level.

This abstract summarised the main results of the Phase I of this project that focused on the characterisation of the deep Otway Basin Cretaceous aquifers and the underlying basement.

Otway basin basement topography

The SEEBASE™ basement surface in the Otway basin has been refined since OZ-SEEBASE™ was released in 2004, based on the most recent available geophysical surveys. The new SEEBASE™ of the Otway Basin is a model of basement topography and provides a new view of the Otway Basin geometry and a context which can be used to better understand the basin depocenters structural development together with the sedimentary facies distribution. It was constructed by combining a structural interpretation with depth information derived from potential field datasets, seismic data, FrOG Tech's seismic interpretation, wells, and published cross-sections. The present SEEBASE™ (Figure 2) is a regional model at ~1:2,500,000 scale. The sediment and basement thickness have been derived from the depth-to-basement interpretation and will be used for the next step, heat flow modeling.

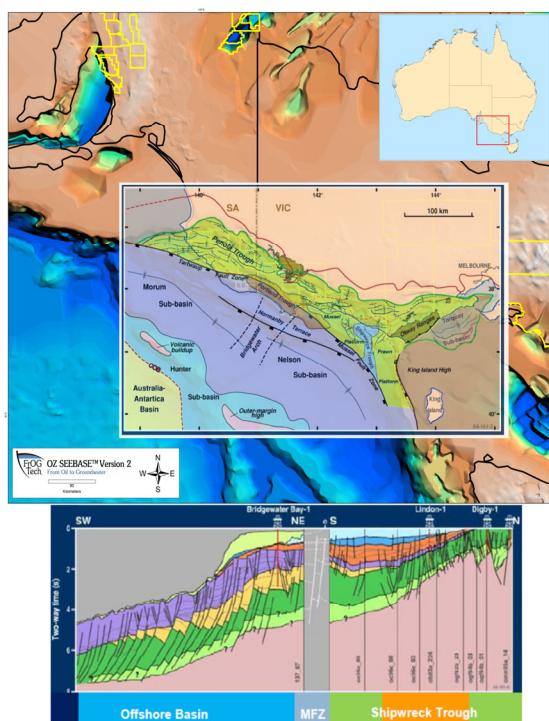


Figure 1: Location of the Otway Sedimentary Basin and a cross-section from the onshore to offshore Otway Basin.

Previous Work

To date, there are no geothermal studies at the regional scale of the entire basin. The current Australian-scale temperature map (Austherm08, 5 kilometres depth) is the result of interpolating dispersed onshore well temperature data and as such it is not appropriate for regional analysis of

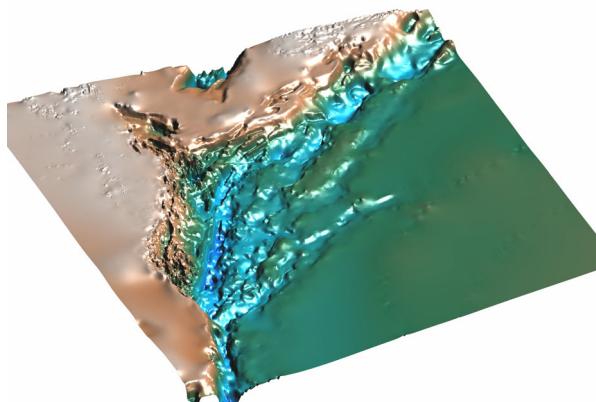


Figure 2: 3D perspective view from the East of the Otway Basin SEEBASE™ (basement topography).

Seismic Interpretation

Seismic profile analysis has permitted identification of the structural signature for 3 main extensional phases contemporary with deposition of the 3 key supersequences (Crayfish, Eumeralla, Sherbrook). The magnitude and type of structural control has been described for each phase. Analysis of timing, displacement, patterns and intersection relations of interpreted seismic faults allows definition of 3 different main sets of faults.

Thanks to seismic-well ties, the different aquifers have been characterized by their specific seismic and sedimentary facies, gamma ray log signature and seismic horizon geometry and amplitude. This characterization allows the study of the vertical distribution of the potential reservoirs in the Penola, Digby, Mocamboro, Ardonachie, Worong, Koroit troughs and in the Tyendarra Embayment. Porosity and permeability qualifiers based on well-tie have been attributed along the stratigraphic chart.

Isopachs of the supersequences have been constructed using the structure time surfaces for top basement, top Crayfish Group (Figure 3), top Pretty Hill sandstone, top Eumeralla and top Sherbrook at basin scale.

Aquifer characteristics

Six sandstone-rich reservoirs or potential deep aquifers have been identified:

1. The basal Late Jurassic to earliest Cretaceous nonmarine sandstones of the Crayfish Group, sometimes informally described as the "McEachern Sandstone".
2. The thick, well developed fluvial channel and bar sandstones of the "Sawpit Sandstone".
3. The Pretty Hill Sandstone is the thickest and most extensively developed Crayfish Group sandstone-dominant unit.

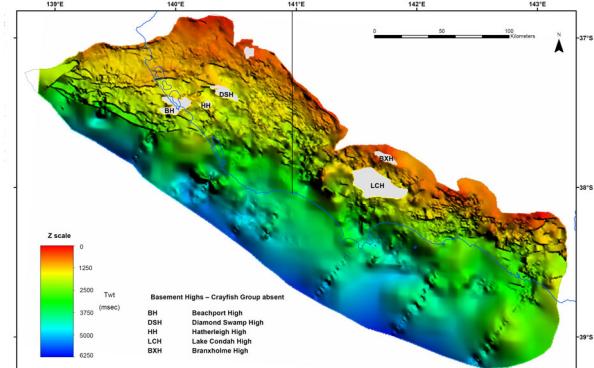


Figure 3: 3D time structure map of the top of the Crayfish Gp.

4. The fine-grained sandstones within the Laira Formation, known as "intra-Laira sandstone".
5. The laterally discontinuous, lenticular channel sandstones of the Katnook Sandstone.
6. The regionally extensive, thin, sheet-like Windermere Sandstone.

The best regional aquifer is the Pretty Hill Formation. It is the thickest (up to 870m) and most extensively developed, but its porosity is strongly facies-dependent (channels = high, floodplain = low). Although thinner, the Sawpit sandstone shows similar characteristics and potential. Alternatively, the Katnook and MacEachern sandstones are more localized, but show higher porosity and permeability values with local thicknesses > 200m.

Compilation of deep water bores salinity data shows that low salinity water is present within the deep aquifers of the Otway Gp.

In parallel, first-pass maps of shallower aquifers in the Wangerrip, Nirranda and Heytesbury groups have also been produced from regional bores/wells databases.

Temperatures

Temperature data from more than 270 wells have been compiled, assessed or re-assessed to attribute confidence values and generate a preliminary linear temperature gradient map at the scale of the Otway basin that will help to target the aquifers that will be the focus of Phase II. The values stored in this temperature database will also serve as a reference for Phase II heat flow modelling. Preliminary linear gradient map shows that the higher gradient values are found in the Penola, Tahara, Morendah and Elingamite troughs. As the number of reliable temperature values in wells diminishes quickly with depth, maps of projected temperature at the top of the deep aquifer surfaces have to be considered with care. Nonetheless temperature at the top of the Crayfish Gp, the shallowest of the targeted deep

aquifers gives values that are locally higher than 100°C along the Victorian coastline.

Conclusion

These preliminary results are encouraging concerning the geothermal exploitation of the deep aquifers in the Otway Basin that seems to be economically viable for a large range of direct-use purposes throughout the basin and potentially locally also for power generation.

But, the Phase I of this project has also shown the limitation of the direct linear gradient temperature approach for the deep aquifers. In phase II, a definition/revision of rock hydraulic properties of each selected aquifer-aquitard pair and prediction of radiogenic heat flow derived from the basement composition and thickness from SEEBASETM to Moho will be performed. These inferred heat flow values together with available estimates of heat flow and corrected temperature at depth will be used to reassess temperature gradients using thermal conductivities derived from mixed-lithology calculations. Heat in place maps, including the errors maps, will be then derived in order to better define the geothermal plays and their associated risks. In addition to the definition of the geofabric and geothermal resources, the project will aim to produce a comprehensive conceptual groundwater model of the Otway Basin. The model will detail groundwater recharge, discharge and the links between the shallow, onshore groundwater resources used for consumptive purposes (e.g. agriculture, environmental services and town water supplies) and the deep groundwater resources available for

geothermal, petroleum and carbon capture and storage.

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