Petroleum source rocks, maturation and thermal history, onshore Tasmania.

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Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy. University of Tasmania.

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ABSTRACT.

Discoveries of bitumen, oil and gas have been made in onshore Tasmania associated with rocks ranging in age from Neoproterozoic to Permian, suggesting that three stacked petroleum systems may occur. The three petroleum systems identified are named Centralian, Larapintine 2 and Gondwanan. As yet no commercial discoveries of oil or gas have been made in these systems. A basin wide reconnaissance level investigation was undertaken, using outcrop samples, to determine petroleum source potential and thermal maturity of available source rocks. The findings add to the basic geoscientific knowledge of these systems and provide a basis for realistic planning of petroleum exploration.

The Kubler Indices of potential Neoproterozoic source rocks were measured to try and overcome the unreliability of maturity results found when using Rock-Eval pyrolysis on outcrop samples. Kubler Indices of potential Neoproterozoic source rocks shows they have very high thermal maturity, up to greenschist facies, so there is no possibility of a viable Centralian petroleum system. Results of Kubler Indices analysis were used to map regional variations in metamorphic grade of northwest Tasmania.

Within the potential Ordovician source rocks the high organic content beds are thin (<200 mm thick) and rare with discontinuous distributions. Even these thin beds have low source potential as measured by Rock-Eval pyrolysis (Hydrogen Index 3-106, average 40, S1 + S2 average 0.3), probably due to the high maturity (Tmax 465-496°C). No evidence for petroleum migration pathways were found during field investigations however hydrocarbon gases were extracted from outcrop samples and identified by gas chromatographic analysis. Biomarker analysis of extracts from Gordon Group samples indicates the hydrocarbons were locally derived from an algal/bacterial source deposited in an anoxic environment. Sterane distribution indicates marine oil derived from carbonates consistent with source rocks within the Gordon Group. Examination of cross cutting relationships of mineralised and bituminous veins from possible Mississippi Valley-type Pb-Zn deposits, hosted by Gordon Group, indicates oil generation occurred in the Early Devonian before
Tabberabberan trap development. Maximum palaeotemperatures were developed due to tectonic thickening during the mid-Devonian Tabberabberan folding and thrusting. This study found that there is no exploration potential within the Larapintine 2 petroleum system of onshore Tasmania.

Previous studies identified potential source rocks within the Parmeener Supergroup and this study found further potential coal and associated siltstone source rocks with high total organic content and high hydrogen index values (TOC up to 75%, HI 442) indicating excellent potential. Maturity within the oil window was determined by Rock-Eval pyrolysis $T_{\text{max}}$ and vitrinite reflectance. Vitrinite reflectance data from coal exploration was collated with data obtained from Rock-Eval pyrolysis and vitrinite reflectance on samples obtained during this study to confirm previous basin maturity assessments.

Near Zeehan, a breached reservoir, in Upper Permian sandstone contains relict bitumen sourced from Permian siltstone and coal. This is positive evidence that the Gondwanan petroleum system has generated petroleum. A potential complication is that depositional conditions for source rocks and higher heat flows during the Cretaceous may have provided conditions suitable for petroleum generation in western Tasmania that did not apply in the Tasmania Basin.

Only the Gondwanan petroleum system is a potential exploration target for onshore Tasmania as source rocks, within the oil and gas maturity range, are widespread across the southern Tasmania Basin. However, the search for suitable trap structures in the complexly faulted sequence will be difficult. Both the Larapintine 2 and Centralian petroleum systems are over mature throughout Tasmania making them poor exploration targets.
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