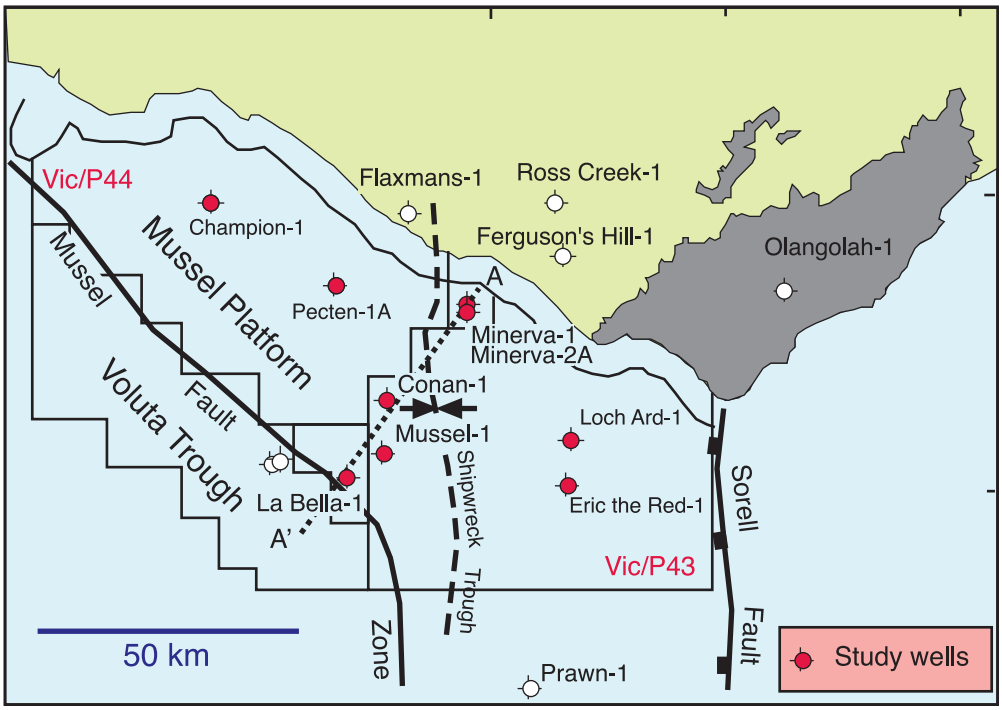
Reconstruction of thermal, structural and source rock maturation histories: Offshore Otway Basin

A non-exclusive study initiated by Geotrack International Pty Ltd



EXECUTIVE SUMMARY

The proposed study incorporates new AFTA® and vitrinite reflectance results to provide a constrained thermal history framework for understanding the structural, source rock maturation and hydrocarbon generation histories of the Vic/P43 area of the Otway Basin.

New data and interpretations will be provided non-exclusively to each participating company from the four exploration wells in Vic/P43; Conan-1, Eric the Red-1, Loch Ard-1 and Mussel-1 and two wells from Vic/P44; Champion-1 and Pecten-1 plus new data and interpretations the three wells in the Minerva and La Bella gas discoveries adjacent to Vic/P43 and Vic/P44.

The study will specifically address key risks to exploration in this area:

- Timing of cessation of active hydrocarbon generation in the permit
- Timing of major episodes of uplift and erosion in the permit
- Regional variation of maturation levels of the Early Cretaceous section

"The study will provide essential, rigorous calibration data for 2D and 3D basin modelling"

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EXPECTED BENEFITS

A thorough understanding of the complex thermal and structural histories of this region of the Otway Basin will result in significant lowering of risks associated with timing of hydrocarbon generation, reservoir charge and breach. Access to this knowledge early in the exploration program will provide a tighter focusing of costly resources to the most prospective targets and allow rigorous calibration, essential for 2D and 3D basin modelling.

IDENTIFICATION OF PROBLEMS AND RISKS

The Early Cretaceous (Otway Group) section contains the only proven oil and gas source intervals in the Otway Basin, but commercial success is so far limited to the Minerva and La Bella gas discoveries adjacent to Vic/P43 and P44. However, this limited commercial success should be seen in the light of the complicated tectonic history of the region which has a profound influence on the heating history of potential source horizons. The thermal history has not been directly constrained in past programs, and hence the hydrocarbon maturation and generation history has been poorly understood.

A key factor is the highly elevated mid-Cretaceous heat flow which has resulted in a significant phase of hydrocarbon generation prior to ~95 Ma and hence before the deposition of both the key Late Cretaceous reservoir targets and formation of the Tertiary traps. Charging of Tertiary traps relies on a second phase of hydrocarbon generation from suitably located Otway Group source rock horizons during burial by Tertiary sediments. For example, if the Tertiary section is too thin, the Otway Group will not be re-heated sufficiently for renewed hydrocarbon generation while if the Late Cretaceous section is too thick, Otway Group source rocks will exhaust all potential prior to Tertiary trap formation. The interaction between changes in basal heat flow and the variation in thickness of the Late Cretaceous and Tertiary sections is thus a key risk in charging what would otherwise be a valid trap. Further discussion of these interactions can be found in Duddy (1997; APPEA, V34, 178-191). Results of a new 2-D Temispack modelling study along a seismic line from Minerva-1 to La Bella-1 based on AFTA-calibrations are reported in Duddy & Erout (EABS 2001 –Attachment B), which also details the approach to be followed in the proposed study.

Integration of AFTA and VR results detailed in this proposal will allow the complex thermal history to be unravelled, including the identification and quantification of key episodes of heating in the Mesozoic and Tertiary. These data are critical to the understanding of maturation and the timing of episodes of hydrocarbon generation relative to structural development.

AIMS AND OBJECTIVES:

The main aim of this study is to provide a comprehensive thermal history framework for Vic/P43 & P44 in which both the structural development and the generation and preservation of hydrocarbons can be understood. The proposed study incorporates AFTA® Apatite Fission Track Analysis results and high quality vitrinite reflectance data as a primary basis for reconstruction of the thermal history in the four exploration wells in the permit and three exploration wells from the adjacent Minerva and La Bella gas discoveries.

<u>Key objectives of the study are the direct determination of:</u>

- The thermal episodes relevant to hydrocarbon prospectivity
- Timing of cessation of active hydrocarbon generation
- Timing and magnitude of maximum paleotemperatures
- Magnitude of paleogeothermal gradients associated with identified thermal episodes
- Timing and magnitude of major structuring episodes

A major element of the study is to provide constrained thermal histories in the Minerva-1, Minerva-2A and La Bella-1 gas discovery wells as a basis for comparison with unsuccessful wells in the permit area.

WORK PROGRAM AND DELIVERABLES

The study is based on new AFTA® and new and quality controlled open file vitrinite reflectance data from seven wells, with at least two AFTA samples and fifteen VR samples in each.
The wells to be included are:

1. Champion-1
2. Conan-1
3. Eric the Red-1
4. Loch Ard-1
5. Mussel-1
6. Pecten-1
7. La Bella-1
8. Minerva-1
9. Minerva-2A

The results of the study will be illustrated by construction of thermal, burial and source rock maturation histories at two "pseudo well" sites. The locations of these sites will be chosen in consultation with participating companies and will rely on depth information provided by participants.

The study will be provided in two volumes. Volume 1 will provide full details of the thermal history interpretation for each well in the form of tables and figures illustrating the constrained thermal, burial and source rock maturation histories. All AFTA and VR data plus supporting geological information and full details of analytical techniques will be provided in four Appendices in Volume 2.

PROJECT STRUCTURE:

- AFTA and VR Results and thermal history interpretations - will be provided for the six wells in the Vic P/43 and P44 permit areas – Champion-1, Conan-1, Eric the Red-1, Loch Ard-1, Mussel-1 and Pecten-1.

- Results and interpretations will be provided for the three wells in the Minerva and La Bella gas fields - La Bella-1, Minerva-1 and Minerva-2A.

- Two pseudo well locations incorporating thermal and structural information derived from the study will be also be included in the study. Locations of the Pseudo wells will be decided in consultation with study participants. See Attachment.

POSSIBLE PROJECT EXTENSIONS:

- Possible extensions to the south include new wells such as Thylacine, Geographe, etc., and could include Prawn-1, Clam-1, Whelk-1 and Cape Sorell-1 at additional cost.

TIMEFRAME: 12 weeks from receipt of order

COST: A$48,000+ GST per company**.** Group escalation discounts for bona fide operating groups**.**

Variations: Additional wells can be analysed on either a non-exclusive or exclusive basis for participating clients with results integrated in the study. Costs for incorporation of these wells will be quoted on an individual basis depending on number of AFTA and VR samples required. Additional pseudo well locations can be modelled at A$1050.00 per location (plus GST if and when applicable). Exclusive individual well studies costed on request. Please contact us.

Further Information: Dr. Ian Duddy

ATTACHMENT

Information required for Pseudo well location reconstructions

1. Water depth

2. Prognosed depths to major stratigraphic units
   a Base Heytesbury Group
   b Top Wangerrip Group
   c Top Sherbrook Group
   d Top Shipwreck Group
   e Top Eumeralla Formation
   f Top Crayfish Group (this is unlikely to be picked and is not essential for the modelling.

3. Any indications from seismic data for significant uplift and erosion at unconformities

We would use our regional understanding of the thermal history of the Otway Basin to provide likely thermal history scenarios at the pseudo locations to deliver the following for each location:

1. Burial history model

2. Thermal history models - end member scenarios

3. Maturation history models - based on end-member thermal history scenarios
   Maturation history can be expressed in parameters of your choice - eg VR with time, rate of oil of gas generation with time, cumulative hydrocarbon production with time etc.

4. Discussion of results at each location in terms of risk of hydrocarbons generated from Otway Group source rocks being available for traps of various age.

5. Other parameters and aspects of the hydrocarbon generation parameters can be addressed at your request.