A Geochemical Overview of Some Gippsland Basin Hydrocarbon Accumulations*

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Abstract

In the 50 years since the first commercial discovery in 1965 at Barracouta-1, and 46 years since production commenced from the Barracouta Field, a total of 16.5 TCF of gas, 4026 MMbbl of oil, 385 MMbbl of condensate and 752 MMbbl of LPG have been found in the Gippsland Basin (Estimated Ultimate Recovery, as at the end of 2012). Despite these extensive resources, all from Cretaceous-Paleogene Latrobe Group reservoirs, there are questions regarding the effective petroleum systems, contributing source rock units, and the migration pathways between source and reservoir. Resolution of these uncertainties is essential to improve our understanding of the remaining prospectivity and for creating new exploration opportunities, particularly in the eastern, less explored part of the basin, but also for mitigating risk for the potential sequestration of carbon dioxide along the southern and western flanks.

Geochemical fingerprinting of reservoir fluids has identified that the oil and gas originate from multiple sources. The most pervasive hydrocarbon charge into the largely produced fields overlying the Central Deep has a terrestrial source affinity, originating from lower coastal plain facies (Kingfish, Halibut, Mackerel), yet the oils cannot be correlated using source-related biomarker parameters to source rocks either within the Halibut Subgroup (*F. longus* biozone) at Volador-1, one of the deepest penetrations of the Upper Cretaceous section, or to older sections, penetrated on the flanks of the basin. However, within the underlying Santonian-Campanian Golden Beach Subgroup an oil-source correlation has been established between the Anemone-1A oil and the marginal marine Anemone Formation (*N. senectus* biozone) at Anemone-1/1A and Archer-1. A similar correlation is indicated for the Angler-1 condensate to the Chimaera Formation (*T. lilliei* biozone) in the deepest section at Volador-1 and Hermes-1. In the Longtom Field, gas reservoired within the Turonian Emperor Subgroup, potentially has a

source from either the lacustrine Kipper Shale or the Albian portion of the Strzelecki Group. The molecular and carbon isotopic signatures of oil and gas from the onshore Wombat Field are most similar to hydrocarbons sourced from the Aptian-Albian Eumeralla Formation in the Otway Basin, also implicating a Strzelecki source in the Gippsland Basin. These results imply that sediments older than the Paleocene are significant sources of petroleum within the basin.

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VICTORIA State Government Australia

CSIRO

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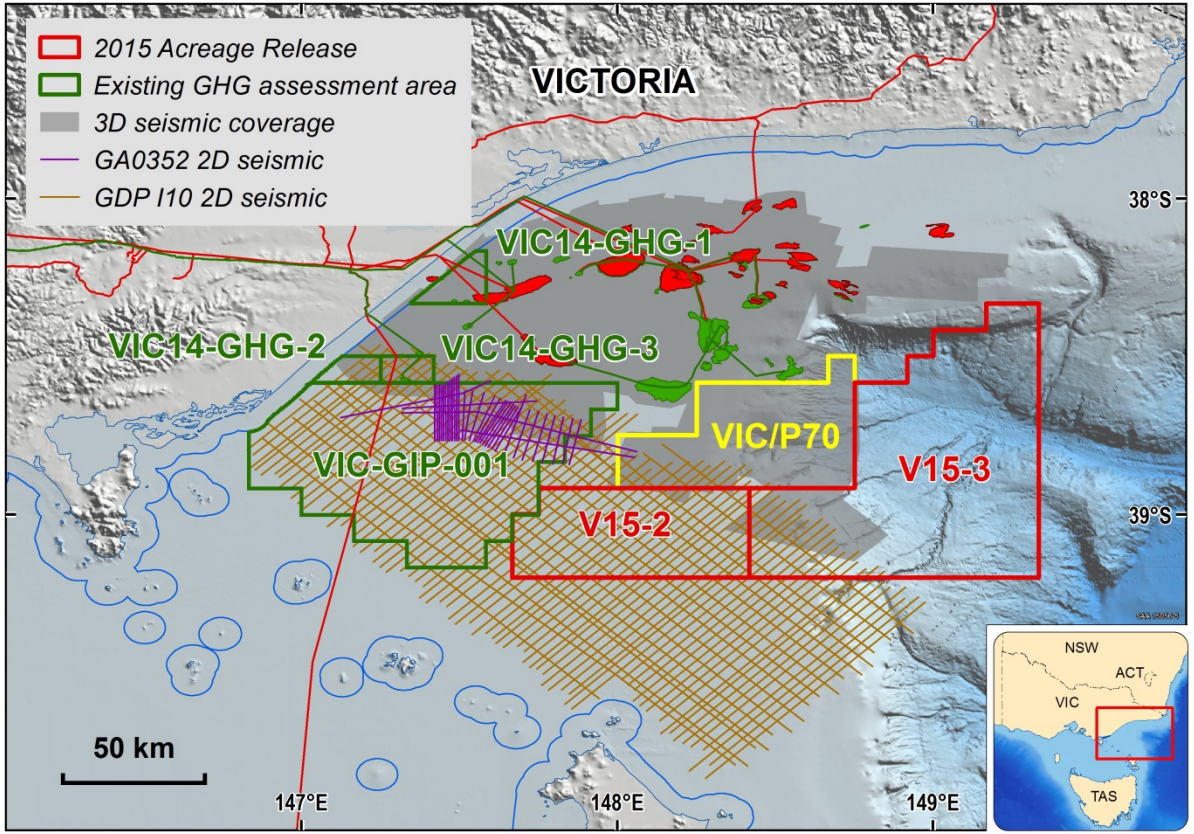
GEOCAT 83902

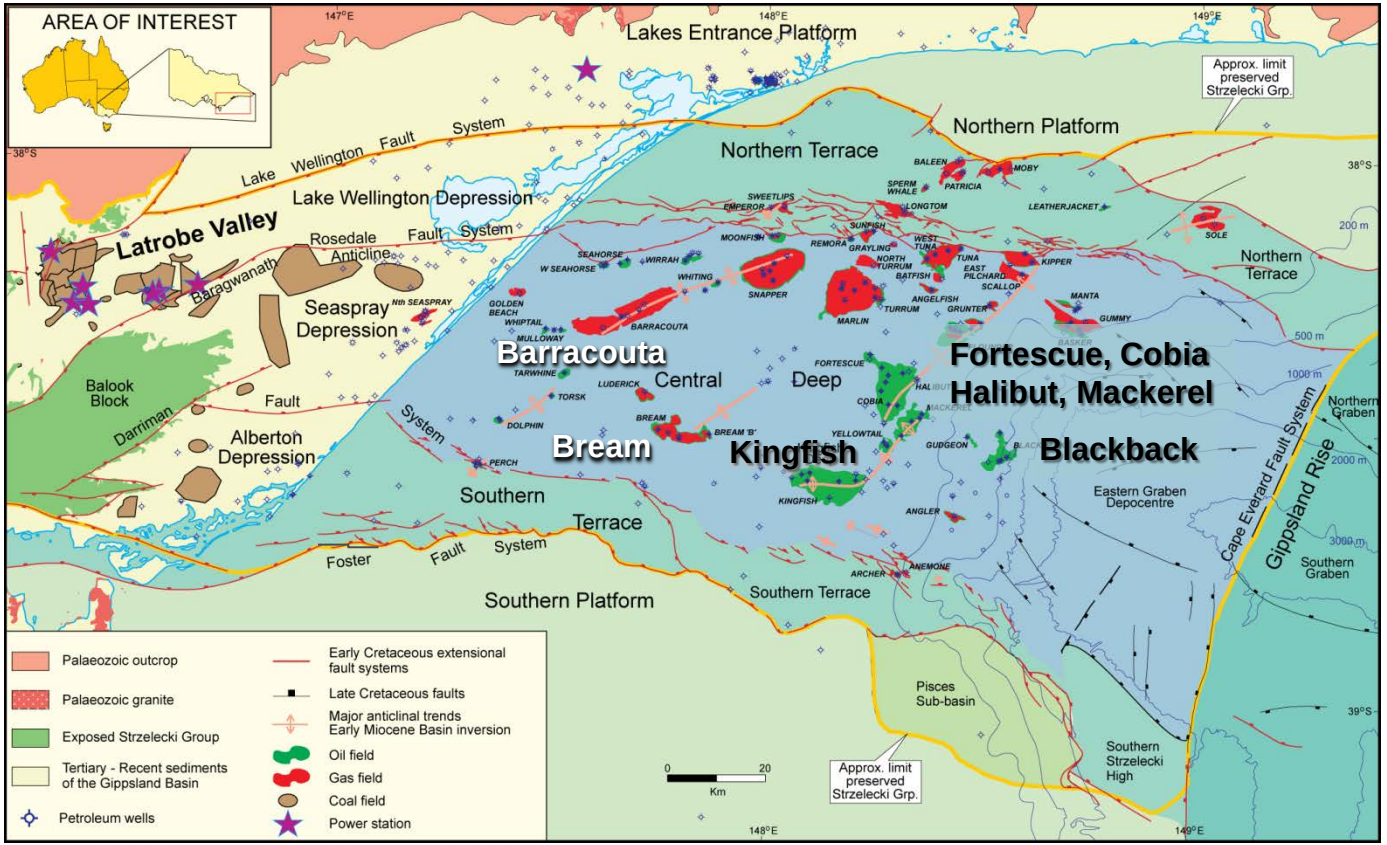
GA's Program in the southern Gippsland Basin

World class producing petroleum province

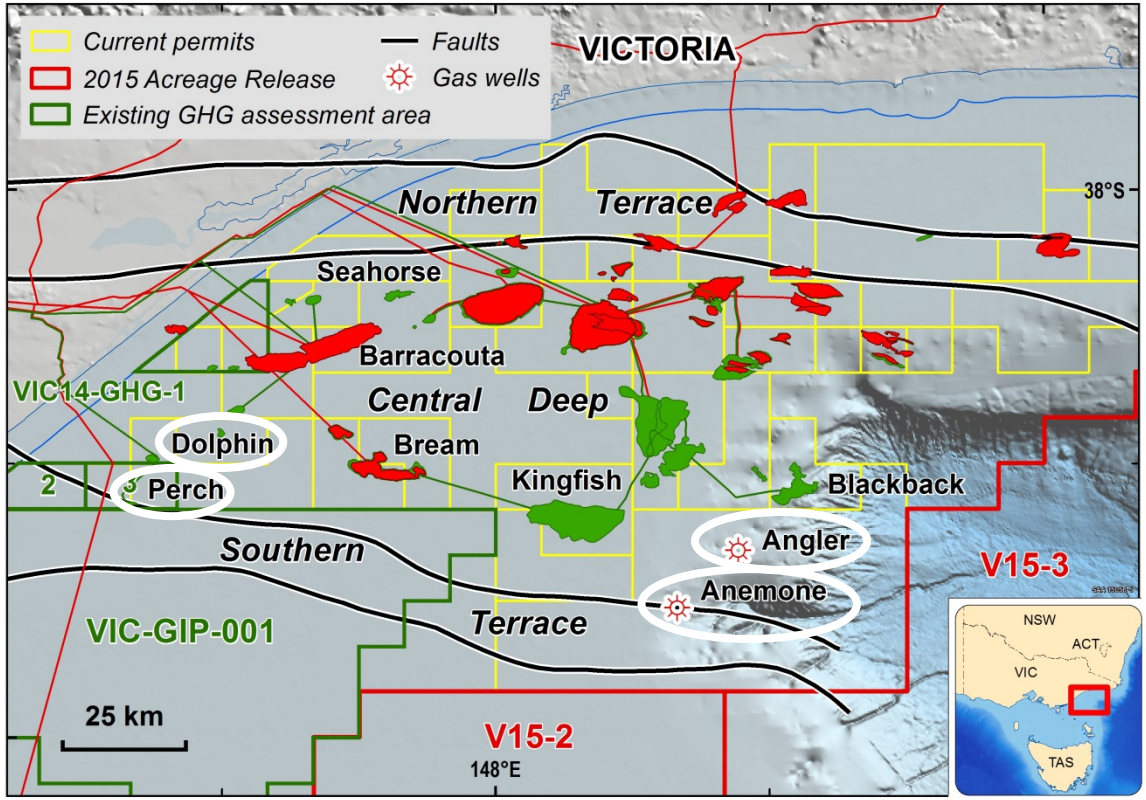
- Under-explored, deep-water part of the basin
- Acreage Release areas
- New seismic surveys
- Is the southern margin suitable for CO_2 storage?
- **What is the potential for finding hydrocarbons within the acreage release areas and GHG assessment permits?**



Gippsland Basin Tectonic Elements



Southern Hydrocarbon Accumulations and Wells



Stratigraphy

SEAL

MAIN RESERVOIRS

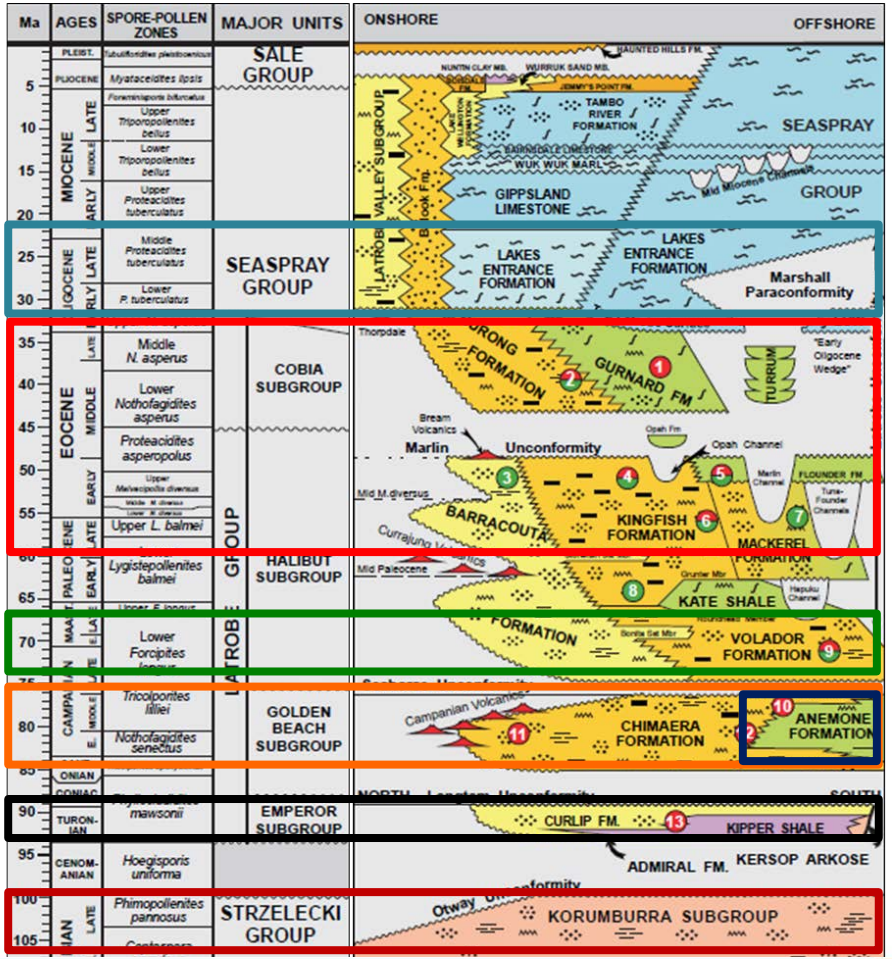
SOURCE ROCKS

Type III & I lower coastal plain lagoons, peat swamps

Type III upper coastal plain/ Type II marine

Type I lacustrine

Type III non-marine



Previous Gippsland Basin Geochemical Studies

Produced oils are sourced by coals and shales within the Latrobe Gp
(Philp & Gilbert, 1986; Burns et al, 1987; Rahmanian et al., 1990; Moore et al, 1992; Grant, 2004)

Marine FI oil in Blackback-2 (George et al, 1998)
Marine source for Anemone-1A oil (Gorter, 2001; Bernecker et al, 2001)

Oils of Eastern Australia (Summons et al, 2002) : Collaborative Studies by GA CSIRO & Geological Survey of Victoria (Volk et al, 2010; 2011; Ahmed et al, 2013)

- 3 Oil families and vagrants
  - GA1 Central Deep (conifer)
  - GA2 Northern Terrace (conifer & angiosperm)
  - GB Western margin (mixed mature/immature, angiosperm)

Oil Family Distribution

OIL FAMILIES

Latrobe Gp

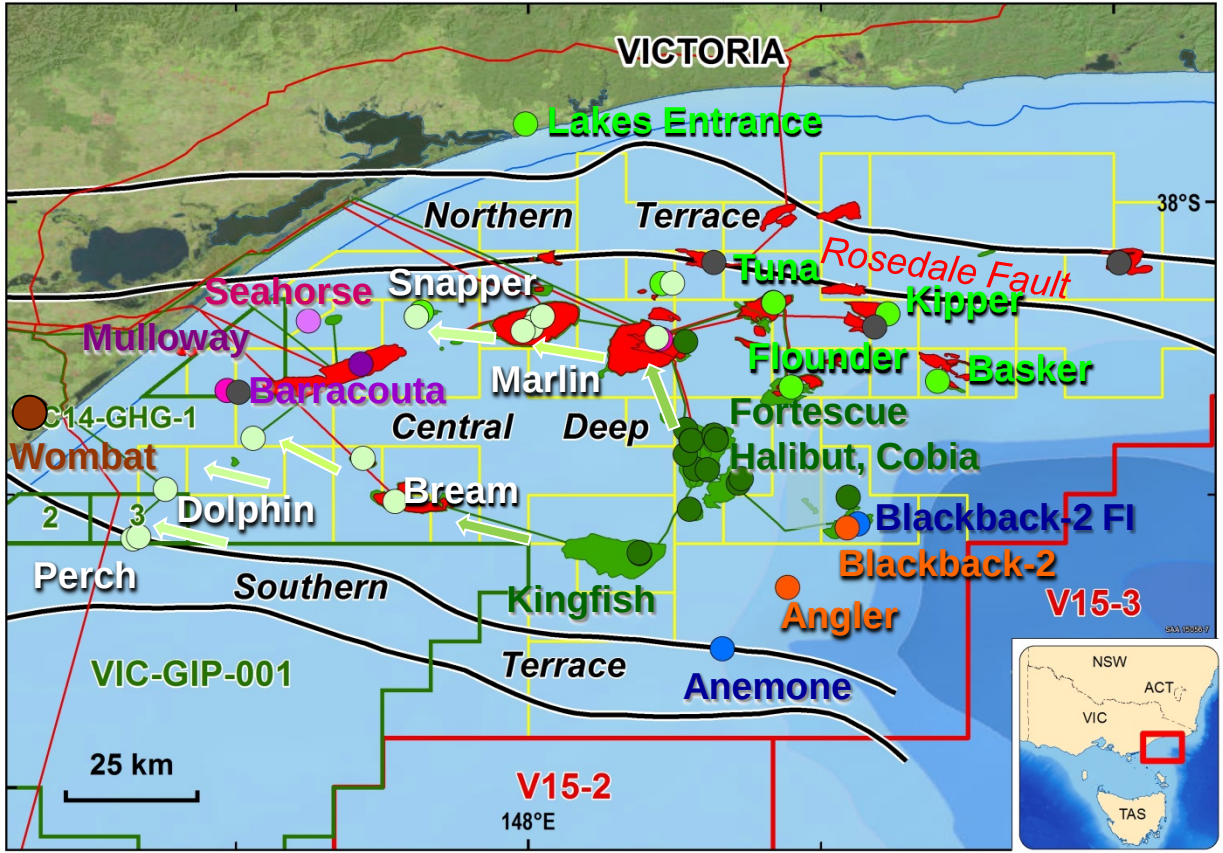
- GA1 conifer
- GA2 conifer+ angiosperm
- GB conifer + **angiosperm**
- Vagrant

Golden Beach SG

- Anemone-1A marine
- Angler-1 fluvial-deltaic

Strzelecki Gp

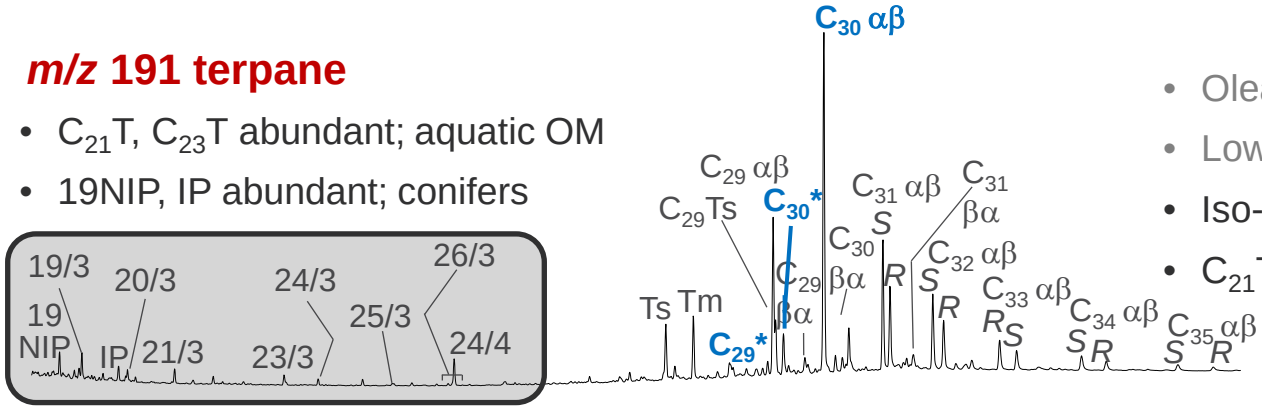
- Wombat-1, -3, non-marine



Marine Biomarker Signature of the Anemone-1A oil

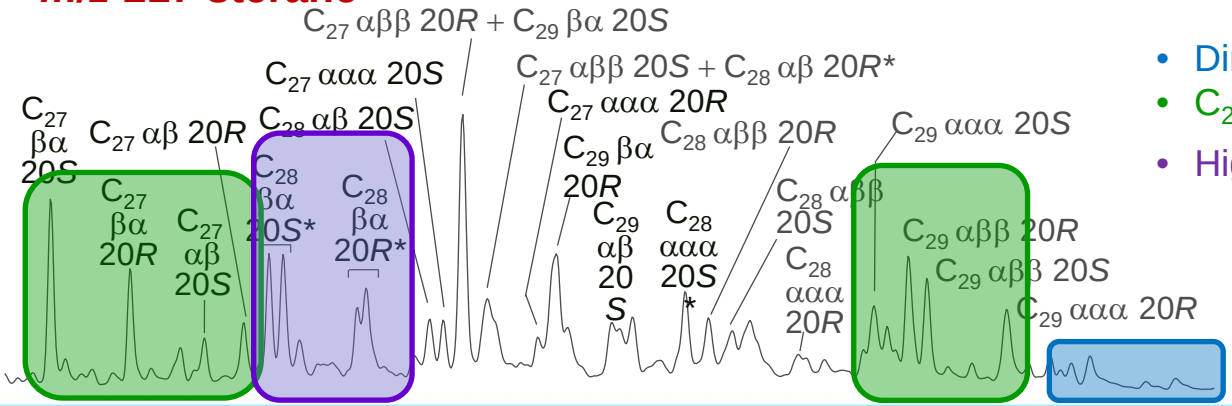
m/z 191 terpane

- $C_{21}T$, $C_{23}T$ abundant; aquatic OM
- 19NIP, IP abundant; conifers



- Oleanane (angiosperm) absent
- Low diahopanes; less terrestrial OM
- Iso-pimaranes; conifer resins
- $C_{21}T$, $C_{23}T$ abundant; aquatic OM

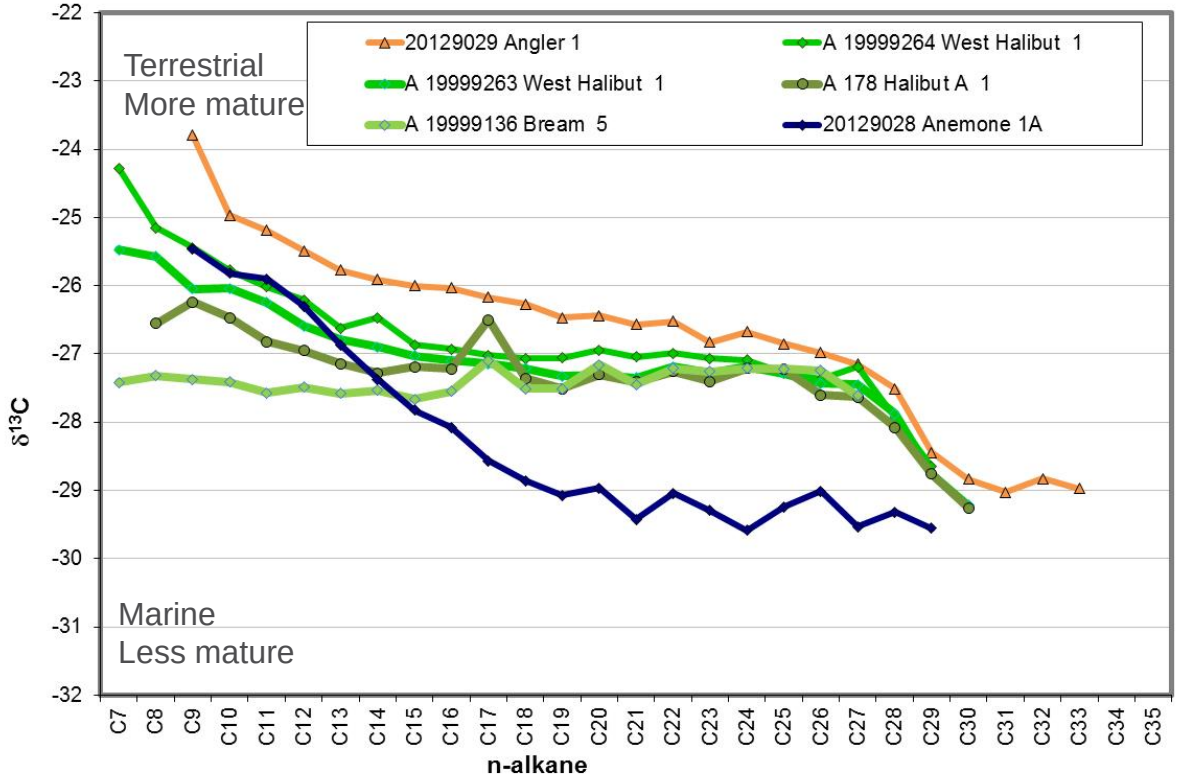
m/z 217 sterane



- Dinosteranes; marine OM
- $C_{27} \geq C_{29}$; aquatic/ terrestrial OM
- High diasteranes; clay-rich

24-*n*-propylcholestanes/dinosterane

Oil–Oil Correlations ^{13}C Isotopes



- Angler-1 oil isotopically heavier
  Terrestrial influence
- Halibut, West Halibut & Bream oils
  Terrestrial influence
- Anemone-1A oil isotopically lighter
  More marine source rock
  ? Mixed sources

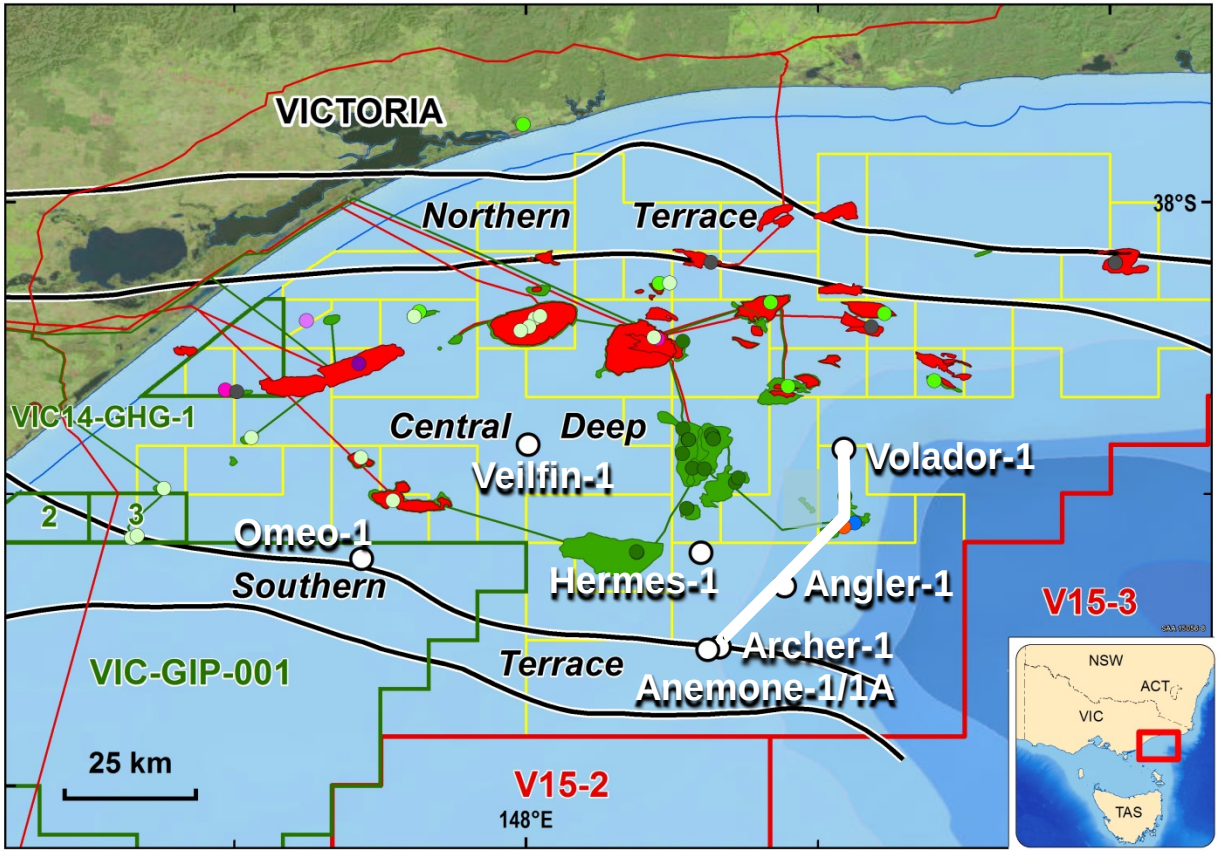
Source Rock Samples

Latrobe Gp

- GA1
- GA2 Conifer
- GB Conifer + Angiosperm
- Vagrant

Golden Beach SG

- Anemone/Anemone Fm
- Angler/Chimaera Fm
- Wombat/Strzelecki Gp



SOURCE ROCKS

22 extracts from 7 wells

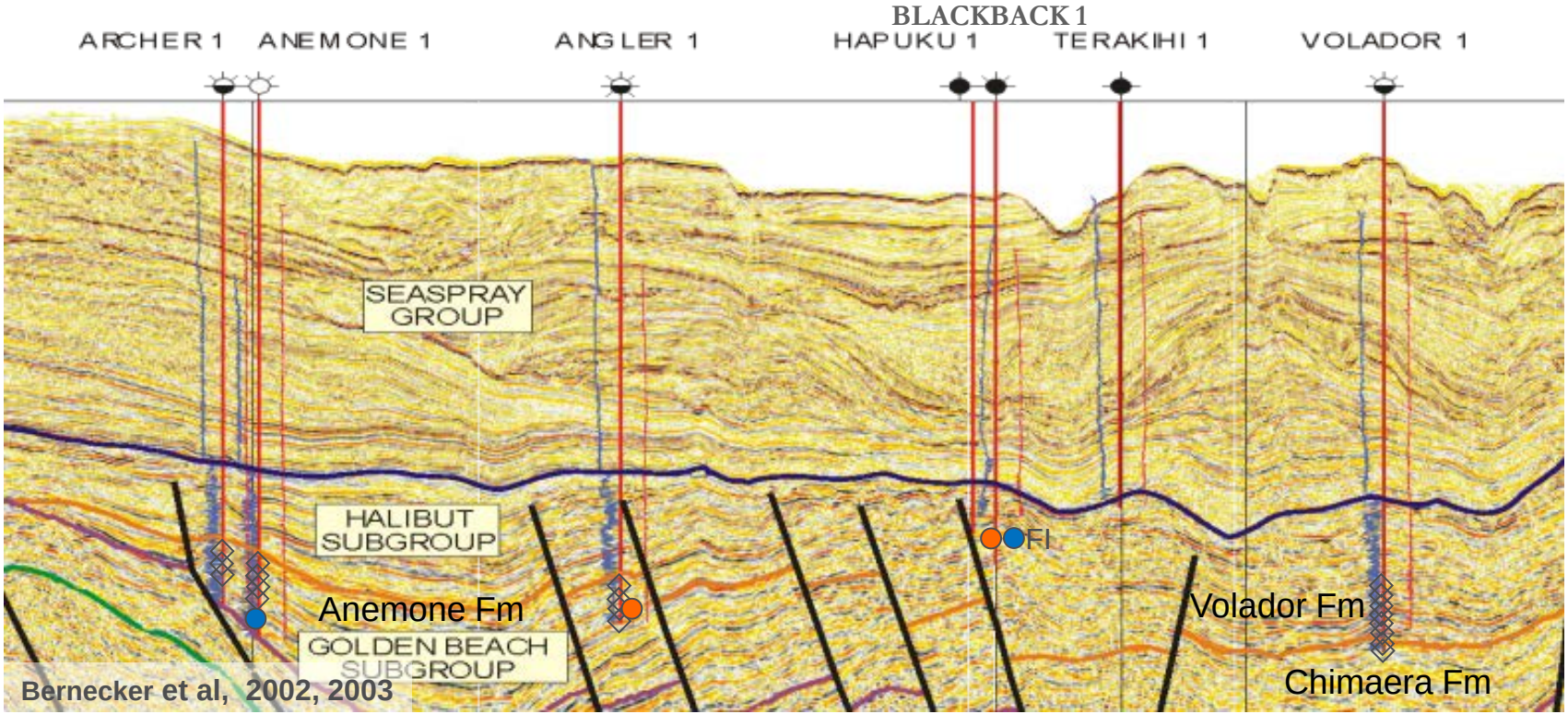
Halibut SG (Veilfin & Volador)

Golden Beach SG

Chimaera Fm: Volador & Omeo

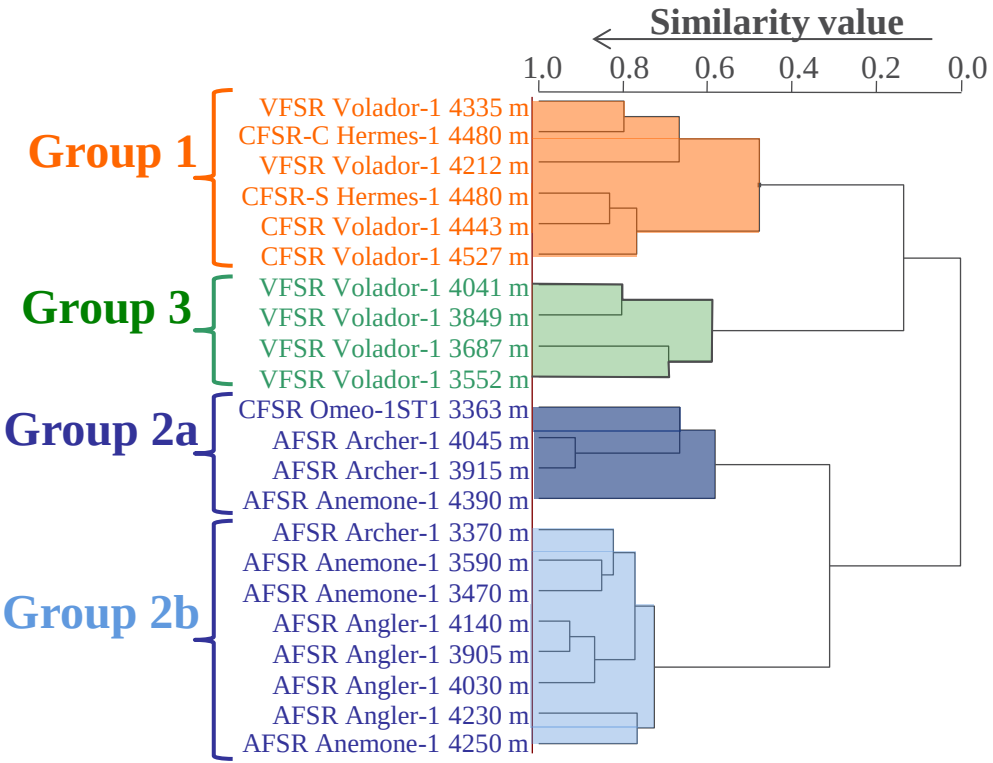
Anemone Fm; Anemone, Archer, Hermes

Halibut (Volador Fm) and Golden Beach SG Source Rocks



● Angler, Blackback oil ● Anemone oil ◇ Volador Fm SR ◇ Chimaera Fm SR ◇ Anemone Fm SR

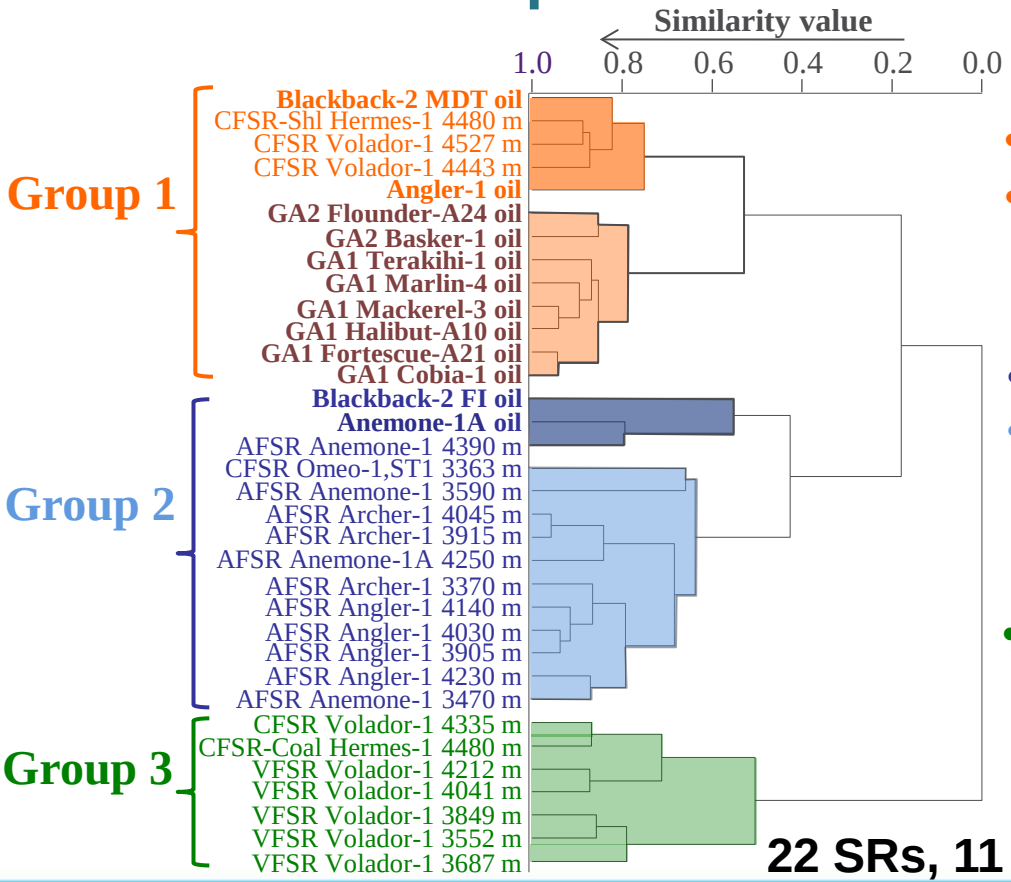
Latrobe Gp Source Rock Biomarkers – multivariate statistics



- Chimaera Fm Source Rocks
  - Terrestrial > Lacustrine
  - Oxic fluvio-deltaic
- Volador Fm Source Rocks
  - Terrestrial >> Lacustrine
  - Strongly oxic fluvio-deltaic
- Anemone Fm Source Rocks
  - Marine > Terrestrial
  - Sub-oxic marine

22 SRs, 42 source variables: terpanes, steranes, bicadinanes, Aromatic HCs

Latrobe Gp Oil–Source Correlations Biomarkers

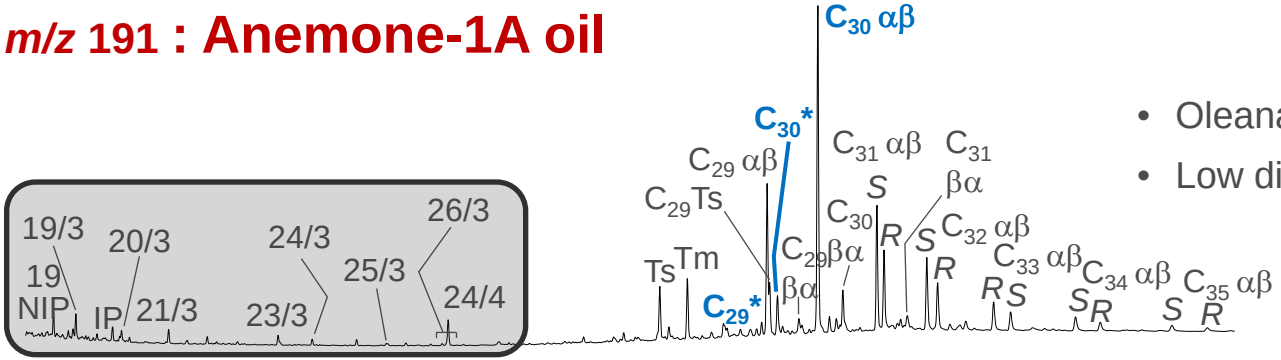


- Angler/Blackback oils – Chimaera SR
- Central Deep oils
  - Oxic, fluvio-deltaic
  - Land-plant > lacustrine
- Anemone oil – Anemone SR
- Mostly Anemone SRs
  - Sub-oxic
  - Mixed marine/terrestrial
- Mostly Volador SRs
  - Mixed terrestrial/lacustrine
    Strongly oxic
  - No oil correlation

22 SRs, 11 oils, one FI oil & 21 source variables

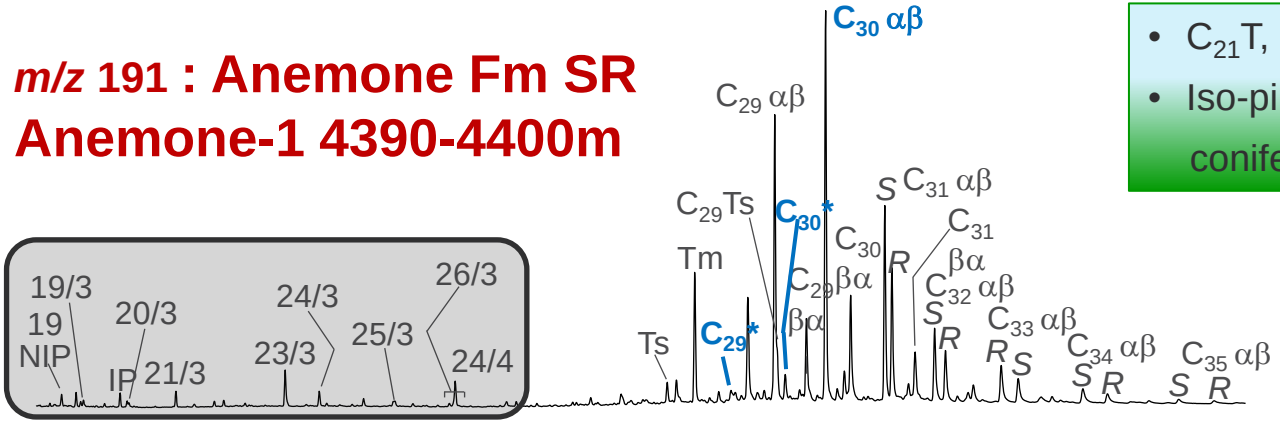
Marine Biomarker Signature: Oil-Source Rock Correlation

m/z 191 : Anemone-1A oil



- Oleanane absent; (no angiosperms)
- Low diahopanes; less terrestrial OM

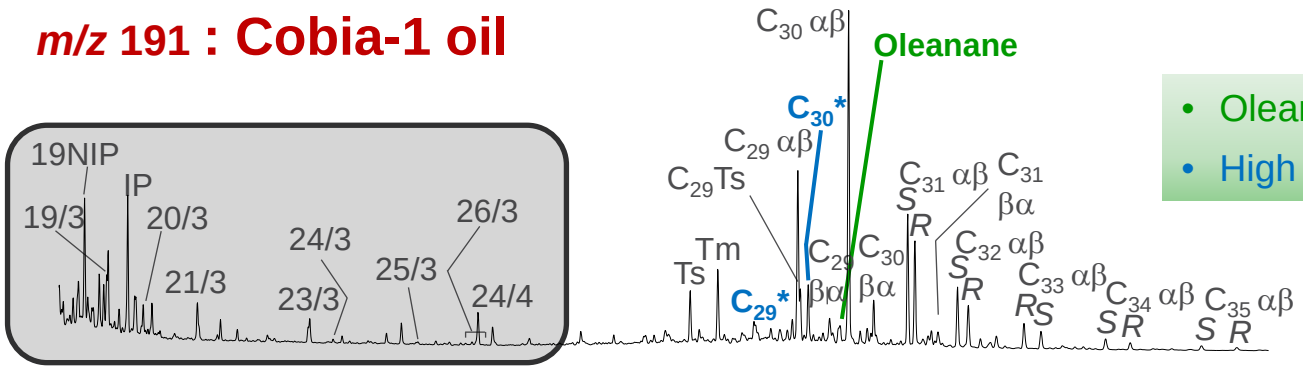
m/z 191 : Anemone Fm SR
Anemone-1 4390-4400m



- $C_{21}T$, $C_{23}T$ abundant; aquatic OM
- Iso-pimaranes abundant; conifer resins

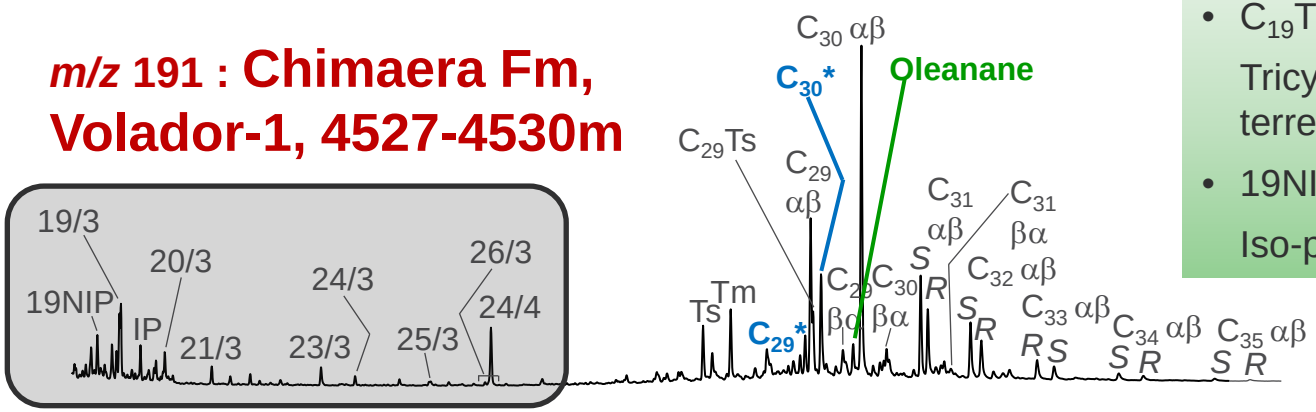
Terrestrial Biomarker Signature: Oil-Source Rock Correlation

m/z 191 : Cobia-1 oil



- Oleanane present; angiosperms
- High diahopanes; terrestrial OM

m/z 191 : Chimaera Fm, Volador-1, 4527-4530m

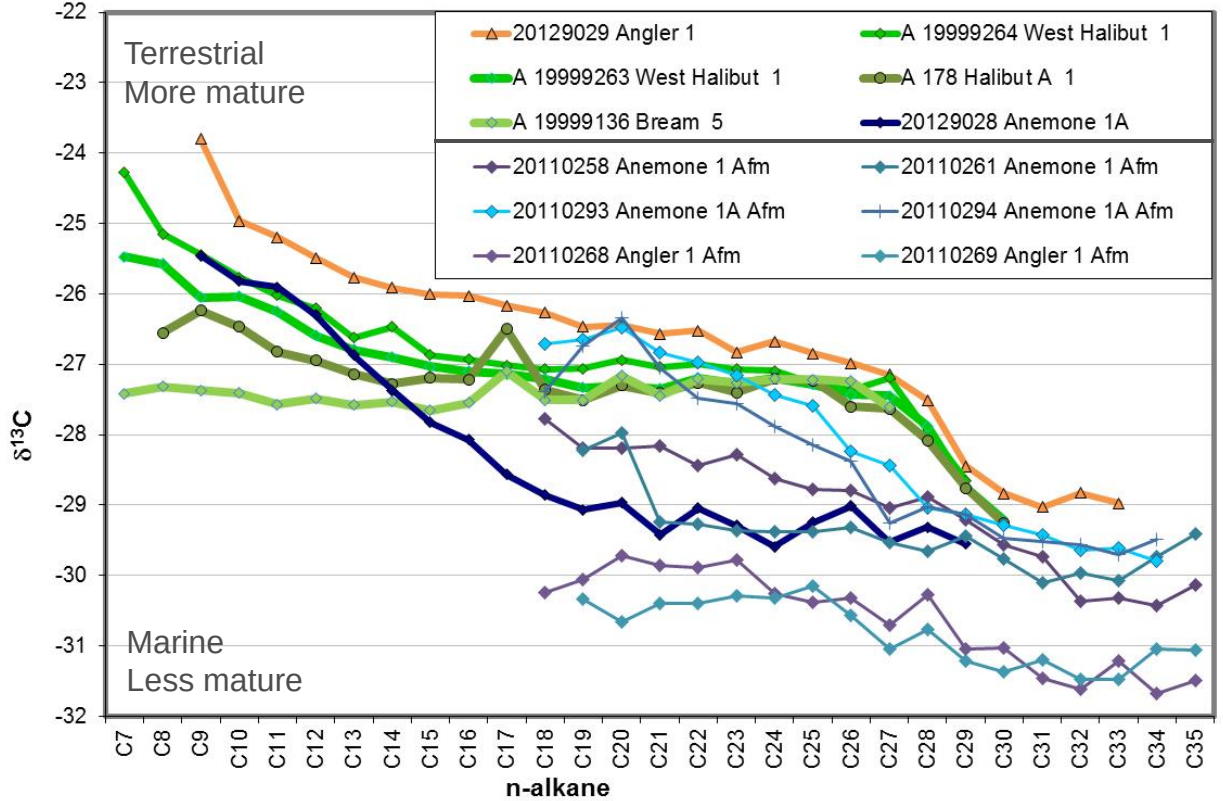


- $C_{19}T$, $C_{20}T$, $C_{24}Tet$

  Tricyclic terpanes abundant terrestrial OM
- 19NIP, IP

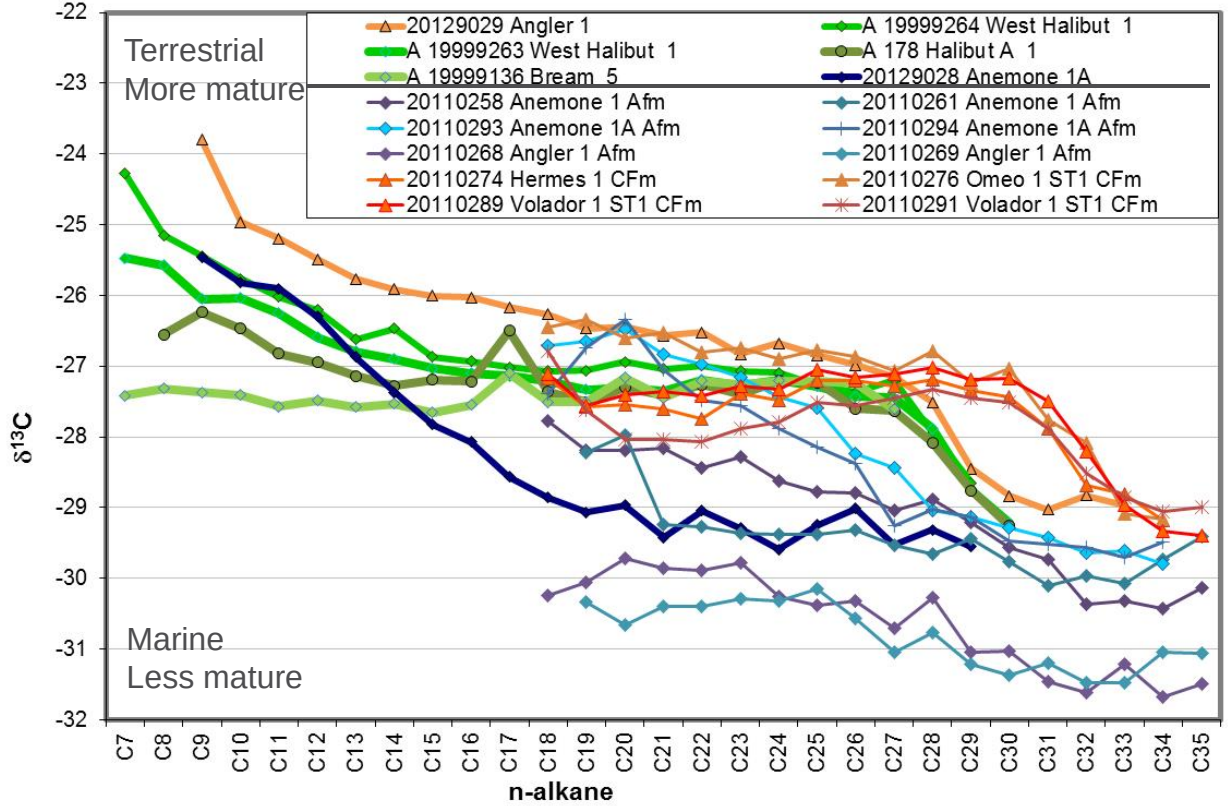
  Iso-pimaranes abundant; conifers

Oil-Source Correlations ^{13}C Isotopes



Anemone Fm
Source rocks

Oil-Source Correlations ^{13}C Isotopes

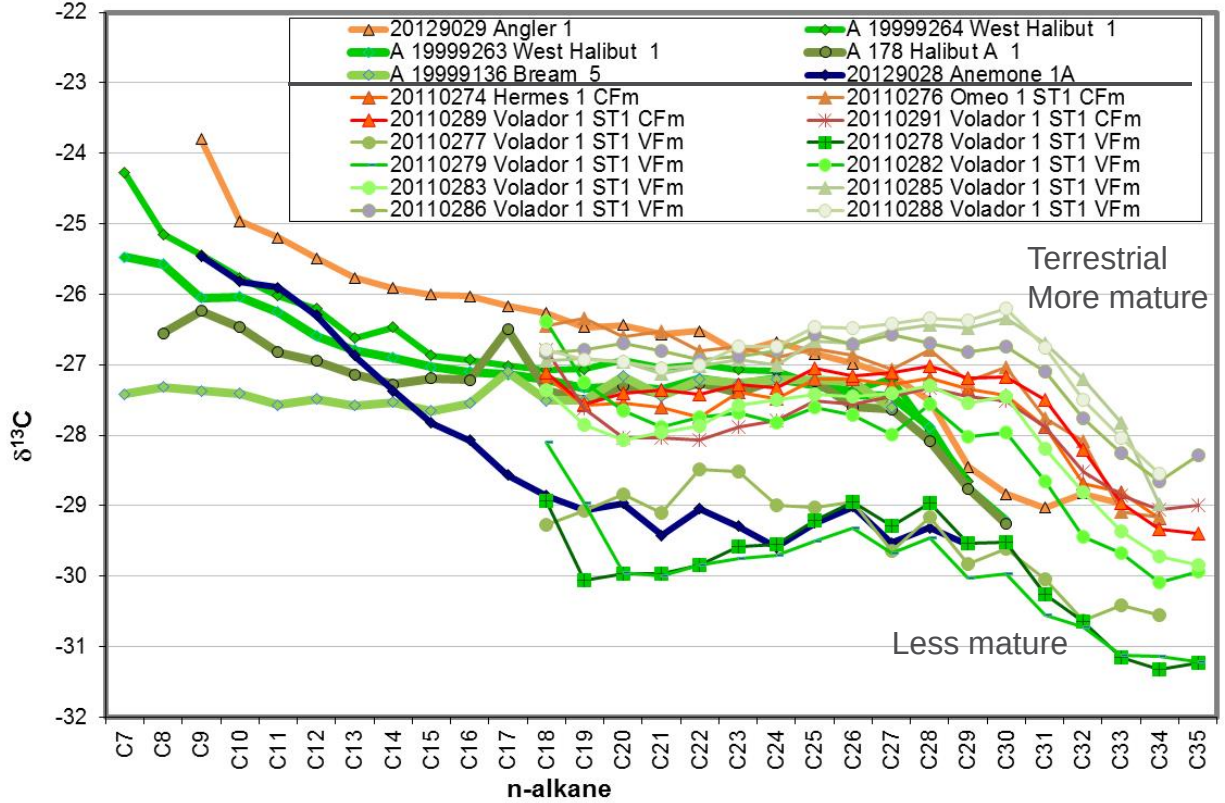


Chimaera Fm

Source rocks

Omeo-1

Oil-Source Correlations ^{13}C Isotopes



Volador Fm

Source rocks

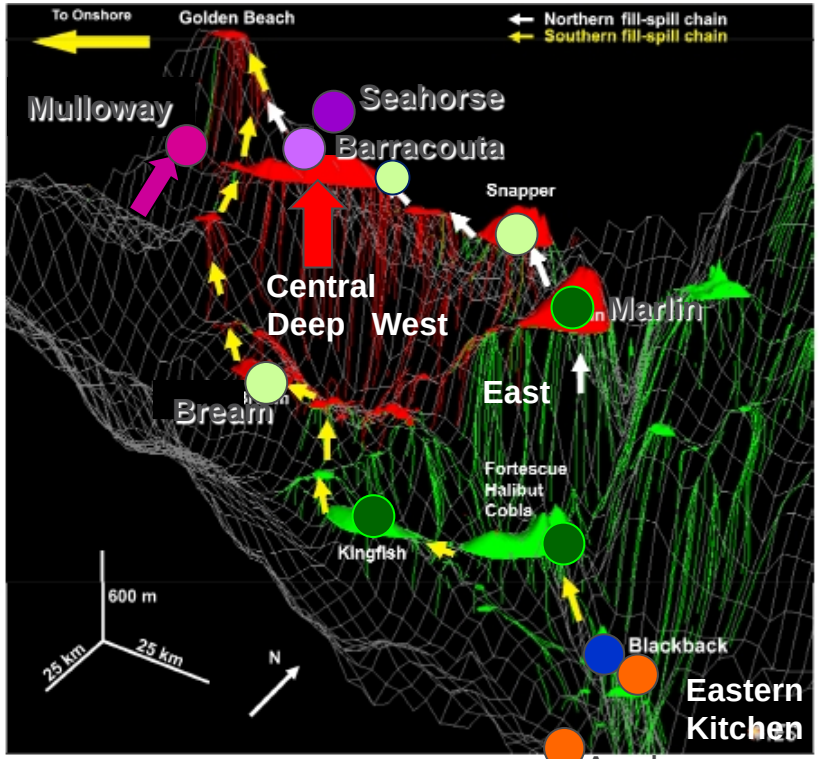
Modelled Hydrocarbon Migration Pathways

Oil Families/Source

Latrobe Gp
- GB conifer+**angiosperm**
- GA1 conifer

Golden Beach SGp
- Anemone Fm marine
- Chimaera Fm non-marine
- Vagrants

Strzelecki Gp
- Wombat-1, -3, non-marine



Inboard source & alteration effects
(Hoffman & Preston, 2014)

Late gas charge

Migration pick-up

Oil charge
Latrobe Gp

Oil & gas charge
Golden Beach SG
Anemone Fm
Chimaera Fm

O'Brien et al, 2008; Miranda et al, 2012

Conclusions

- Anemone-1A oil and Blackback-2 FI oil correlate with the marine Anemone Fm, Golden Beach Sub-group
- Angler-1 and Blackback-1 oils correlate with the fluvial Chimaera Fm, Golden Beach Sub-group
- Produced oils from the Central Deep do not correlate with the lower coastal plain coals and coaly shales in the Volador Fm, Halibut Sub-group, but show some affinity to the Chimaera Fm
- Significant potential for hydrocarbon generation in the southern Central Deep and migration onto the Southern Terrace

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