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Research paper

# On the filling and leakage of petroleum from traps in the Laminaria High region of the northern Bonaparte Basin, Australia

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ABSTRACT

A 3D petroleum systems model of the northern Bonaparte Basin indicates that the potential Nancar Trough source kitchen could be currently expelling hydrocarbons from numerous Jurassic source rocks into traps on the Laminaria High. Based on a range of kinetic models defined for such source rocks within the Plover, Laminaria and Frigate formations, two phases of hydrocarbon generation are predicted. Source rocks within the Lower Cretaceous Echuca Shoals Formation are immature for hydrocarbon generation in this region. Hydrocarbon generation in the Laminaria High commenced during the mid to late Cenozoic, and in the Nancar Trough during the Early Cretaceous, in response to elevated heat flow during the syn-rift phase. The second and main phase of hydrocarbon generation and expulsion started in the mid-Eocene and is ongoing. This phase was controlled by deposition of the thick Cenozoic carbonate shelf, which resulted in deep burial and continued heating of the Mesozoic source rocks. This second phase of expulsion coincided with the reactivation of fault-bounded traps, the consequence of which is that either some or all of the initially trapped hydrocarbons have escaped out of the charged structures. Thus, the most plausible explanation for the occurrence of under-filled and dry structures within the study area is that the faults bounding these traps remained permeable from the late Miocene to the present-day. Secondary alteration processes including water washing and phase fractionation are necessary to explain the bulk composition of Laminaria High and neighbouring under-saturated light oil accumulations.



## 1. Introduction

Under-filled structures are considered potential risks for hydrocarbon exploration in many basins in Australia and globally. Several mechanisms have been proposed to explain the insufficiency of hydrocarbons in these traps. Vertical leakage due to fault reactivation is thought to play a major role in controlling hydrocarbon column heights (Sibson, 1996). The loss of initial hydrocarbon charge can also be affected by in-situ alteration (Newell, 1999; Aitken et al., 2004). Alternatively, the initial hydrocarbon charge may be insufficient to fill the traps (Brincat et al., 2004; Dyt et al., 2012).

In the northern Bonaparte Basin, which is located in the Timor Sea (Fig. 1), hydrocarbons have been discovered in Middle Jurassic sandstones in tilted, fault-bounded traps (Whittam et al., 1996; Longley et al., 2002). These structures are sealed by thick mudstones of the Upper Jurassic to Lower Cretaceous Flamingo Group and Echuca Shoals Formation (de Ruig et al., 2000). Middle Jurassic to Lower Cretaceous deltaic to marine source rocks within the Plover, Laminaria, Frigate, Flamingo and Echuca Shoals formations are believed to have generated the accumulations found within this region (Gorter and Kirk, 1995; Preston and Edwards, 2000; George et al., 2004b). Despite the exploration maturity of the Laminaria High and the neighbouring Nancar Trough and western Sahul Syncline, under-filled structures and structures without hydrocarbons continue to be drilled. The first commercial petroleum success in the Laminaria High region occurred in 1994, when Laminaria-1 discovered liquid petroleum and identified a new oil play. Within a few years, oil fields such as Laminaria, Corallina and Buffalo were

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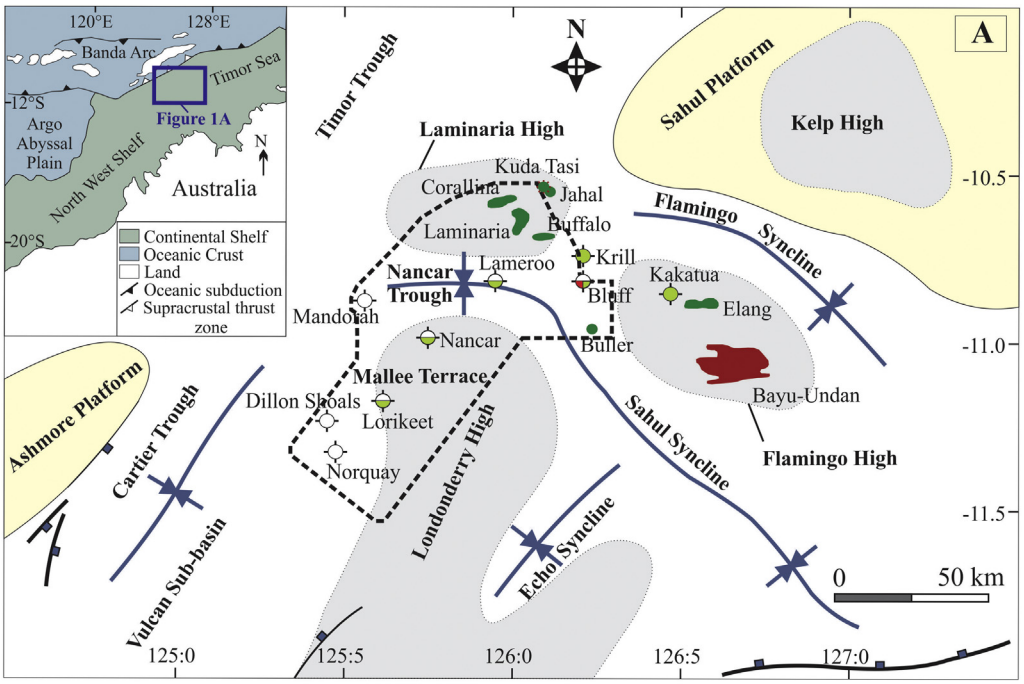
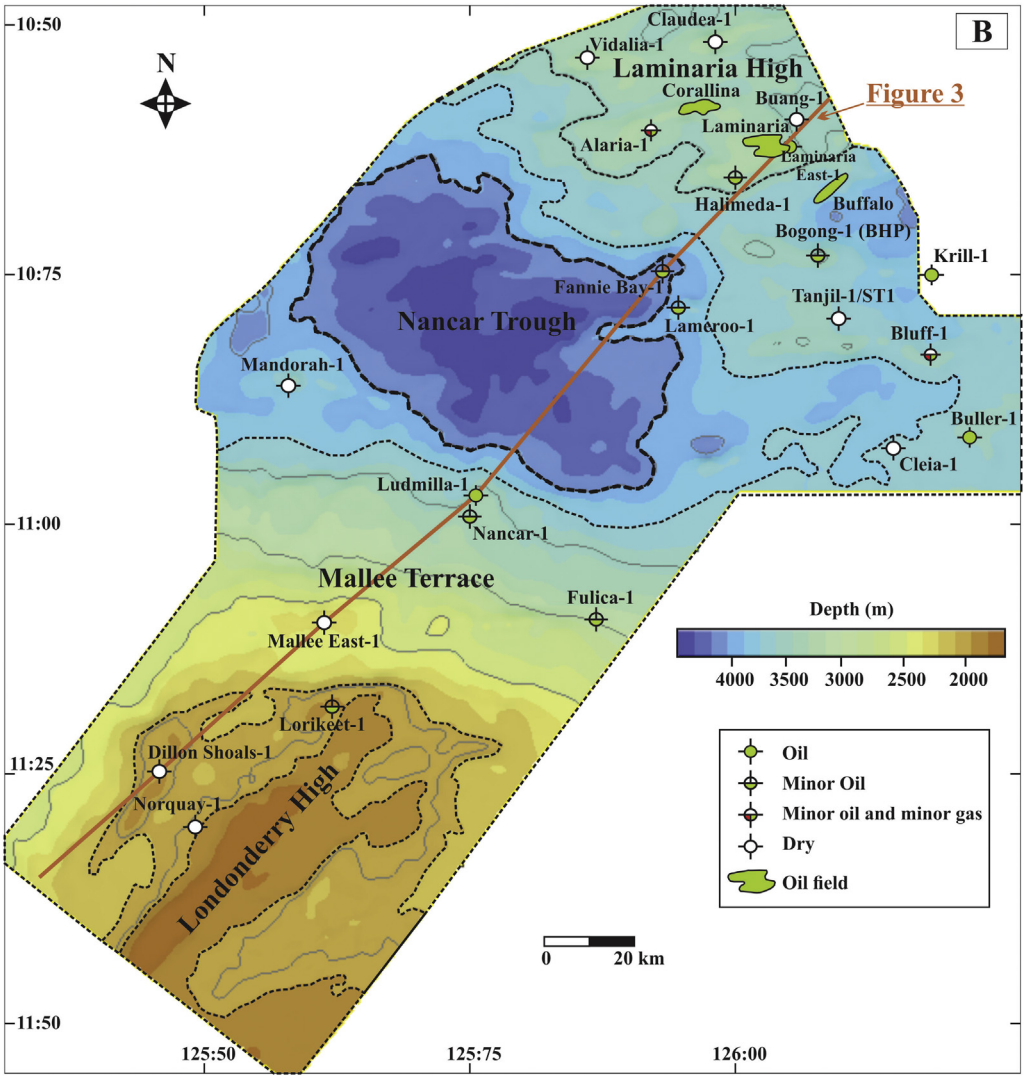

A
120°E
128°E
Banda Arc
Timor Sea
12°S
Figure 1A
Argo Abyssal Plain
North West Shelf
Australia
20°S
N
Continental Shelf
Oceanic Crust
Land
Oceanic subduction
Supracrustal thrust zone
Timor Trough
Laminaria High
Kuda Tasi
Corallina
Jahal
Laminaria
Buffalo
Lameroo
Krill
Nancar Trough
Bluff
Mandorah
Nancar
Buller
Mallee Terrace
Dillon Shoals
Lorikeet
Norquay
Londonderry High
Sahul Platform
Kelp High
Flamingo Syncline
Kakatua
Elang
Bayu-Undan
Flamingo High
Sahul Syncline
Echol Syncline
Ashmore Platform
Cartier Trough
Vulcan Sub-basin
-10.5
-11.0
-11.5
0
50 km
125:0
125:5
126:0
126:5
127:0


B
N
-10:50
-10:75
-11:00
-11:25
-11:50
125:50
125:75
126:00
Claudea-1
Vidalia-1
Laminaria High
Corallina
Buang-1
Figure 3
Laminaria
Alaria-1
Laminaria East-1
Halimeda-1
Buffalo
Bogong-1 (BHP)
Krill-1
Fannie Bay-1
Tanjil-1/ST1
Nancar Trough
Lameroo-1
Bluff-1
Mandorah-1
Buller-1
Cleia-1
Ludmilla-1
Nancar-1
Mallee Terrace
Fulica-1
Mallee East-1
Depth (m)
4000 3500 3000 2500 2000
Lorikeet-1
Dillon Shoals-1
Norquay-1
Londonderry High
Oil
Minor Oil
Minor oil and minor gas
Dry
Oil field
0
20 km