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Professor Brent I. A. McInnes (b.mcinnes@curtin.edu.au; +61 411 800 875)

"This paper has not been presented at another technical meeting."

# Tube Fossils in the Lelet Formation, New Ireland: Evidence for Miocene Hydrocarbon Seepage in the New Ireland Basin?

Brent I.A. McInnes*[1,2], Michael Nongkas[2], Harvey Cook[2], Kai Rankenburg[1], Noreen J. Evans[1], Brad J. McDonald[1] and MD Zakaria Quadir[1]

1. John de Laeter Centre, Curtin University, Perth, Australia
2. Peak Oil (PNG) Pty Ltd, Australia

## Abstract

The Lelet Limestone formation is a thick buildup of neritic platform carbonate rocks exposed on the island of New Ireland. Sedimentary facies of the Lelet include coralgal biostromal calcarenite, calcirudite and foraminiferal biomicrite (Hohnen, 1978). *In situ* coral and biohermal reef facies are also reported as present but are relatively uncommon. The base of the Lelet Formation lies unconformably over Oligocene volcanic rocks of the New Ireland island arc. It is estimated that 1,000 m of carbonate buildup occurred following the cessation of island arc volcanism in the Early Miocene (Exon and Marlow, 1988).

In the Late Miocene, a regional microplate reorganization event linked to the arrival of the Ontong Java Plateau at the Pacific-Australian plate boundary, caused rapid tectonic inversion along the New Ireland basin margin. This resulted in the former volcano-plutonic arc rocks and the overlying carbonate cap emerging above sea level throughout the Pliocene-Pleistocene and created the extensive high relief, karstic terrain on present day New Ireland.

Logging activity on the island has provided new access to the densely forested central highland region, and a recent geological expedition to fresh roadcut and quarry exposures has led to the discovery of two tube fossil locations within the Lelet Formation. These fossil tubes are comparable to ancient (Peckmann et al., 2005) and modern (Southward et al., 2002) chemosynthetic vestimentiferan worm fauna found at hydrocarbon seep deposits. Worm tubes in the Lelet localities occur in both weathered biomicrite and massive calcareous concretions in various orientations. The tubes are infilled with matrix sediment with no soft tissue preservation. Mouldic casts of gastropod and mollusk shells are found adjacent to tubes.

The tubes are non-tapered and have diameters ranging from 20-30 mm, which are some of the largest diameters reported in the fossil literature (Peckmann et al., 2005). It was not possible to determine original lengths since no unbroken specimens were observed. The tube walls are up to 2 mm thick, dark brown to tan color relative to the whitish matrix limestone, and show a concentrically laminate structure. SEM images of wall cross-sections show that the lamellae consist of ultrafine (2-4 µm) and fine (5-12 µm) calcite crystals. The roughly equant crystal sizes and curviplanar grain boundaries suggest that the tubes have experienced diagenetic recrystallisation. Age dating of the worm tubes was carried

out via *in situ* laser ablation $^{87}Sr/^{86}Sr$ mass spectrometry. Values for the two sites were 0.70837-0.70843 and 0.70845-0.70846, indicating Upper Miocene ages of 20-21 Ma and 19 Ma, respectively, however considering analytical uncertainty the two sites may be coeval.

The Miocene Lelet worm tubes can be compared to chemosynthetic fauna discovered at active hydrocarbon seeps in the offshore New Ireland basin, such as at the Edison Seamount (Herzig et al., 1994) and Mussel Cliff (Herzig et al. 1998) localities located south of Lihir Island. The Mussel Cliff locality is characterized by methanotrophic tube worms (Southward et al. 2002) and *Bathymodiolus* mussels (von Cosel and Jansen. 2008), and authigenic carbonate cements generated by thermogenic hydrocarbons (Schmidt et al. 2002). The modern Mussel Cliff tube worms described by Southward et al (2002) were identified as a new species (*Paraescarpia echinospica*), and are larger (1.0-1.5 mm diameter) than other vestimentifera varieties described from Gulf of Mexico seep localities. The Miocene Lelet worm tubes at 20-30 mm diameter, are much larger than modern New Ireland worm tubes.

Carbon and oxygen isotope studies of the samples are underway, and $\partial^{13}C$ values will shed light on whether the carbon in the Miocene worm tubes may have originated from methane seepage. Previous studies of carbonates from northwestern New Ireland with $\partial^{13}C$ of -35 to -37 per mil PDB led Rigby (1986) to hypothesize that methane seepage has been occurring since the Pliocene. If the Miocene worm tubes reported here are also confirmed to have had a methane food source, then the Lelet Limestone, with up to 25% porosity (Sandy 1986), can be considered as potentially significant hydrocarbon reservoir facies, both offshore and onshore New Ireland (Exon and Marlow, 1988).

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**Presenter CV**

Brent McInnes completed his PhD at the University of Ottawa in 1995 and has subsequently worked in geoscience research at Caltech and CSIRO. In 2009, he co-founded Peak Oil to explore for hydrocarbons in the New Ireland Basin and joined Curtin University as Executive Director of the John de Laeter Centre. His honours include the 2018 Paul Dunn Award for Research Development, the 2007 Fulbright Coral Sea Scholarship (NASA Goddard Space Flight Centre), the 2007 CSIRO National Service from Science Award (Technology Commercialisation) and the 2003 CSIRO Chairman's Gold Medal for Research Excellence (Marine Exploration).