Impact Sedimentation of the Tookoonooka and Talundilly Marine Impact Structures, Australia: An Impact Reservoir Generated by Cratering in a Petroleum Basin

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Abstract

Tookoonooka and Talundilly are two large meteorite impact structures buried in the sedimentary rocks of central Australia, and are among the largest impact structures known on Earth. They are shown to be a rare example of an ancient marine impact event and are also an extremely rare terrestrial example of a probable binary impact event. A preserved marine impact ejecta horizon, interpreted to span a vast area of the continent and corresponding to the extent of a Cretaceous epicontinental sea, is used to biostratigraphically constrain the impact age to the Barremian-Aptian boundary (125 +/- 1 Ma) in the Lower Cretaceous. Evidence is presented that the Wyandra Sandstone Member petroleum reservoir overlying the horizon is, in part, a binary impact tsunamiite.

Analyses of drill core, subsurface drilling data, and geological outcrops over >805,000 km^2 show that the base of the Wyandra Sandstone Member is an impact horizon: a widespread scour surface that is attributed to impact-related excavation and tsunami scour mechanisms. The impact horizon is underlain by seismites and overlain by very poorly sorted sediment with highly polymictic exotic clasts, imbricated pebbles, and intraformational cobble rip-up clasts. Exotic clasts are predominantly interpreted as impactoclasts, and include complex accretionary and armoured impactoclasts of vapour plume origin, shock-metamorphosed lithic fragments, and altered melt impactoclasts. Some lithic fragments resemble basement lithologies from the Tookoonooka and Talundilly target rock sequences.

The stratigraphy of the Wyandra Sandstone Member contains elements characteristic of impact tsunami deposition including ejecta entrained in high flow regime bedforms, pebble to boulder-sized clasts, >16m thick beds, and cyclic sedimentation of tsunami couplets, across five depositional realms. These elements are in stark contrast to the persistently low-energy nature of the ambient sedimentation and overlying quiescent marine shales, but are consistent with the intense seismicity, high energy seiche action and rapid deposition expected from a marine impact in a mostly enclosed basin. A dual impact source is indicated, based on sediment distribution patterns in combination with the proximity of the impact structures in age and location. The Wyandra Sandstone Member records both marine impact depositional processes as well as the waning of the event; the upper part of the Wyandra returns to background depositional energies and intense bioturbation and is conformably overlain by transgressive marine shales.

The Tookoonooka-Talundilly impact event may be an extreme prototype, as very few doublet craters, marine craters, impact tsunamiites, or economic impactites are individually known or preserved on Earth, yet this crater pair may represent all four. This impact crater pair provides a model for binary marine impact sedimentation and highlights the significance of ancient impact sediments to petroleum basins. Sedimentation patterns evidence a dual crater source even in a marine impact scenario where reworking and burial complicate the interpretation of depositional indicators; observations suggest that Tookoonooka-Talundilly may be the largest doublet crater discovered on Earth.

Thesis Declaration

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