THE TOOKOONOOKA TSUNAMI SEQUENCE: EVIDENCE FOR MARINE IMPACT IN AUSTRALIA'S LOWER CRETACEOUS.

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Introduction: The Tookoonooka Impact Structure is located in the subsurface of central Australia. It was initially discovered by seismic exploration and was confirmed to be of impact origin with the detection and measurement of PDFs (Planar Deformation Features) in shock metamorphosed quartz [1, 2]. Tookoonooka ejecta have recently been discovered in drill core in the extensive Eromanga Basin sedimentary succession within the Wyandra Sandstone Member [3-5]. The discovery has stratigraphically constrained the time of impact to approximately 125 Ma, in the Lower Cretaceous. The Wyandra Sandstone overlies the fine-grained sandstones and siltstones of the largely paralic Cadna-Owie Formation and precedes deposition of the marine shale of the Walumbilla Formation. Sedimentary evidence within ejecta beds has pointed to the probability of Tookoonooka being a marine impact event. The investigation of the broader sedimentary & stratigraphic context of the ejecta is the subject of this paper.

Background – Tsunami Sedimentation: Tsunami sedimentation is not well known from the ancient rock record [6]. Tsunami or resurge sedimentation known to originate from ancient marine impact events is even rarer. However, tsunami deposits have been associated with a few marine impact events, Chicxulub [e.g. 7], Alamo [8], Chesapeake [9], and Lockne [10] among them. Evidence cited as proof of impact provenance of tsunami deposits usually includes stratigraphic proximity to the timing of impact and entrainment of impact ejecta.

Methodology: Subsurface datasets are required to analyze the largely buried sediments of the Eromanga Basin. Whole rock samples are sparse and often discontinuous, but can be supplemented with digital data gained from petroleum exploration. Examination and detailed core-logging of 22 drill cores (including 13 continuously cored stratigraphic bores) and correlations with petroleum logs were used to provide a robust indication of the distribution of impact-related sedimentation across the basin and the stratigraphy of the Wyandra Sandstone.

Observations and Discussion: In the cores logged, the thickness of the Wyandra Sandstone varies from few meters to about 60 m. Ejecta is confined to the Wyandra Sandstone, except for a brief return to background Cadna-Owie sedimentation styles in a few locations. Only rarely do ejecta appear to be reworked into the overlying Walumbilla Formation. Plant debris is common in the Wyandra compared to the underlying Cadna-Owie, and may be an important indication of tsunami sedimentation. In none of the wells observed has ejecta been found to be deposited in a non-aqueous depositional context.

Detailed core-logging confirmed that coarse impact ejecta (up to cobble and boulder-sized) is present throughout the Wyandra Sandstone. It occurs as floating clasts within fine- to coarse-grained (usually planar-bedded or massive) matrix-supported sandstones and concentrated in clast-supported breccia-conglomerate layers. The latter are often repeated throughout the Wyandra, and occur as the basal lags of sediment packages. Thus sedimentation cycles can be resolved. Core-logging revealed that regionally the Wyandra Sandstone is comprised of a sequence of fining-upward sediment packages of decreasing energy that are thinning upward overall. Sediment packages are often capped with thin siltstones. Where fining upward trends are subtle or coarse basal layers are absent, patterns of sedimentary structures as they represent gradual waning flow energies were found to be reliable correlation tools. Individual packages, where interpreted to represent continuous deposition of a complete cycle, show a neat trend of sedimentary structures that grade from high-energy at the base (e.g. massive- and planar-bedded sandstones often with floating clasts entrained) to low-energy at the top (e.g. rippled sandstones and thin laminated siltstones).

Based on the occurrence and depositional setting of the ejecta and the sedimentation style of the Wyandra, the Wyandra Sandstone appears to be intimately linked with the impact event. It is proposed that the Tookoonooka Impact was a paralic to shallow marine target impact and that the Wyandra represents an impact tsunami sequence. It is interpreted that each fining-upward package of the Wyandra represents a single tsunami wave cycle. Based on the incompleteness of many packages, it is inferred that significant erosion would have occurred prior to the deposition of many of the sediment packages. Thus multiple tsunami cycles are represented by the thickness of the Wyandra. It is inferred that the Wyandra Sandstone was deposited very rapidly in geological terms, likely within days. Time between waves (possibly hours) is implied by the siltstone layers that would have required periodic quiescence for suspension-settling. While it is believed that individual wave cycles are not correlatable across the breadth of the basin due to localized scouring, the overall sedimentation style is consistent across most of the basin where data exists.

Conclusions: Detailed core-logging and correlation of the Wyandra Sandstone in 22 wells across the Eromanga Basin has been accomplished, and results correlated against multiple digital logs of the same section. Results show that, in concert with previous sedimentological and petrographic evidence, the Tookoonooka Impact was a paralic to shallow marine impact and the Wyandra Sandstone is an ejecta-bearing tsunami sequence originating from the impact.

This tsunami sequence is one of the few recognized impact tsunami sequences in the world. These findings have important implications for the consideration of impacts into extremely shallow marine epicontinental basins, the extent of the Tookoonooka Impact's effect on the paleo-basin, the recognition of tsunami sedimentation (and particularly *impact* tsunami sedimentation) in the ancient rock record, and the stratigraphic status of the Wyandra Sandstone Member.

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