TURBIDITE BED THICKNESS DISTRIBUTIONS SURROUNDING THE PARABURDOO SPHERULE LAYER.
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Introduction: The Paraburdoo Spherule Layer (PSL) in the Hamersley Basin of Western Australia is the distal remnant of a 2.57 Ga bolide impact formed from the vaporization, condensation, and subsequent fallout of target rock and bolide material during impact. It is preserved as a 2-cm-thick discreet direct fallout layer within thin-bedded dolomitic turbidites [1] in three locations within the Hamersley Basin: the Governor, Weeli Wolli, and Paraburdoo sites (Fig. 1).

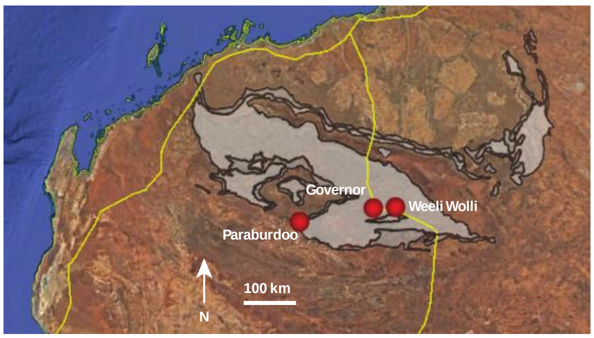

Fig. 1. Locations of the three exposed PSL sites. Overlay of Hamersley sediments on Google map image, light grey is Hamersley Group; dark grey is Jeerinah Fm.

The impact that created the PSL would have caused environmental upset on a global scale, as the bolide had an estimated diameter of 24-31 km [2]. Impact-induced atmospheric inputs, such as NO_X, SO_X, and CO_2, and subsequent rain-out of these gases in the form of acid rain [3] [4] [5] would likely have affected sedimentation on a large scale. These changes should manifest in the sedimentary record as changes in sedimentation rate, geochemistry, grain size, shape, mineralogy, composition, and altered patterns in the stratigraphy. This study primarily investigates the stratigraphic patterns associated with change in sedimentation rates, while later touching on sediment composition.

Altered patterns in the stratigraphy due to a large bolide impact may be investigated via turbidite bed thickness measurements. Turbidite bed thickness distributions can be described by the following power-law relation: $N(h) = ah^{-B}$, where N equals the number of beds with thicknesses greater than h, a is a constant, and B is the scaling exponent, or fractal dimension [6] [7] [8]. Furthermore, the shape of power-law cumulative distributions can be related to the submarine fan position [8] and basin-floor topography [9].

Power-law Distributions: Bed thicknesses of the three known sections of exposed turbidites surrounding the PSL were measured. Approximately up to 900 beds were measured, depending on available exposure at each site. Cumulative bed thickness distributions are found to follow a power-law relation. Both the shape and the slope of the curve can be used to infer paleoenvironment conditions, and here they are used to infer the fan position within the local environment as well as changes in sediment supply.

The shape of the cumulative distributions can be applied to basin-floor topography. In a base-of-slope scenario, a cumulative distribution curve is generally more convex at the base-of-slope, due to non-deposition, erosion, and amalgamation, which then progressively straightens out distally [9]. Overall, all three PSL sections exhibit power-law distributions consistent with middle to lower fan environments.

The Weeli Wolli section is the most eastern of the three exposed PSL locations. Its more curved cumulative distribution shape indicates that deposition occured in the middle fan, as opposed to the more western Governor and Paraburdoo sections, whose cumulative distributions point to a more outer fan position. This hypothesis is supported by field and rock slab observations. The Governor and Paraburdoo sections are more similar to each other, while the Weeli Wolli section shows several different features, such as soft sediment deformation and lensing of spherules above the PSL.

The shape of the cumulative distribution curve changes from below to above the impact layer in each case (Figs. 2 and 3). All three sections display a power-law distribution with two distinct segments, as opposed to an overall arch to the curve below the PSL. This change may be interpreted as transitioning to more proximal fan environments; however, this is a somewhat unlikely interpretation, given that the local environment and/or submarine fan position did not change post-impact. The change in cumulative distributions post-impact might better be interpreted in terms of other variables, such as sediment volume. Increased sediment volume into the basin post-impact may explain the changes in cumulative distribution shape at the three PSL locations.

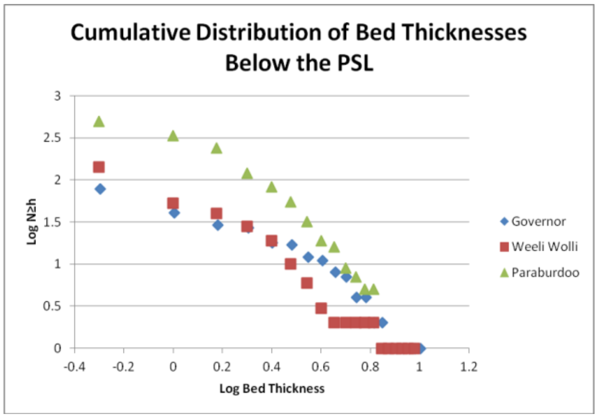

Fig. 2. Cumulative distribution of bed thicknesses below the PSL.

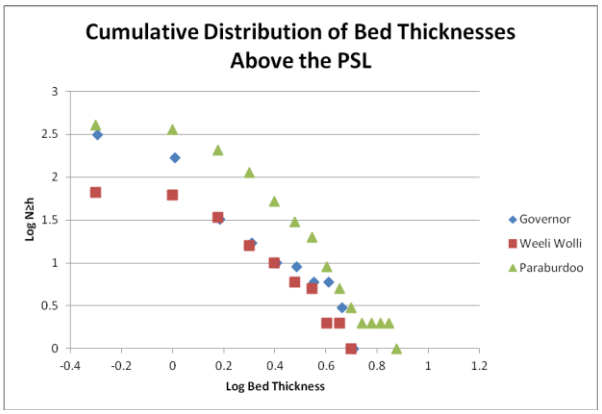

Fig. 3. Cumulative distribution of bed thicknesses above the PSL.

Adjusted R^2 values show goodness-of-fit results for power-law distribution fits to the six data sets [8] (Fig. 4). R^2 values above 0.9 are considered good fits to the power-law, although 0.85 is shown as the cutoff in Fig. 4. All of the data clearly follow a power-law distribution, as all R^2 values are greater than 0.9.

B, or the fractal dimension, decreases from below to above the PSL in each section. *B* at the Governor section decreases from -0.200 to -0.354. In the Weeli Wolli location, *B* decreases from -0.180 to -0.415. Finally, the Paraburdoo site decreases from -0.346 to -0.355. A decrease in the fractal dimension at all three PSL locations demonstrates a post-impact decrease in the self-similarity of bed stacking patterns in the turbidite sequences. This may be due to a change in the stability of the environment after impact, with more rapid environmental change. Further investigation will look at shorter term changes above the bed to see if this diminishes through time.

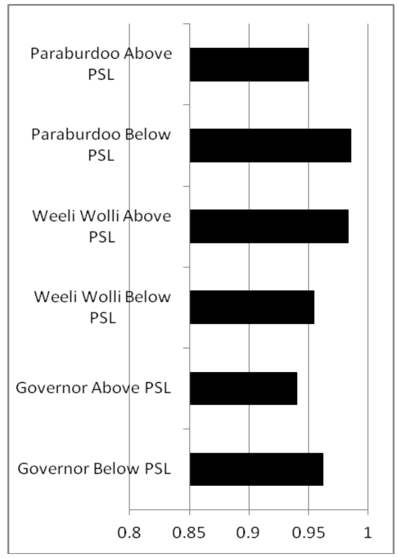

Fig. 4. Adjusted R^2 values for power-law fits to all six data sets.

Point Counts: Preliminary point counts of two sandy beds below and above the PSL at the Governor and Weeli Wolli sites show different amounts of mud overall when compared to each other. Paraburdoo point counts are ongoing. The Governor section exhibits more mud in the four point counted sandy beds than does the Weeli Wolli section. This observation of more sand in the Weeli Wolli location may further support its mid-fan assignment.

When only one sandy bed below and above the PSL in both locales is considered, a decrease in the amount of mud in comparison to the carbonate grains is apparent. From this result, we may speculate that the ratio of mud to carbonate grains in the system are affected immediately following the impact. More investigation is required, however, to make a definite statement. Ongoing point counts should lend support or refute this initial conclusion.

References: [1] Hassler S. W. et al. (2011) *Geology, 39*, 307–310. [2] Goderis, S. et al. (2013) *Earth and Planetary Science Letters, 376*, 87-98. [3] Melosh, H. J. (1989) *Oxford University Press*, 245. [4] Pierazzo, E., and Melosh, H. J. (2013) *Wiley-Blackwell*, 146-156. [5] Prinn, R. G., and Fegley, B. Jr. (1987) *Earth and Planetary Science Letters, 83*, 1-15. [6] Hiscott R. N. et al. (1992) *Proceedings of the Ocean Drilling Program, 126*, 75–96. [7] Rothman D. H. et al. (1994) *Journal of Sedimentary Research, 64A*, 59–67. [8] Carlson J. and Grotzinger J. P. (2001) *Sedimentology, 48*, 1331–1351. [9] Sinclair H. D. and Cowie P. A. (2003) *The Journal of Geology, 111*, 277–299.