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How can we assess the processes that control recurrence intervals of landslide-generated turbidites?

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We analyse sedimentary deposits from three distal basin plain settings that are disparate in terms of their geography, physiography and age. These include an outcrop study (N=696 turbidites) from the Miocene Marnoso Arenacea Formation in the Italian Apennines, cores from the Balearic Abyssal Plain (N =151) and boreholes from the Madeira Abyssal Plain (N=108). In each case, stacked sequences of turbidity current deposits intercalated with subordinate hemipelagite beds are identified. On the basis of bed geometries and inferred deposit volumes (0.7 to 500 km^3), the turbidity currents are interpreted to have been triggered by slope failures on the basin margins, rather than in relation to hyperpycnal flood discharge. Inter-event times (i.e. recurrence intervals) are determined from hemipelagic bed thicknesses and from a calibrated age-stratigraphic framework. Erosion of hemipelagite beds beneath turbidites is non-existent or negligible; hence these distal depositional sequences can be regarded as long term catalogues of landslide activity that may also be used to understand tsunami risk.

The distribution of inter-event timings is indicative of an exponential relationship (i.e. Poisson process). This satisfies two conditions: 1) a lack of memory, and 2) a constant probability of event occurrence through time. An exponential distribution can be characterised by just one parameter, λ, which is defined as the rate parameter, or mean inter-event time. To test this inferred distribution, each data set is normalized to λ and exceedance plots are generated in relation to R_T (a dimensionless expression of inter-event time). Remarkably, the data align extremely well, despite their disparity in age, location and setting. A fit with an exponential growth curve is good (R^2=0.98); however, the longest inter-event times (R_T >3) are slightly underrepresented. A similar observation is made by comparing suites of randomly generated synthetic data against the actual data. A Generalised Linear Model is fitted to the data, using a Gamma distribution (of which the exponential is a special case). This indicates a dispersion parameter, α, of between 1.2 and 1.8 is appropriate for the data sets. This can be regarded as an exponential distribution and the small deviation in shape parameter accounts for the slight overpopulation in the tail of the data.

Statistical tests, including survival analysis, Cox's proportional hazards model and Hurst statistic, indicate that event timings do not show significant clustering and, surprisingly, occur independent of variations in sea level. Despite this, event magnitude does appear to be related to eustatic variations. It is suggested, that a governing discrete stochastic process controls the timing of landslide-triggered turbidity currents in distal basin plain settings, regardless of their locale or age. This may be explained by exponential distributions that have been identified for recurrence times of large magnitude earthquakes globally. A determination of event frequency distribution and related dispersion parameter, can inform predictions of future events or inference of larger data populations from small samples. This will support statistically meaningful analyses for forward-looking geohazard assessment.