Forum Comment

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Can turbidites be used to reconstruct a paleoearthquake record for the central Sumatran margin?

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We question the methods and conclusions of Sumner et al. (2013) who claim that their study casts doubt on the use of turbidites in paleoseismology. We believe their results are more simply explained.

Their introduction and their table 1 are inaccurate because: (1) the "confluence test" entry shows the number of turbidites varies with height above the thalweg; yet the relevant cores came from channel thalwegs (Nelson et al., 2000; Goldfinger et al., 2012); (2) mineralogy (Nakajima and Kanai, 2000), biota (Pouderoux et al., 2012), event counts (Adams, 1990), and current directivity (Van Daele et al., 2014) show that confluence tests can establish synchronous triggering and earthquake origin versus storms or floods; "synchronous deposition" depends not only on ages, but on tephras (Adams, 1990; Pouderoux et al., 2012), lithostratigraphic correlation, relative dating tests, and seismic profiles (Goldfinger et al., 2012, 2013); (3) turbidite volumes in cores may show relative event "size," but spatial density is required for replication and validation (Goldfinger et al., 2012).

With nine coring locations (mostly short multicores) on the ~900 km margin, the sampling of Sumner et al. was inadequate. Spatial extent (with good site selection) is a primary test of earthquake origin. Adams (1990) and later Goldfinger et al. (2012) used >100 cores, preceded by decades of research on transport paths, mineralogy, and sedimentology; Patton et al. (2013) used 109 cores off Sumatra.

Understanding of flow paths, source zones, and depositional subtleties is critical. Without this analysis, results may be determined by site selection, as likely occurred in this study. Sumner et al. state that few coherent slides are found on the Sumatran margin, but these are not required, nor is the observational scale appropriate. Coherent failures and turbidity currents are different processes, and the former may not transform into the latter. The Sumatran margin is in fact riddled with eroded fold limbs and small slides, evidence of widespread failures. Sumner et al.'s sites 5 and 12 are in wide flat basins, a morphology proven to be ineffective in Cascadia (Goldfinger et al., 2012) and which was therefore avoided by Patton et al. (2013). Core 5 is located >30 km from the mouth of a local canyon, and 20 km from local slopes. Local wall failures are not channelized and turbidity currents wane rapidly across basins (in <2 km at Hydrate Ridge basin; Goldfinger et al., 2012). Core 4 is located in a small basin in subdued complex topography with no clear pathway for turbidity currents. Cores 7 and 14 are located ~1 km from steep local slopes and do have turbidites. The authors also focused on segment boundaries (Simeulue and Batu areas; seven out of nine sites) that are characterized by low slip and complex structural and slip transfer mechanisms during earthquakes. Coring sites focused near segment boundaries, with large gaps in between, severely hampered this study.

Patton et al. (2013) found evidence of a 2004 turbidite in 15 of 17 cores; i.e., a very young, soupy, surficial turbidite, near zero ^{210}Pb and radiocarbon ages, and no surface hemipelagite. The Sumner et al. cores were not in the 2004 zone. Cores 2 and 4 are ~20–30 km south, and core 5 was ~50 km south of the 1 m slip contour. Globally, seismic triggering distances for failures are short in low-Q accretionary wedge settings. Proximal core 2 appears to contain a 2004 turbidite and no surface hemipelagite. Patton et al. (2013) also found that the 2005 rupture area has a limited turbidite record, possibly due to deeper slip in that area (e.g., the 2005 rupture). More distant cores (11–18) may not be relevant to the ruptures mentioned.

The limited radiometric data in the paper are misleading. ^{210}Pb count data are not provided (except for 4MC), making interpretation problematic. Additionally, too few samples were collected from which to draw conclusions. Sedimentation rates are not resolved properly; e.g. in core 4, there are some possible turbidites between the ^{210}Pb sample locations. The paper also lacks support for the lithology from paleontology, chemistry, grain size (data, only sketches shown), or other avenues.

The authors assume that because they do not see a 2004 turbidite, that great earthquakes do not always generate turbidity currents. They may not, but a more likely explanation in this case is poor experimental design and lack of data in the 2004 zone. Sumner et al. conclude with the question "can we determine which settings are most suitable for turbidite paleoseismology?" An extensive and growing literature does just that (e.g., see Pouderoux et al., 2012; Patton et al., 2013; Goldfinger et al., 2012, and references therein; Van Daele et al., 2014; and many other resources).

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