Geology

Sea-level–induced seismicity and submarine landslide occurrence: COMMENT

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Geology 2014;42;e337
doi: 10.1130/G35254C.1

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doi:10.1130/G35254C.1

Sea-level–induced seismicity and submarine landslide occurrence

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Brothers et al. (2013) present modeling showing how rapid sea-level rise (SLR) could generate increases in stresses experienced by fault systems, which may lead to increased seismicity. This potential for linkage between rapid SLR and increased seismicity is an important result of widespread interest. However, a key assertion by Brothers et al. is that such increases in seismicity can then explain the "temporal coincidence between rapid late Pleistocene sea-level rise and large-scale slope failures." The primary purpose of this Comment is to note that available age-dating of large submarine landslides (hereafter: slides) is not consistent with such a view. Once realistic uncertainties in slide ages are considered (Urlaub et al., 2013), there is either (1) no statistical relationship between rapid SLR and large slide frequency, or (2) the uncertainties in age-dates are too large for a correlation between rapid SLR and landslide timing to be recognized, even if a correlation existed.

It is important to have a clear understanding of whether the frequency of large slides is (or is not) dependent on sea level. First, submarine slides can potentially generate damaging tsunamis. We need to understand whether there is an increased landslide-tsunami risk in the future as sea level rises. Second, these large slides are one of the major processes for moving sediment across Earth, and factors that precondition and trigger these prodigious failures are still poorly understood.

Urlaub et al. (2013) provide the most recent and largest (n = 68) collection of ages for large (>1 km^3) submarine slides. Importantly, this study considered the uncertainties in these ages, which are mainly due to the position of samples relative to the slide deposit, and to vertical mixing of sediment by organisms (Urlaub et al., 2013, their figure 1). Urlaub et al. show that large slide ages can be described by a Poisson distribution that characterizes a temporally random process, and that peaks in slide frequency can be reproduced when ages are drawn from a temporally random distribution. The frequency distributions of ancient slides surrounding a basin margin, which disintegrate to form large turbidity currents, also appear to have a temporally random Poisson distribution (Clare et al., 2014).

DATABASE OF LANDSLIDE AGES

The following points are pertinent to the data of slide ages presented by Brothers et al. in their Table DR1.

(1) Error bars on slide ages: The real uncertainties in slide ages are typically much greater than those presented in Table DR1, with the exception of Grand Banks and Nice events. A full discussion of the uncertainties of many slide ages is given by Urlaub et al. (2013).

(2) The criteria according to which slides were selected for the database is not clear*:* Relatively well-dated large slides are omitted in Table DR1, such as those recorded by turbidites in the Madeira, Agadir, Seine, and Herodotus basins, or the Balearic and Tagus Abyssal plains. Some ages are not well supported by the cited reference. There is no evidence of an event at 15 ka in the Madeira Abyssal Plain, but it is likely that events occurred at 0.93 and ca. 30 ka (Wynn et al., 2002). The Sahara Slide is counted twice. It is unclear why four dates from the Baltimore–Norfolk Canyon slide indicate four slides, as this is not supported by the original study (Embley, 1980). The canyon-head slide off Nice Airport was relatively small (0.008 km^3; Piper and Savoye, 1993) and it is not clear what constitutes a 'large' slide. The Canary Slide originated from a volcanic island where processes may differ from those on passive margins, modeled by Brothers et al.

SLIDE FREQUENCY AND MELTWATER PULSES

Brothers et al. conclude that ~50% of the total volume of submarine sediment remobilized in the last 125 k.y. was moved by large slides in the period 15–8 ka. Such a conclusion is not warranted because numerous large slides are yet to be dated or mapped, and core penetration biases available dates to younger events (typically <30 ka; Urlaub et al., 2013). The available slide ages (Urlaub et al., 2013) also do not appear to support Brothers et al.'s proposal that slides cluster at 15 and 11 ka, linked to meltwater pulses 1A and 1B. This casts further doubt on whether observed changes in atmospheric methane concentrations are linked to more frequent slides.

MASS FLOW ACTIVITY ON SUBMARINE FANS

Brothers et al. propose that increased seismicity due to rapid SLR could account for "unexpected deep-water sandy turbidite and debris flow deposition during sea-level transgression." We now know that the timing of increased flow activity on fans is highly variable, such that flow activity during transgression is not unusual (Covault and Graham, 2010). Increased turbidity current activity during deglaciation is likely to result from increased sediment supply from rivers, even in systems where turbidity currents are triggered by processes other than plunging hyperpycnal flow.

SUMMARY

The modeling by Brothers et al. is timely and innovative, and it suggests that rapid SLR may have important additional consequences beyond coastal flooding. There could be a link between large slide occurrence and climatic change or sea level that is as yet hidden by the large uncertainties in most slide dates. The only precisely (±150 yr) dated pre-historical large slide is the Storegga Slide off Norway, and it coincides with the significant and well-dated 8.2 ka cold event recorded by Greenland ice cores (Bondevik et al., 2012). However, care must be taken when asserting that the temporal coincidence between rapid SLR and increased slide frequency is well documented, as this is not supported by available field data.

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