Nat. Hazards Earth Syst. Sci., 10, 713–715, 2010
www.nat-hazards-earth-syst-sci.net/10/713/2010/

Natural Hazards and Earth System Sciences

Brief communication
"Does the Eltanin asteroid tsunami provide an alternative explanation for the Australian megatsunami hypothesis?"

J. R. Goff and D. Dominey-Howes

Australian Tsunami Research Centre and Natural Hazards Research Laboratory, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney 2052, Australia

Received: 30 November 2009 – Accepted: 22 March 2010 – Published: 12 April 2010

Abstract. The Australian megatsunami hypothesis has been developed over two decades. It charts repeated inundation of the South East Australian coast during the Holocene by bolide impact megatsunamis. The most enigmatic evidence for these proposed events are high elevation cliff-top boulders. There is however an absence of known sources for these megatsunamis, and as such we question whether the researchers may have the correct mechanism but the wrong events. Given the low denudation rates of this passive, intraplate environment, we suggest that boulder emplacement may have been solely the result of the much older Eltanin asteroid tsunami about 2.5 Ma ago.

1 Brief communication

Boulders deposited on cliff-tops up to 33 m above sea level (m a.s.l.) along the coast of South Eastern Australia may attest to the occurrence of numerous Holocene megatsunamis reportedly associated with bolide strikes into the Tasman Sea at intervals of 1:600–800 years (Bryant et al., 2001; Bryant, 2008). This has been termed the Australian megatsunami hypothesis (Goff et al., 2003). The proposed late 15th century Mahuika Comet is used as a case study to describe the geological and geomorphological after-effects of such impacts (Bryant et al., 2007). The evidence however, for such megatsunamis represents a marked disjunct with other geological traces for smaller prehistoric events along the same coast (Dominey-Howes, 2007). Although controversial, if true, the implications for coastal tsunami risk management are profound and emergency management agencies are entirely unprepared for the future occurrence of such events. Determination of the actual source events and mechanisms for these proposed SE Australian megatsunamis is critical for gaining an improved understanding of risk.

In all cases, boulders are derived from, and rest unconformably upon, the underlying regional geology (Bryant, 2008 and references therein). It seems most plausible that the boulders owe their origin to one or more unusually large waves because they rest well above the highest historic storm wave height (Bryant, 2008). Determining the origin of such unusually large waves however, is problematic. All known possible earthquake sources are too small to generate tsunamis with run-ups in excess of 30 m a.s.l.; there are no known significant local or regional volcanic sources; and there is no known evidence for sufficiently large submarine mass failures off the adjacent continental shelf during the Holocene (Bryant, 2008). This leads to the conclusion that these boulders must have been emplaced by megatsunamis following bolide impacts (Bryant et al., 2007; Bryant, 2008). There is however, no evidence to support the claim of a comet impact in the Tasman Sea around the late 15th century (Sekinina and Yeomans, 1984; D. K. Yeomans, personal communication, 10 March 2009; Goff et al., 2010) and there are no known Holocene asteroid strikes in the Tasman Sea. These astronomical data are borne out by a comprehensive study of Holocene palaeotsunami deposits in New Zealand (Goff, 2008; Goff et al., 2010). Several 15th century palaeotsunami deposits representing different local or regional events are reported (Goff, 2008). A trans-Tasman Sea comparison however, shows no correlation between evidence from the New Zealand and the east coast of Australia (Goff and Dominey-Howes, 2010) – a very powerful argument for rejecting a region-wide signal associated with a 15th century bolide impact.

Correspondence to: J. R. Goff
(j.goff@unsw.edu.au)

Published by Copernicus Publications on behalf of the European Geosciences Union.

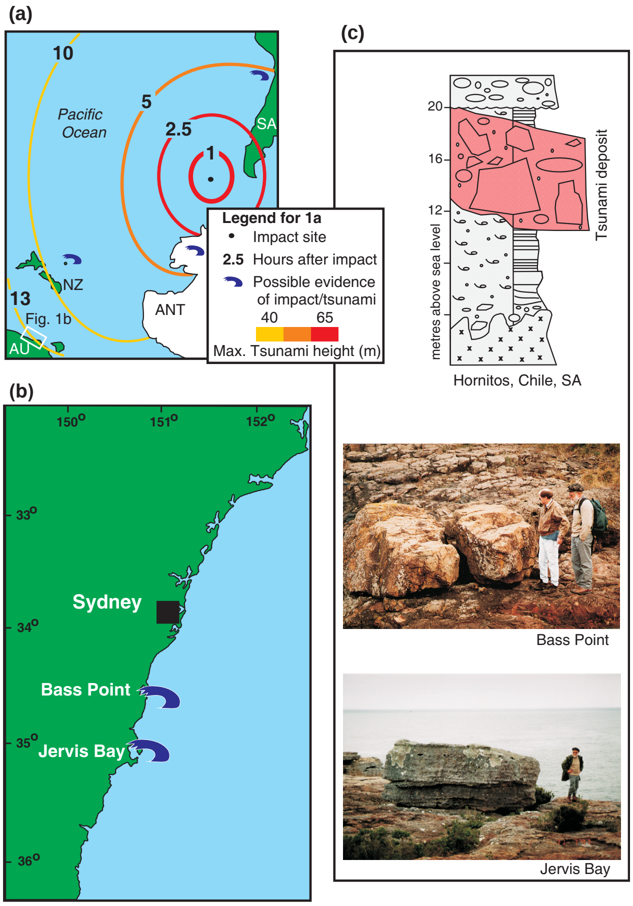

Fig. 1. **(a)** Eltanin asteroid impact location and maximum tsunami wave heights at noted time intervals after impact (based upon data from (Ward and Asphaug, 2002). Small blue waves indicate the approximate locations where possible evidence for Eltanin asteroid impact or tsunami inundation has been reported (Gersonde et al., 1997; Holdaway et al., 2001; Hartley et al., 2001). AU = Australia, NZ = New Zealand, ANT = Antarctica, SA = South America. **(b)** Detail of SE Australian coast showing the location of two sites where elevated cliff-top boulders have been reported (Bryant, 2001). **(c)** Summary stratigraphic column for evidence from Chile (after Hartley et al., 2001), and photographs of boulders from the two sites shown in (b) (Geological Traces of Giant Tsunamis on the New South Wales south coast of Australia, http://omzg.sscc.ru/tsulab/austral.html).

If we assume that the boulders we see were the result of megatsunami emplacement and that submarine landslides, volcanoes, and earthquakes were not the cause, is it possible that researchers have the correct source mechanism (bolide impact) but the wrong event(s)? We ask whether the Eltanin asteroid (Gersonde et al., 1997) tsunami could have been a sufficiently large source to explain elevated cliff-top boulder deposits along the SE Australian coast and if so, whether dating and other chronological evidence exists to better constrain the ages of the observed cliff-top boulders?

The Eltanin asteroid impact and tsunami occurred ca. 2.5 million years ago (Gersonde et al., 1997, 2002). The impactor was 1–4 km in diameter and initial deep-ocean wave heights are calculated to have exceeded 65 m (Ward and Asphaug, 2002). Models indicate maximum open water wave heights of 40 m at New Zealand and SE Australia from 10 to 13 h after impact, respectively (Fig. 1). It is surprising therefore that there is a paucity of evidence for megatsunami inundation in the southern Pacific Ocean (Fig. 1). Passing reference is made to the possible effects of inundation on the terrestrial fauna of the Chatham Islands, New Zealand (Holdaway et al., 2001). A tentative interpretation is also made for Eltanin asteroid tsunami deposits up to 10 m thick and between 12 and 20 m a.s.l. in northern Chile (Hartley et al., 2001). The most controversial evidence for an Eltanin asteroid impact however, relates to the presence of marine diatoms in the Sirius Formation, Antarctica (Gersonde et al., 1997). Given the capacity of these coastal margins to actively obscure post-depositional evidence through tectonic or glacial activity, it may be more appropriate to investigate the sedimentary records of passive, intraplate environments and the New South Wales coast of SE Australia provides just such a place.

Recent ^{10}Be and ^{26}Al dating by Switzer et al. (2009) indicates that some of these cliff-top boulders have consistent exposure ages of ∼250 ka and ∼300 ka. Furthermore, the boulders rest upon a contemporary platform with an exposure age of ∼145 ka. These data raise two key issues. First, that at least some of the cliff-top boulders are considerably older than the Holocene and the proposed late 15th century event. Second, these cliff-top surfaces experience extremely slow denudation rates and as such the boulders resting on them are most likely related to an earlier overlying sequence exposed by surface erosion at least 250 ka years ago.

The work of Switzer et al. (2009) concurs with existing evidence for exceptionally low rates of land surface denudation in Australia (Tomkins et al., 2007). It is therefore conceivable that the elevated cliff-top boulders along the New South Wales coastline were deposited by the Eltanin tsunami and have experienced little post-depositional movement. If our proposition is correct, and it does need to be properly tested, it has important implications for the timing of events associated with the Australian megatsunami hypothesis.

Modelling work suggests that the Eltanin Asteroid tsunami was large enough to have had a significant impact on coasts bordering the south Pacific, but evidence to date appears to be equivocal. Perhaps this is not the case and the elevated cliff-top boulder deposits along the coasts of SE Australia provide evidence of this single megatsunami and not as previously reported, that of numerous Holocene events.

Edited by: S. Tinti
Reviewed by: W. Dudley and another anonymous referee

References

Bryant, E. A.: Tsunami: The underrated hazard, 2nd edn., Springer Praxis Publishing, Chichester, 2008.

Bryant, E., Walsh, G., and Abbott, D.: Cosmogenic mega-tsunami in the Australia region: are they supported by Aboriginal and Maori legends?, in: Myth and Geology, edited by: Piccardi, L. and Masse, W. B., Geol. Soc. London Special Pub. No. 273, 203–214, 2007.

Dominey-Howes, D.: Geological and historical records of tsunami in Australia, Mar. Geol., 239, 99–123, 2007.

Gersonde, R., Deutsch, A., Ivanov, B. A., and Kyte, F. T.: Oceanic impacts – a growing field of fundamental geoscience, Deep-Sea Res. Pt. II, 49, 951–957, 2002.

Gersonde, R., Kyte, F. T., Bleil, U., Diekmann, B., Flores, J. A., Gohl, K., Grahl, G., Hagen, R., Kuhn, G., Sierro, F. J., Volker, D., Abelmann, A., and Bostwick, J. A.: Geological record and reconstruction of the late Pliocene impact of the Eltanin asteroid in the Southern Ocean, Nature, 390, 357–363, 1997.

Goff, J., Dominey-Howes, D., Chagué-Goff, C., and Courtney, C.: Analysis of the Mahuika comet impact tsunami hypothesis. Mar. Geol., 10.1016/j.margeo.2010.02.020, in press, 2010.

Goff, J., Nichol, S. L., and Kennedy, D.: Development of a palaeotsunami database for New Zealand, Nat. Hazards, , doi:10.1007/511069-009-9461-5., in press, 2010.

Goff, J.: The New Zealand Palaeotsunami Database, NIWA Technical Report 131, ISSN 1174-2631, 24 pp. + Appendix, 2008.

Goff, J. and Dominey-Howes, D.: Australasian palaeotsunami – Do Australia and New Zealand have a shared Trans-Tasman prehistory?, Earth-Sci. Rev., 9, 847–854, 2009.

Goff, J., Hulme, K., and McFadgen, B. G.: "Mystic Fires of Tamaatea": Attempts to creatively rewrite New Zealand's cultural and tectonic past, J Roy. Soc. New Zeal., 33, 1–15, 2003.

Hartley, A., Howell, J., Mather, A. E., and Chong, G.: A possible Plio-Pleistocene tsunami deposit, Hornitos, northern Chile, Rev. Geol. Chile, 28, 117–125, 2001.

Holdaway, R., Worthy, T. H., and Tennyson, A. J. D.: A working list of breeding bird species of the New Zealand region at first human contact, New Zeal. J. Zool., 28, 119–187, 2001.

Sekanina, Z. and Yeomans, D. K.: Close encounters and collisions of comets with the Earth, Astron. J., 89(B1), 154–161, 1984.

Switzer, A., Felton, A., and Fink, D.: The age of the coastal cliff-top platform and boulders at Little Beecroft Head, southeast Australia, International Conference on Geomorphology 2009, Ancient landscapes – Modern perspectives, Melbourne, Abstract 1169, 2009.

Tomkins, K. M., Humphreys, G. S., Wilkins, M. T., Fink, D., Hesse, P. P., Doerr, S. H., Shakesby, R. A., Wallbrink, P. J., and Blake, W. H.: Contemporary versus long-term denudation along a passive plate margin: the role of extreme events, Earth Surf. Proc. Land., 32, 1013–1031, 2007.

Ward, S. N. and Asphaug, E.: Impact tsunami-Eltanin, Deep Sea Res. Pt. II, 49, 1073–1079, 2002.

Young, R. W., Bryant, E. A., Price, D. M., Dilek, S. Y., and Wheeler, D. J.: Chronology of Holocene tsunamis on the southeastern coast of Australia, T. Jpn. Geomorp. Un., 18, 1–19, 1997.