January 1992

Catastrophic wave erosion on the southeastern coast of Australia: Impact of the Lanai tsunamis ca. 105 ka?: Reply

R. W. Young
University of Wollongong

Edward A. Bryant
University of Wollongong, ebryant@uow.edu.au

Catastrophic wave erosion on the southeastern coast of Australia: Impact of the Lanai tsunamis ca. 105 ka?: Reply

Keywords
tsunami, bedrock erosion, Hawaii, New South Wales, submarine landslide

Disciplines
Life Sciences | Physical Sciences and Mathematics | Social and Behavioral Sciences

Publication Details
This article was originally published as Young, RW and Bryant, EA, Catastrophic wave erosion on the southeastern coast of Australia: Impact of the Lanai tsunamis ca. 105 ka?: Reply, Geology, 20, 1992, 1151.

curred, and any one of them could have been responsible for the loss of the sand barrier. A causal relation between tsunami erosion in Australia and a tsunami generated from submarine slides on the Hawaiian Ridge would therefore seem unlikely.

REFERENCES CITED

Imbrie, J., and eight others, 1984, The orbital theory of Pleistocene climate: Support from a revised chronology of the marine $\delta^{18}O$ record, *in* Berger, A., ed., Milankovitch and climate: Hingham, Massachusetts, D. Reidel, p. 269–305.

Moore, J., Clague, D., Holcomb, R., Lipman, P., Normark, W., and Torresan, M., 1989, Prodigious submarine landslides on the Hawaiian Ridge: Journal of Geophysical Research, v. 94, p. 17,465–17,484.

Moore, G., and Moore, J., 1988, Large scale bedforms in boulder gravel produced by giant waves in Hawaii, *in* Clifton, H.E., ed., Sedimentologic consequences of convulsive geologic events: Geological Society of America Special Paper 229, p. 101–110.

Moore, J., and Moore, G., 1984, Deposit from a giant wave on the Island of Lanai, Hawaii: Science, v. 226, p. 1312–1315.

Tucholke, B., 1992, Massive submarine rockslide in the rift-valley wall of the Mid-Atlantic Ridge: Geology, v. 20, p. 129–132.

Van Dorn, W., 1961, Some characteristics of surface gravity waves in the sea produced by nuclear explosions: Journal of Geophysical Research, v. 66, p. 3845–3862.

Young, R., and Bryant, E., 1992, Catastrophic wave erosion on the southeastern coast of Australia: Impact of the Lanai tsunamis ca. 105 ka?: Geology, v. 20, p. 199–202.

REPLY

R. W. Young
E. A. Bryant
Department of Geography, University of Wollongong, Wollongong 2500, Australia

We agree that our proposal linking erosion on the coast of southeastern Australia with the long-distance effect of the Lanai tsunamis is conjectural, as indicated by the question mark ending the title of our paper (Young and Bryant, 1992). Even so, we cannot agree with Jones's argument that such long-distance effects are impossible.

We are in no position to argue the details of Hawaiian geology, but we must say, albeit from the southwestern Pacific rim, that the documented evidence of extremely high wave runup on Lanai still seems compelling. We cannot see how the data presented in Jones's Figure 2 are at odds with this proposal. On the contrary, the range of ages ca. 200 ka between 10 and 75 m on Lanai shown in that figure demonstrates that the 105 ka sea level was at a lower elevation, and therefore that the presence of wave-deposited sediment of that age currently to an elevation of 326 m is still indicative of colossal runup, not uplift.

The central issue raised by Jones is the long-distance attenuation of tsunamis. However, perusal of studies of tsunamis in recent times (Bryant, 1991) suffices to invalidate Jones's claim that a wave with a runup of at least 326 m on Lanai would be reduced to 10 cm when it reached the Australian coast. For example, the tsunami of 1877, which produced a surge of 14 m on the nearby Chilean coast, elevated the tide gauge by 1 m when it reached Sydney, 10 000 km away, despite being refracted around New Zealand. The 1960 Chilean tsunami produced an elevation of 0.85 m at Sydney and 3.5 to 6 m on the Japanese coast; the great tsunami of 1755, which surged 15 m deep over parts of Lisbon, was still 3 to 4 m high when it reached Barbados and Antigua in the West Indies. Thus, Jones's use of Van Dorn's equation (Van Dorn, 1961) is inappropriate.

Van Dorn (1961) proposed that wave phenomena such as those generated by atmospheric nuclear bomb blasts and maybe tsunamis could be modeled as dispersive waves. Our argument is not with the accuracy of this model, but with its applicability to tsunamis generated by slides. The examples given above show that tsunamis in the Pacific do not behave necessarily as dispersive waves. More important, the wave heights generated by subaqueous slides depend upon the volume of the slide and its acceleration. Harbitz (1992) has modeled the wave dynamics for the Storegga slides in the Norwegian Sea, the first of which had a volume of 3880 km^3. He assumed that the slide had an acceleration approximating that of the well-documented Grand Banks, Newfoundland, event of 1929. While the modeled open-ocean water displacement was around 2 m, the resulting wave heights on the Greenland coastline 1200 km away reached heights over 5 m. The Alika slides in Hawaii, which have been associated with the Lanai gravel deposits at 105 ka (Moore et al., 1989), and which be believe to be related to the Tura Point erosional event in New South Wales, had a maximum volume of 400 km^3. If these slide are the cause of the deposition of the Lanai gravels (Jones is correct in pointing out that this is conjectural), then the slide generated a runup of over 350 m (Moore and Moore, 1984) after traveling 150 km. These exceptional runup heights have been documented only over short distances of several kilometres, as evidenced by the Alaskan slide of 1958 which sloshed water to a height of 524 m within the confines of a fjord (Moore and Moore, 1984). Even allowing for uplift at Lanai as suggested by Jones, the Lanai sands and gravels represent the presence of a large slide-induced tsunami event.

We are not inflexible regarding the Alika slide of Hawaii as the source of the Tura Point erosion, although directional indicators of erosion along the southern New South Wales coastline point in this direction. There have been at least six slides on the southwestern flanks of the Hawaiian Islands, any one of which could have generated the waves required for the erosion evidenced in New South Wales. The crucial factor is not one necessarily of distance, as modeled by Van Dorn (1961) and supported by Jones, but one of flow volume and acceleration, as modeled by Harbitz (1992). Further investigation of the Hawaiian slides is warranted, particularly regarding their dating and the modeling of their local and long-distance wave effects.

We do not want our hypothesis for the erosion of the Tura Point ramp to be overwhelmed by debate about the source of the event or by the nature of the wave progression. We have described for the first time evidence of dramatic erosion in the coastal zone analogous to that summarized by Baker (1978) for fluvial systems in the Scablands of Washington State. The impact of this event was profound. In suggesting that any of a postulated 250 tsunamis "could have been responsible for the loss of the sand barrier," Jones has not recognized this impact. Pleistocene barriers along a 500 km stretch of coast were completely destroyed or severely eroded. Surely our evidence is not unique. If the tsunami that produced this erosion had a distant source such as the Hawaiian Islands, then our conclusion that such an event must have left an imprint elsewhere along the Pacific coastline is still applicable.

Ours was obviously a controversial claim, and we thank Jones for debating it. We hope that our differences of opinion will encourage further research into the imprint of catastrophic events on the coastal record.

REFERENCES CITED

Baker, V.R., ed., 1978, Catastrophic flooding: The origin of the Channeled Scabland: Stroudsburg, Pennsylvania, Dowden, Hutchinson and Ross.

Bryant, E.A., 1991, Natural hazards: Sydney, Cambridge, 294 p.

Harbitz, C.B., 1992, Model simulations of tsunamis generated by the Storegga slides: Marine Geology, v. 105, p. 1–21.

Moore, J.G., and Moore, G.W., 1984, Deposit from a giant wave on the island of Lanai, Hawaii: Science, v. 226, p. 1312–1315.

Moore, J.G., Clague, D.A., Holcomb, R.T., Lipman, P.W., Normark, W.R., and Torresan, M.E., 1989, Prodigious submarine landslides on the Hawaiian ridge: Journal of Geophysical Research, v. 94, p. 17,465–17,484.

Van Dorn, W., 1961, Some characteristics of surface gravity waves in the sea produced by nuclear explosions: Journal of Geophysical Research, v. 66, p. 3845–3862.

Young, R., and Bryant, E., 1992, Catastrophic wave erosion on the southeastern coast of Australia: Impact of the Lanai tsunamis ca. 105 ka?: Geology, v. 20, p. 199–202.