The Hawaiian megatsunami of 110 ± 10 ka: the use of microfossils in detection

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INTRODUCTION
McMurtry et al. (2004) described a thin (c. 20–50 cm) bioclastic, carbonate gravel from the NW coast of Hawaii, on the flanks of the extinct Kohala volcano (Fig. 1). This unit is found between modern altitudes of c. 1.5–61 m above sea-level. The deposit is sandwiched between a fossil soil below and a modern soil above in Keawe’ula Bay (Fig. 2). Dating of coral fragments from within the deposit indicate an age of 110 ± 10 ka (McMurtry et al., 2004). Given rates of subsidence on Hawaii, this would place the deposit at an original palaeo-altitude up to 491 m. The deposit contains a range of bioclasts including bivalves, gastropods, corals, bryozoans and foraminifera, largely representing assemblages from a reef flat. The geological setting of the unit, coupled with the evidence from the contained marine fossils, indicate a megatsunami genesis, probably linked to the collapse of the submarine Alika Slide at about 120 ka and with a run-up in excess of 400 m and at least 6 km inland (McMurtry et al., 2004).

FOSSILS PRESERVED IN THE TSUNAMI DEPOSIT
Fossils of the tsunami, and adjacent deposits, have been collected at 14 sites (material is deposited in the collections of the British Geological Survey, registered as MPA51883–51891, 51893–51897). Further information is available in BGS archives (see report IR/02/197R, available through the BGS library at: http://www.bgs.ac.uk and http://geolib.bgs.ac.uk).

The tsunami deposit on the flank of Kohala volcano contains a range of macrofossil debris and prolific microfauna (Fig. 3). The macrofauna is pummelled to sub-centimetre fragments, indicating a high-energy milieu depositional setting. Microfauna comprise predominantly the benthic foraminifer Amphistegina lessoni d’Orbigny, though several other Amphistegina morphotypes occur less commonly (Figs 3, 4a). Live A. lessoni has a modern coral reef, coral flat and lagoonal distribution around Hawaii (Coulbourn & Resig, 1975) but, because of its robust test, dead specimens are preserved abundantly in Hawaiian beach sands (Fig. 4b). Specimens of A. lessoni in the tsunami deposit are coated by carbonate cement (Fig. 4a).

Modern beach sands of Keawe’ula Bay to the west of Kohala volcano, assessed by McMurtry et al. (2004), contain large numbers of dead A. lessoni, but also a range of smaller foraminifer tests not found in the tsunami deposit (see Fig. 3; Coulbourn & Resig, 1975). The modern beach deposits also contain ostracods (Wilkinson & Williams, 2004), particularly the interstitial-dwelling Semicytherura challengeri Wilkinson & Williams, 2004, which are also absent in the tsunami deposit. This suggests that the lighter, less robust elements of Hawaiian shallow-marine fauna (and beach sands) were selectively removed during genesis of the tsunami deposit.

As part of a multidisciplinary study, microfossils and the geological setting have provided critical evidence for the identification of this Hawaiian deposit as the product of a

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Fig. 1. Outline map of Hawaii showing the position of Keawe’ula Bay.

Fig. 2. Photograph of the fossiliferous marine gravel in Keawe’ula Bay identified in Stearns & Macdonald (1946) (they located it on the north side of Keawanui Bay) and lost to science for over 56 years.
megatsunami (McMurtry et al., 2004). They provide unequivocal evidence of a marine source for the sediments and they also suggest possible taphonomic differences between microfossils preserved in tsunami deposits and those typical of beach sands around Hawaii. In the evaluation of known or putative products of tsunamis, microfossils provide vital evidence elucidating the passage of such events. They should be studied actively in any sedimentological or genetic evaluation of ancient or more recent tsunami deposits.

**ACKNOWLEDGEMENTS**

MW publishes with permission of the Director of BAS (NERC) and IPW and DJT publish with permission of the Executive Director, BGS (NERC).

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**CALCAREOUS MICROFAUNA**

| Foraminifera                        | Beach Sand | Tsunami deposit |
|-------------------------------------|------------|-----------------|
| Amphistegina lessoni                | ■          | ■               |
| Amphistegina lobifera               | ●          | -               |
| Quinqueloculina cf. curta (fragment) | +          | -               |
| Siphonina sp (fragment)             | +          | -               |
| Hauerinoides pacifica               | ○          | -               |
| Spirillina inaequalis               | ○          | -               |
| Fissurina sp                        | +          | -               |
| Balanina limbata                    | +          | -               |
| Peneroplis pertusa                  | ○          | -               |
| Rosalina vilardoebana               | ○          | -               |
| Cassidulina sp                      | +          | -               |
| Buliminella sp                      | ○          | -               |
| Amphistegina cf. bicirculata        | -          | ○               |
| Amphistegina cf. lobifera           | -          | ○               |
| *Saccammina sp                      | -          | ○               |
| Spirillina sp                       | -          | +               |
| Ostracoda                           |            |                 |
| *Semicytherura sp nov.              | ■          | -               |
| *Kestoleberis hawaiiensis           | +          | -               |
| *Balidia sp                         | -          | +               |

**Key:**

- ■ Abundant: >20 specimens/sample
- ● Frequent: 10–19 specimens/sample
- ○ Rare: 1–9 specimens in some samples
- ‑ Very rare: few specimens in few samples
- - Absent

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Fig. 3. Calcareous microfauna recorded from the tsunami deposit (Unit 2) and those present in recent beach sand (after McMurtry et al., 2004).

References

Coulbourn, W.T. & Resig, J.M. 1975. On the use of benthic foraminifera as sediment tracers in a Hawaiian bay. *Pacific Science,* 29: 99–115.

McMurtry, G.M., Fryer, G.J., Tappin, D.R., Wilkinson, I.P., Williams, M., Fietzke, J., Garbe-Schoenberg, D. & Watts, P. 2004. Megatsunami Deposits on Kohala Volcano, Hawaii from Flank Collapse of Mauna Loa. *Geology,* 32: 741–744.

Stearns, H.T. & Macdonald, G.A. 1946. Geology and groundwater resources of the island of Hawaii. *Bulletin of the Hawaii Division of Hydrography,* 9: 1–363.

Wilkinson, I.P. & Williams, M. 2004. Interstitial ostracods from a beach sand habitat. NW flank of Kohala Volcano, Hawaii. *Revista Española de Micropalaeontología,* 36: 101–108.