Megatsunami Deposits vs. High-stand Deposits in Hawai‘i

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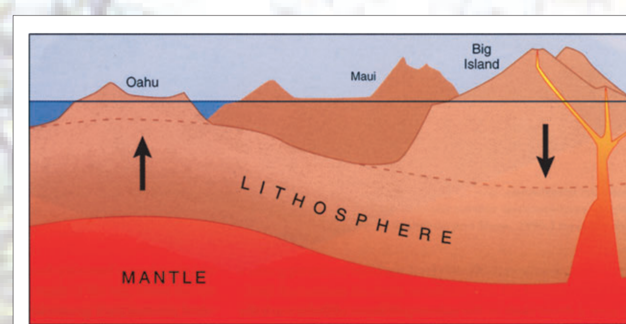
Summary

Two hypotheses have been proposed to explain fossiliferous marine conglomerates on the Hawaiian islands of Lana‘i and Moloka‘i. Either they were left by prodigious tsunamis generated by giant submarine landslides, or they are the result of prodigious uplift. Flexural models require subsidence rather than uplift, but these models assume the along-chain flexural properties are the same as the across-chain properties. Since that assumption may not be valid, the arguments have raged. With the discovery of matching conglomerates on Kohala, the northernmost volcano of the Island of Hawai‘i, it is now clear that the conglomerates are indeed from tsunamis: Kohala is known to be subsiding at at least 2.5 mm/yr, which puts the 110 ka Kohala conglomerates at an elevation of at least 275 m at the time of their deposition. The date of the Kohala deposit actually matches that of a 400-m-deep terrace offshore, implying that the incoming tsunami reached runups of 400 m.

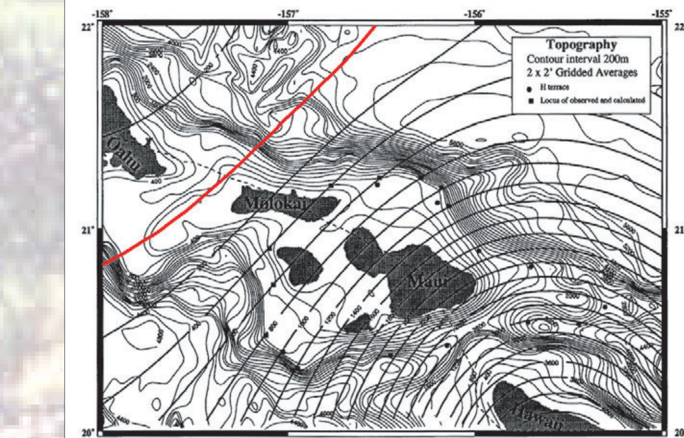
Comparing the megatsunami deposits with reefs and other shoreline structures exposed by the uplift of ‘Oahu (lithospheric flexure lifts ‘Oahu at about 0.08 mm/yr), we can begin to work out the differences upraised shorelines and tsunami deposits.

Our conclusions are tabulated lower right.

Uplift. Wai‘anae Coast of ‘Oahu. The bluff below the cars with white (coral) boulders at its base is an upraised reef. A higher, larger, older (but less photogenic) terrace exists off to the right.



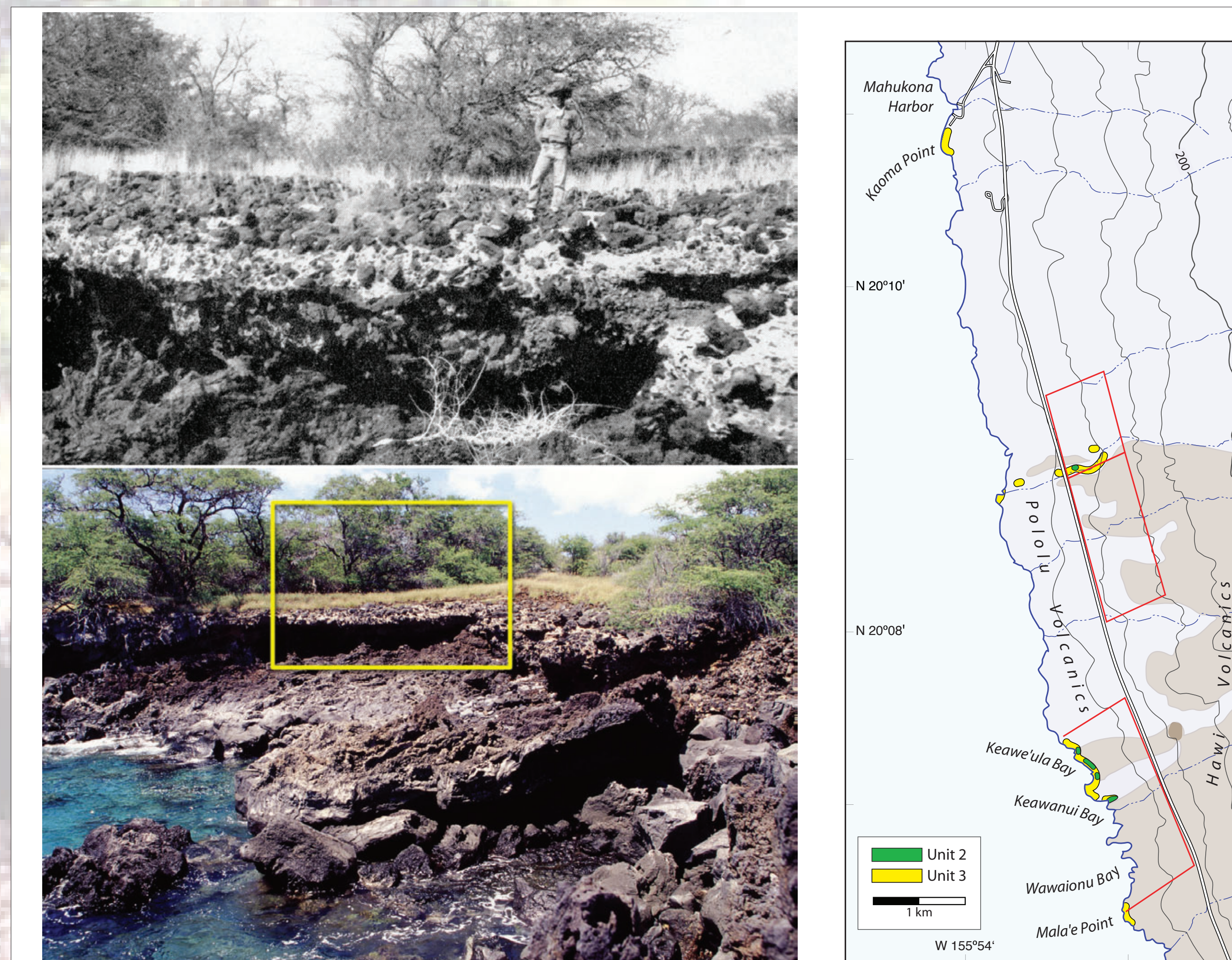
Subsidence and uplift. As the Big Island sinks, ‘Oahu rises. But what about the islands in between? The lower figure shows the static flexure computation of *Watts & ten Brink* (1989). The red line marks the zero crossing, which runs along the Ka‘iwi Channel between Moloka‘i and ‘Oahu. Northwest of that line land is rising; to the southeast it is sinking.



Details of the tsunami deposit at Kohala, Unit 2. *Left:* the deposit overlying a truncated soil with root casts. Because corraline ssand in the tsunami deposit has dissolved and reprecipitated, the unit is well cemented. The softer underlying soil is preferentially eroded.

Above right: a rare coral clast at the Stearns Site.

Below right: rip up clasts of an oxisol incorporated into the unit.



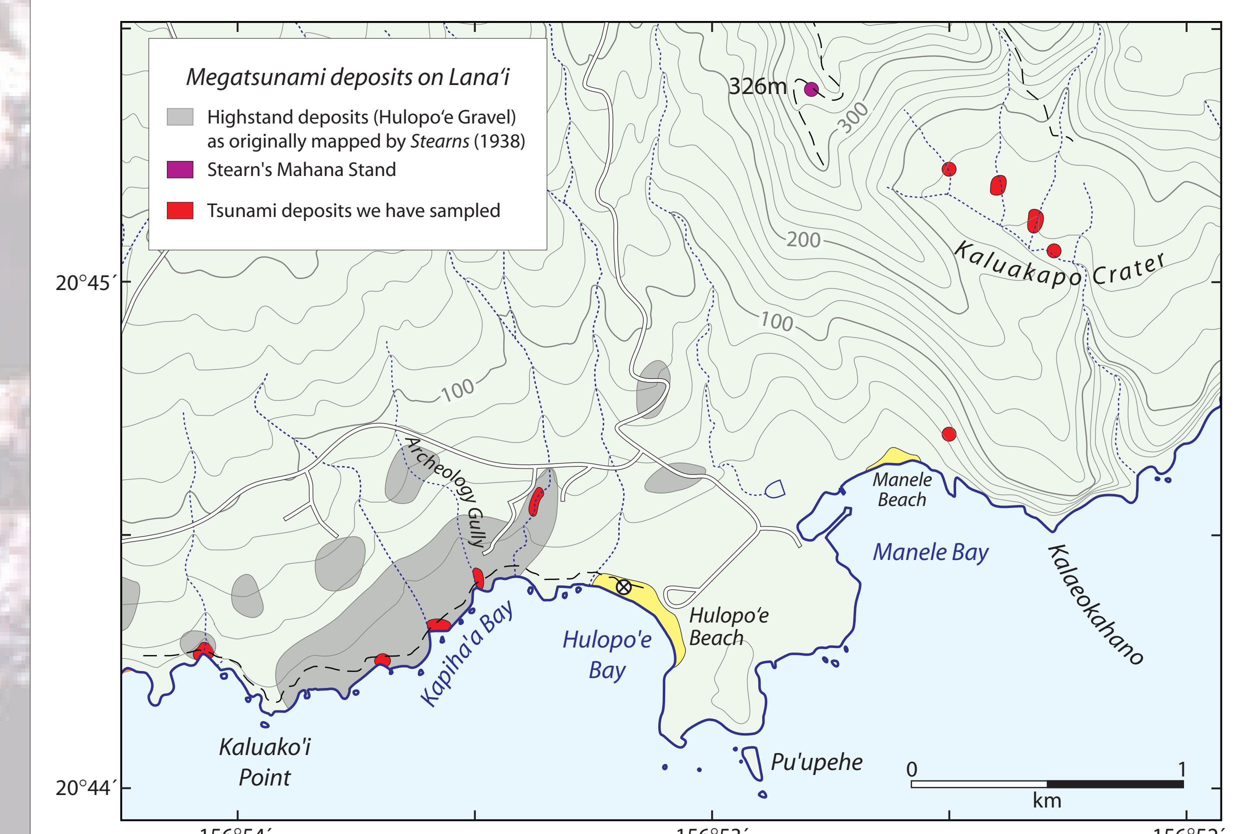
The “Stearns Site” at Keawe‘ula Bay, Kohala, Big Island. The upper photograph, of a supposed high stand, is from *Stearns & Macdonald* (1946). Inconsistency in geographic names left the location uncertain. The lower image is from our visit in May 2002. The approximate framing of the original photo is shown in yellow. The tsunami deposit, which we call Unit 2, is about 0.5 m thick. It is laden with back-reef fossils (quite unlike the fauna od the present shoreline), and is about 120 ka. It overlies another carbonate conglomerate, Unit 3, which we have been unable to date. The maximum elevation of Unit 2 is 61 m, about 750 m inland (map).

Tsunami deposits in Kaluakapo Crater, Lana‘i. *Above:* at an elevation of 180 m a deposit chokes a gully. Note that it overlies a soil which has been undercut. This deposit is also 120 ka.

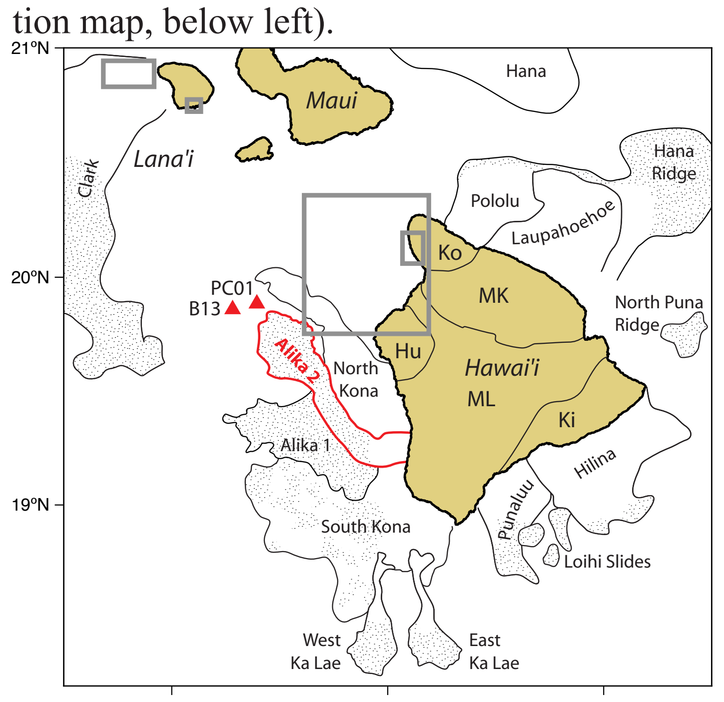
Top right: A distinctly different unit, with much larger clasts, overlies the smaller-clast 120 ka conglomerate. This large coral boulder is 80 ka.

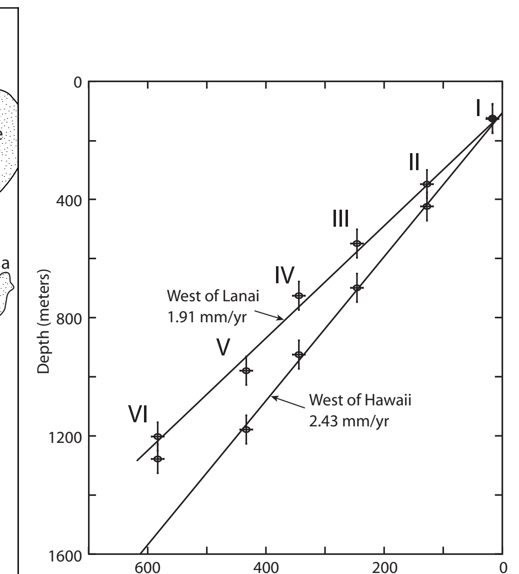
Middle right: Two tsunamis? Higher up the same stream bed, Gary McMurtry stands on the upper of two thin units (120 ka and 80 ka?).

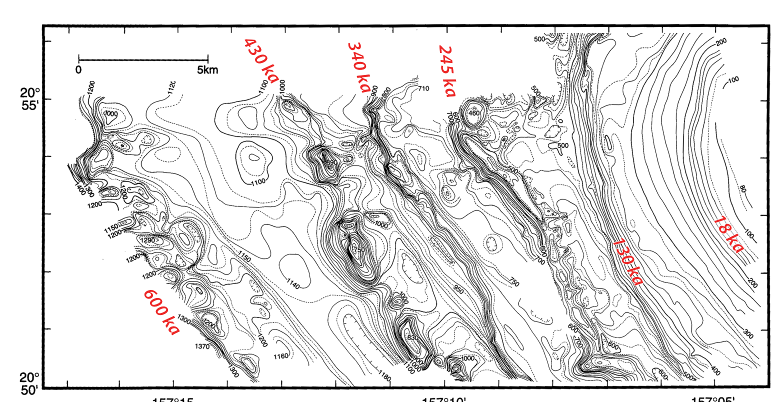
Bottom right: A clastic dike at 190 m elevation laden with marine fossils.

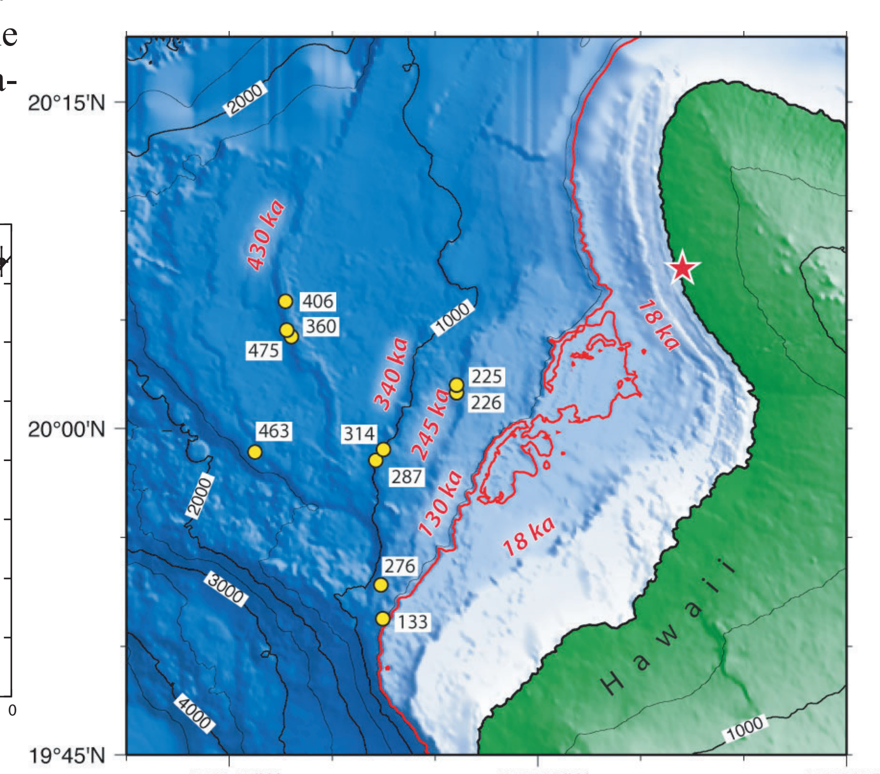


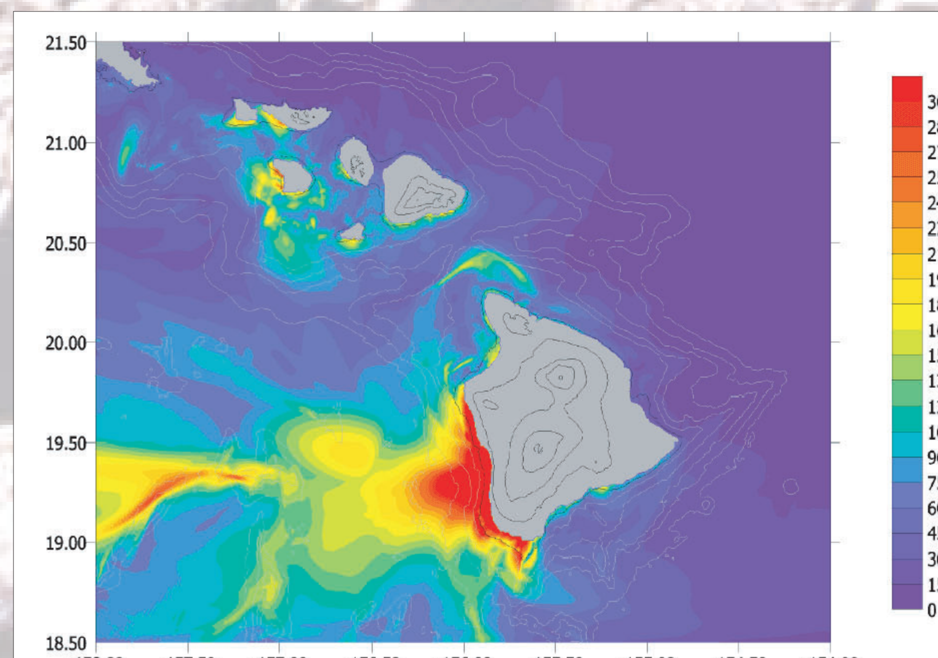
Subsidence. By comparing the depth and spacing of drowned reef terraces off Lana‘i (right) and Kohala (below right) with global sea level curves, *Cambell* (1987) worked out average subsidence rates of 1.9 mm/yr for Lana‘i and 2.4 mm/yr for Kohala (below center). His Kohala computation was subsequently verified by sampling and dating (*Ludwig, et al.*, 1991). The red line on the Kohala map is the location of the coastline at the time of the Alika slide (location map, below left).











Megatsunami. Maximum wave heights if the Alika-2 landslide were to occur today. The tsunami easily accomplishes the runups we infer from tsunami deposits (*McMurtry, et al.*, 2004).

	Tsunami Deposit	*High Stand Deposit*
Appearance	Random mix of materials of offshore and onshore provenance	Massive reef off paleo-shoreline, sand or beach rock onshore; distinct facies
Corals	Randomly oriented	In growth position
Grading	Both normal and reversed grading present, never more than poorly developed	None
Fining	Continuous landward fining	Absent or discontinuous (coral clasts on back reef, sand on beach)
Elevation	Smeared upslope like plaster, variable elevation	Terraces of uniform elevation
Thickness	0-2 meters	0.5-10 meters
Soil	Often overlies friable soil	Never overlies friable soil
Fossils	Need not match paleoenvironment	Must match paleoenvironment
Best preserved	in valley bottoms	on promontories and ridges
Age relationships among deposits	Younger deposits reach to higher elevations because of progressive subsidence	Because of progressive uplift, the highest deposits are the oldest