Using Geochronology of Shoreline and Coral Reef Deposits to Study Uplift and Subsidence at Tropical Volcanic Ocean Islands: Examples from Hawaii with Applications to the Galapagos

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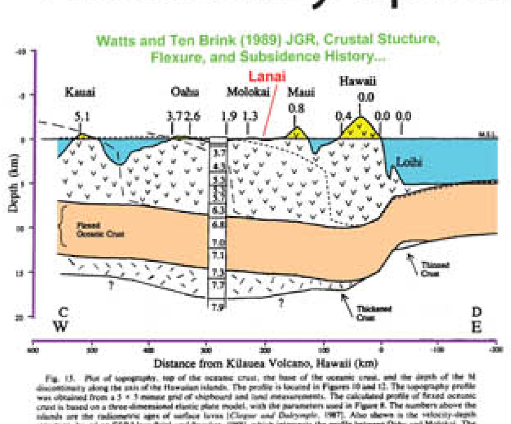
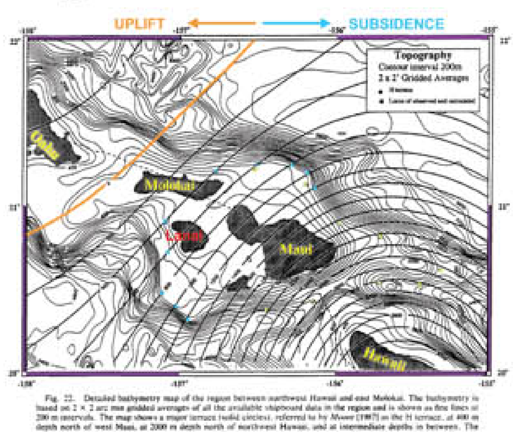
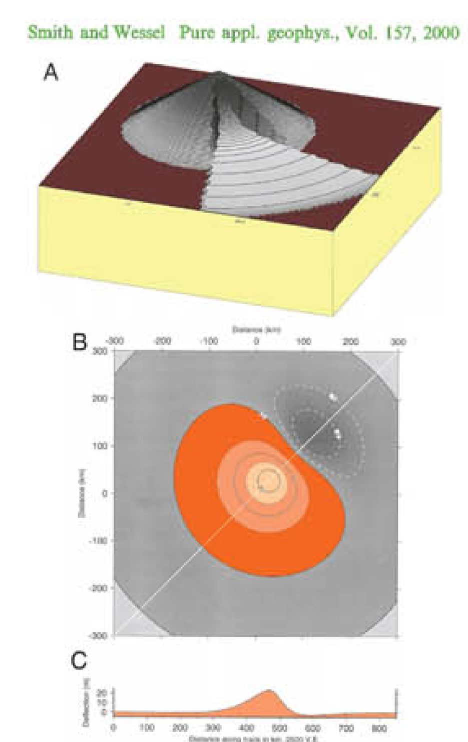
Intro:

Ocean islands can experience vertical tectonic shifts due to effects such as:

+ volcanic loading induced flexure of the lithopsphere
+ edifice failure
+ plate subsidence
+ plume flux variations
+secondary upwelling







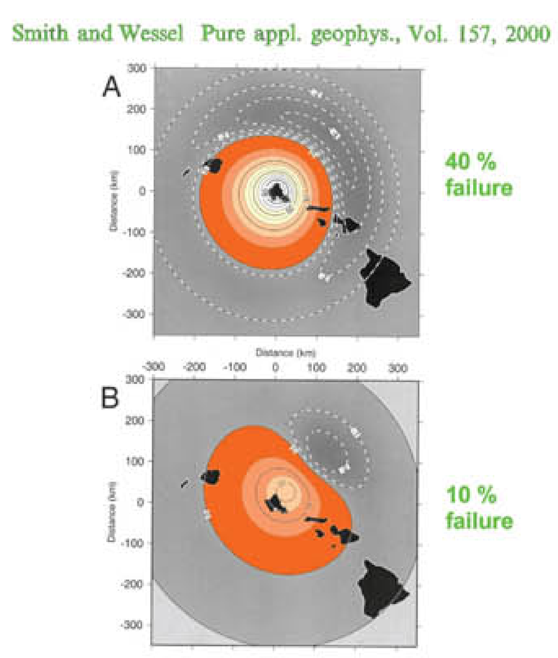


Figure 6
Overlay of present-day Hawaiian Islands on isostatic adjustment plots of the simulated Nuuanu debris avalanche for A) maximum 40% failure B) minimum 10% failure. Contour intervals same as in Figures 2b and 3b, respectively.

Fossil coral reef (FCR) deposits can provide excellent constraints on relative sea level because:

+ they form in restricted depth intervals
+ record depositional and paleo-ecological conditions
+ are readily dated by 230Th-238U and/or 14C.

In Hawaii, FCR have been used to constrain the relative rates of uplift and subsidence of indivdual islands via lithospheric flexure, in response to volcanic loading on the big island. This in turn provides constraints on mantle and lithosphere rheology and on island paleoenvironment changes with time. FCR deposits have also been used to date eruptions and to constrain relative sea level (RSL) motion over shorter time intervals. This poster shows examples of each of these applications (#1 -#3).

early work

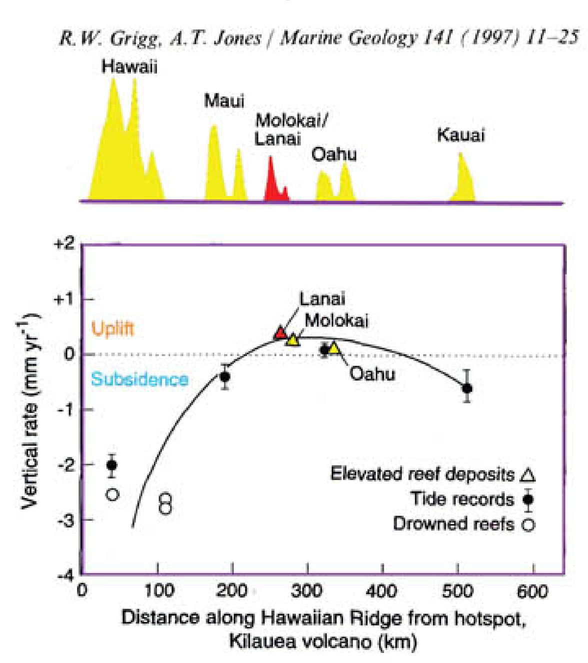
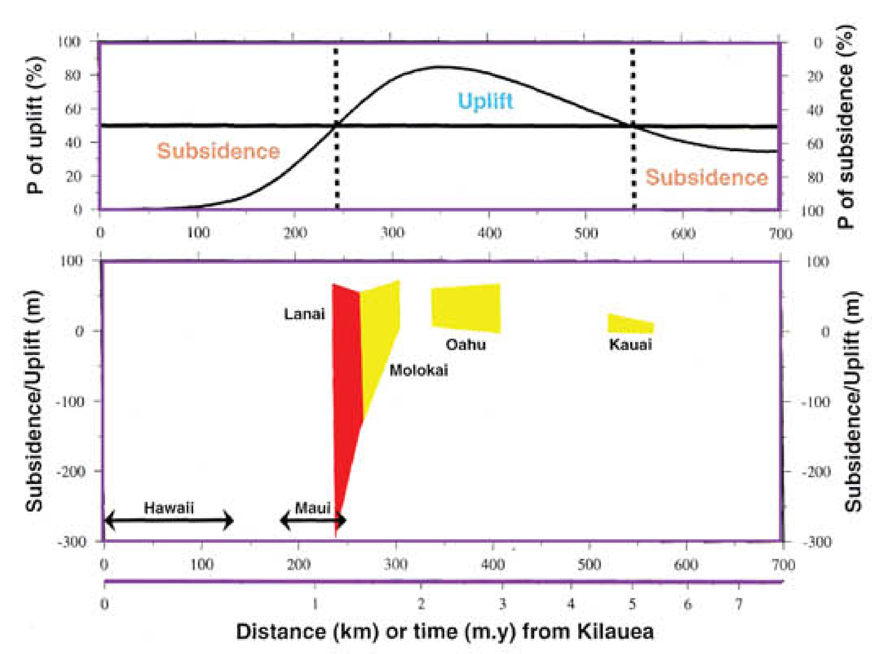
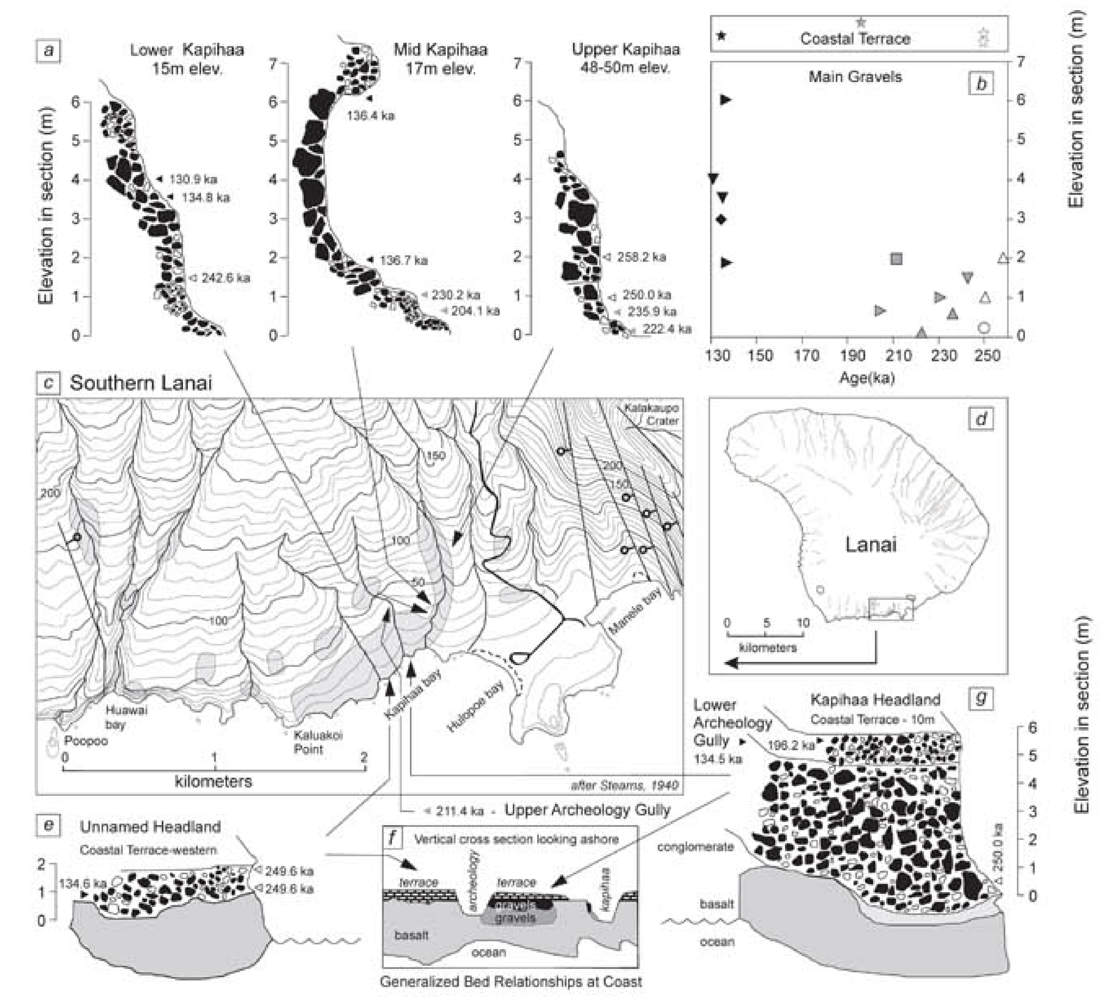


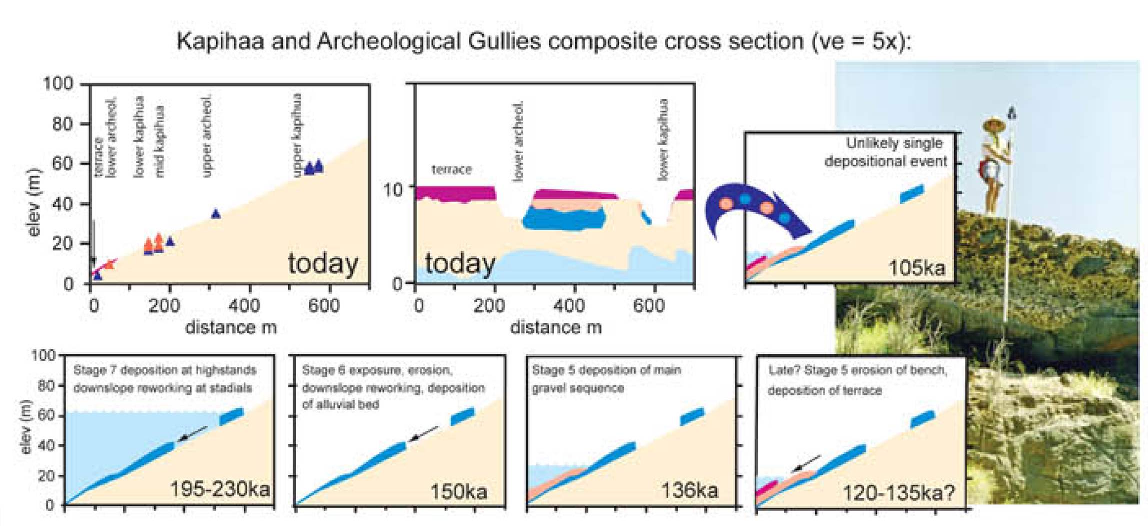
Fig. 7. Subsidence and uplift rate curve for major Hawaiian Islands. Data for tide records in Jones (1993b), for drowned reefs in Ludwig et al. (1991), and for elevated beach deposits in Muhs and Szabo (1994), Szabo et al. (1994), and this paper. Tide data are less robust than drowned or uplifted coral reef data because they represent a short time period.

flexure predictions from Wessel et al.

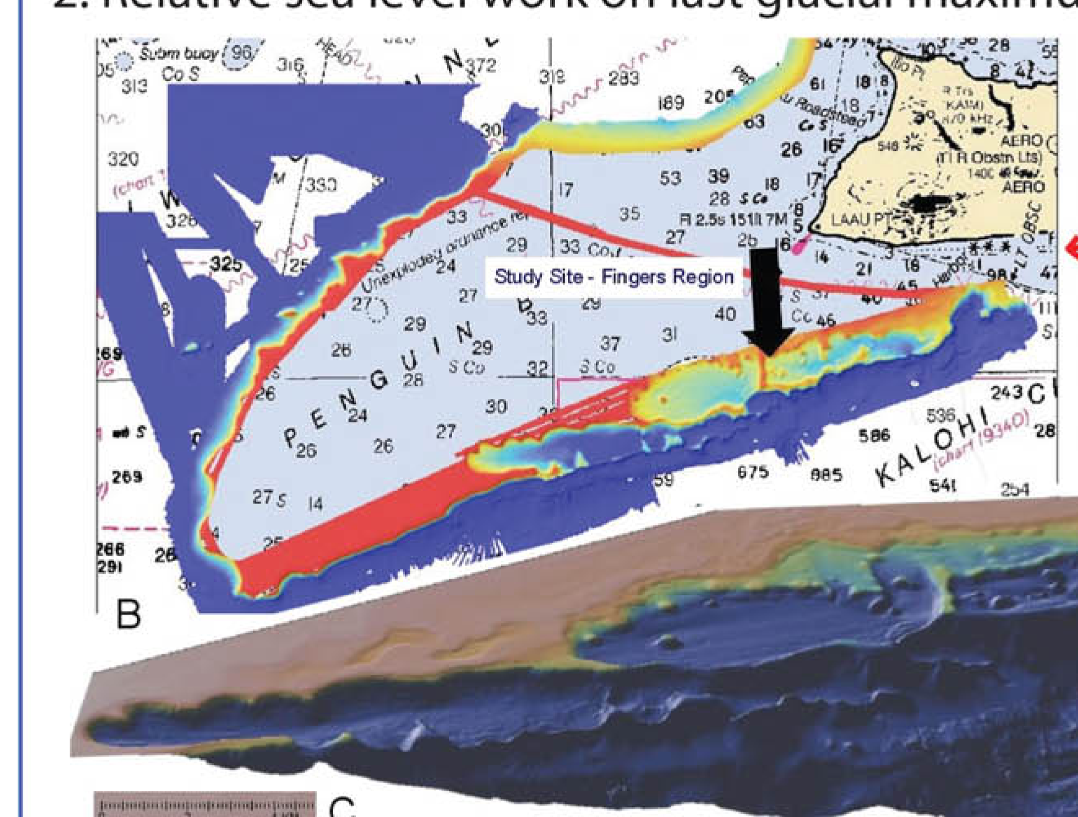


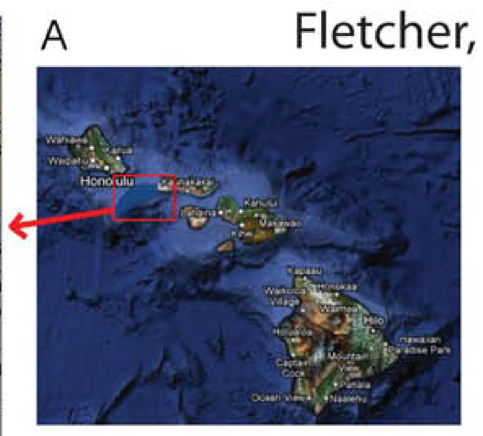
1. Results of a detailed study on the island of Lana'i (Rubin et al., 2000):
Lanai is uplifting, at about 2 to 2.5x as fast as oahu





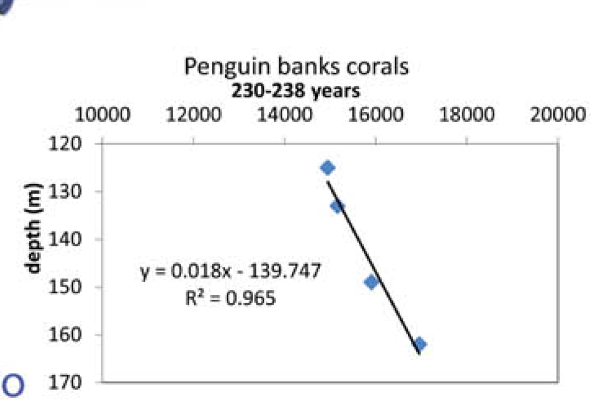
2. Relative sea level work on last glacial maximum reefs in Hawaii (Rubin and Fletcher, in prep.)





master frodo, a 10m high coral head at 150m water depth (at left).

Result: Relative sea level curve from Th-U dated corals (at right) translates into 8.4 cm/yr of relative sea level change over this time interval.



3. Coral fragments and a large tract of intact reef embeded in volcanic ash deposits from the Hanauma Bay eruption, SE Oahu. Result: Th-U dating tells when the eruption(s) occured (85 ka), the age of the reef they intersected (MIS7), and the amount of apparent uplift of this part of the island (10m) (Rubin et al., in prep).

(a) Hanauma Bay; (b) coral lithic in ash; (c) in situ reef fragment (~8m high by 30m wide).

Why do Coastal Geology using FCR in the Galapagos?

+ We know very little about the vertical history of the islands
+ Many important questions related to volcanism and plate loading history
+ 1000 km of coastline, nearly all of which is pristine
+ a globally unique tropical ocean island setting
+ There is great potential for similar studies/applications in the Galapagos

Coral patchreef habitat is widespread in the Galapagos

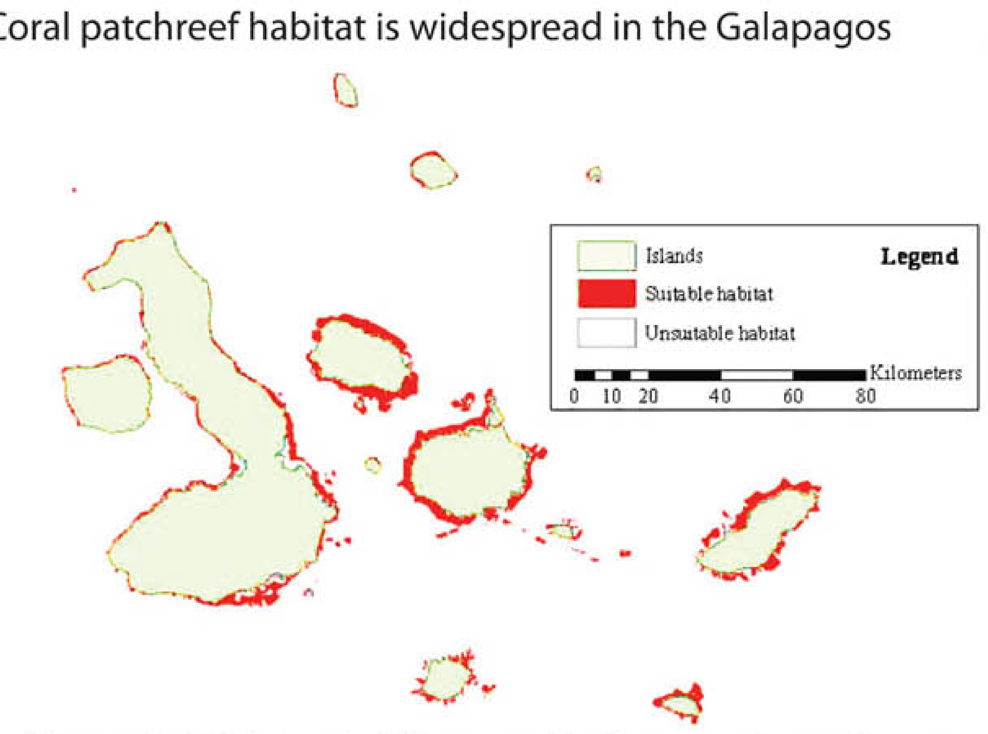
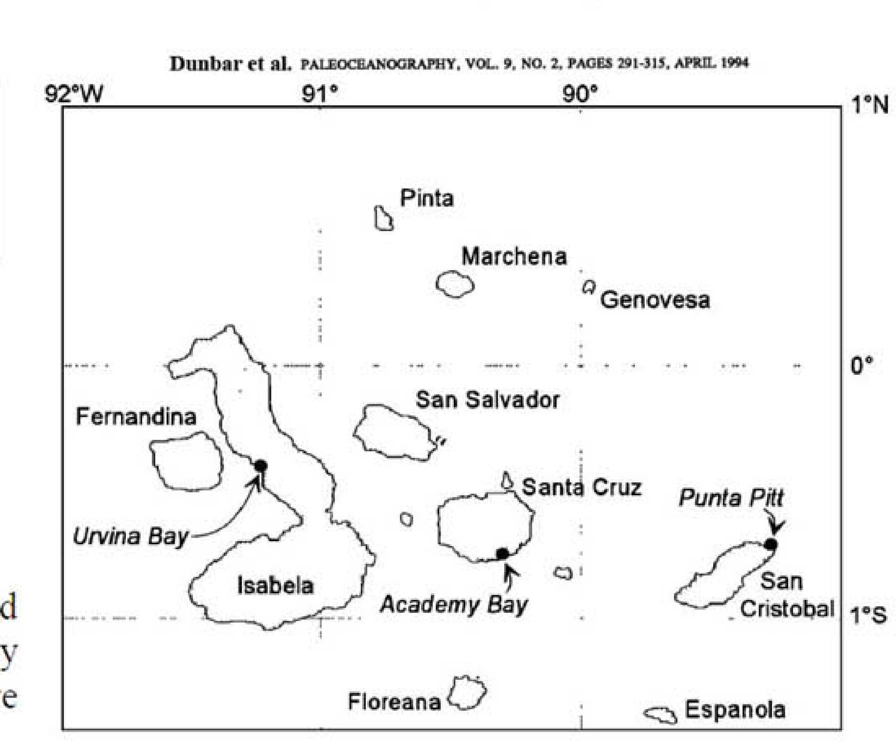


Figure 5. Habitat suitability map for hermatypic corals around the Galápagos Islands, based on bathymetry and SST variability (1985-2001). Note the northern islands of Wolf and Darwin are excluded from this map for clarity. Dawson et al., 2006

According to the literature, relatively few sites have been used for paleo oceanographic, ecological or climate studies, and none for coastal geology or island tectonics



fossil corals at Urvina Bay, Isabella Is., Galapagos were exposed in 1954 by coseismic uplift . This deposit has been the focus of multiple paleoecological and paleo-oceanographic studies.