International Tsunami Study Team, Samoa, October 2009

Geology Team Preliminary Report 10/22/09

TEAM MEMBERS

Dr. Bruce M. Richmond, Research Geologist, Geology Team Leader
Mr. Mark Buckley, Geologist
U.S. Geological Survey, Pacific Science Center
400 Natural Bridges Drive, Santa Cruz, CA 95060
brichmond@usgs.gov, mbuckley@usgs.gov, Phone: 831.427.4731

Dr. Samuel Etienne, Physical Geographer
Universite De La Polynesie Francaise
Campus D'Outumaoro-Punaauia
B.P. 6570 – 98702 Faa`a Tahiti, French Polynesia
samuel.etienne@upf.pf , Phone 689.803.961

Dr. Luke Strotz, Postdoctoral Research Fellow (Microfossils)
Dr. Catherine Chague-Goff, Research Fellow (Geochemist)
Prof James Goff, Director (Geologist)
Natural Hazards Research Lab and Australian Tsunami Research Centre
University of New South Wales
UNSW Sydney NSW 2052 Australia
l.strotz@unsw.edu.au, c.chague-goff@unsw.edu.au, j.goff@unsw.edu.au

Dr. Kate Wilson, Earthquake Geologist
GNS
PO Box 30368, Lower Hutt 5040, New Zealand
k.wilson@gns.cri.nz, Phone: +64-4-570-4530

Dr. Walter C. Dudley, Professor of Oceanography
Director, Kalakaua Marine Education Center
University of Hawaii at Hilo
200 W. Kawili Street, Hilo, Hawaii, 96720
dudley@hawaii.edu

Mr Faigame "Me" Sale, Technician
Ministry of Natural Resources and Environment, Meteorology Division
PO Box 3020
Mulinu`u, Apia, Samoa
Phone: 20855

Methodology.

The geology team focused on documenting the tsunami geologic signature and the physical processes of tsunami erosion, transport, and deposition of material. Our studies were of two types: 1) reconnaissance site visits where a number of observations and measurements were made in a short time period, and, 2) detailed investigations of selected areas. Appendix I summarizes Geology Team daily activities as reported to the Government of Samoa in UNESCO Samoa ITST Daily Reports.

Reconnaissance site visits. The visits were usually less than one hour and typical observations and measurements made at each site visited include:

-General morphology and characteristics of the coast.

-Observations on the presence or absence of sedimentary deposits and erosional features.

-Inundation and runup measurement(s) using a laser rangefinder.

-Flow depth and wave height if suitable markers could be identified.

-Flow direction indicators (in many areas multiple flow directions were identified).

Detailed study sites. Extended studies of critical sites based on Geology Team reconnaissance and consultation with Samoa Government representatives and members of the ITST. In addition to the data collected in the reconnaissance sites, the detailed studies typically included:

-Topographic mapping using both backpack mounted Differential GPS (DGPS; USGS system; requires post-processing for sub-meter accuracy) and/or a backpack mounted Real Time Kinematic GPS (RTK GPS) system with base station (NZ GNS system). The topographic surveys extended from the nearshore (inner reef flat) landward to beyond the limit of inundation. Survey transects were collected in both shore-parallel and shore-normal lines. Line-spacing density was a function of the size of the study area and time spent at the site. Offshore distance of nearshore surveys were partially controlled by tide stage at the time of survey, with lower tides allowing a greater distance to be traversed. The topographic mapping will be used to characterize the study area and for use in model studies of tsunami wave propagation along the coast.

-Surficial and sub-surface sampling of tsunami deposits. Sub-surface samples were either collected by push cores of plastic pipe, gouge core, Russian peat borer (D-core) or from hand-excavated trenches (Figure 1). Surficial samples consisted of scraping the upper layers of sediment in both subaerial and submarine environments.

Extensive measurements of flow depth and orientation indicators.

Where boulder deposits occurred, boulder size (a,b,c axis), orientation of long (a-axis), and location were recorded.

Material used for identification of tsunami impact characteristics:

Marine material deposited landward (Halimeda clusters, coral debris, microatolls, *Foraminifera* sp., and basalt boulders with marine encrustations.

Transported boulders from shoreline engineering structures.

Wrack (debris) lines of vegetation and human artifacts (clothing, appliances, household items, automobiles, plastic debris etc.).

Ballistic impacts on solid structures such as buildings, trees, and bedrock.

Water-level indicators such as watermarks or debris deposits on suitable surfaces.

Indicators used for specific measurements include:

Flow direction was recorded from a number of field observations and measured by compass (either magnetic or GPS): alignment of bent vegetation (palm trees or coconut trees; figure 2), alignment of collapsed building structure (*fale* pillars or water pipes), alignment of fence posts anchored on the seaside walls of some partially destroyed building, and material such as metal roofing wrapped around tree trunks.

Flow depth was measured with a laser range finder using field evidences such as scratched trunk, bark removal, broken branches, rubbish trapped in branches (figure 3).

Delineation of inundation was made using GPS measurements at the marine water inundation limit. Marine inundation can be recognised in the field by observing the contact between salt-burnt yellow grass and non flooded green grass, limit of debris wrack line, and eyewitness accounts (figure 4).

A boulder field of particular interest was investigated in Satitoa (Aleipata District, east coast Upolu; figure 5). Boulder granulometry was recorded along both transverse and longitudinal profiles, according to field evidence of the tsunami primary flow direction in this area (N340 to N010): *A, B, C* axes and long-axis orientation have been measured. A waypoint was recorded for each measured boulder. We assume that the damaged seawall along the coast road is the source for boulders. Few small rounded boulders were encountered on field, but have been rejected from the collection as they are not the usual material used in seawall engineered structure. They may come from some "marae" encountered in the surveyed area and partially damaged by the tsunami. 160 boulders were measured in this location (see results section).

Commonly measured parameters and their definitions:

Runup – Maximum tsunami water level elevation above mean seal level (MSL, approximate) measured at the landward extent of inundation.
Inundation – The horizontal distance from the shoreline of the maximum inland incursion of the tsunami.
Flow depth – Water elevation above the ground surface at locations along the tsunami pathway.
Tsunami wave height - Water elevation above ~MSL at locations along the tsunami pathway.

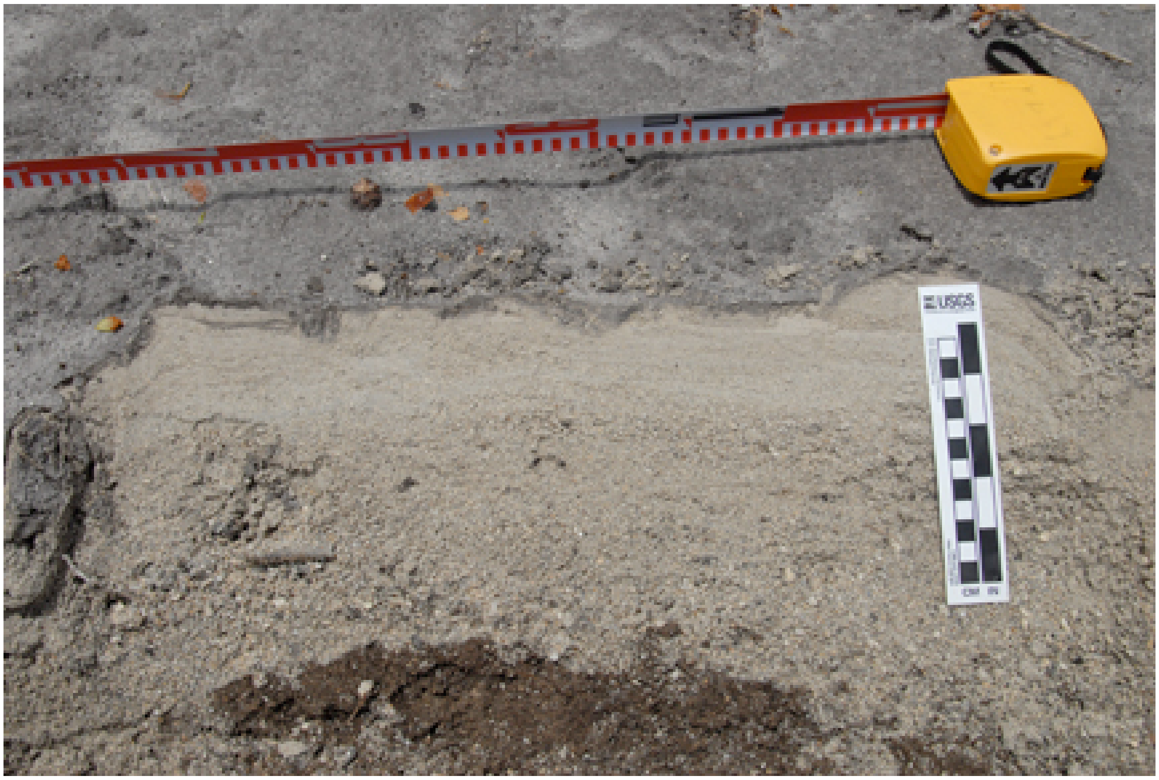

Figure 1. Shallow trench from Satitoa, Alaeipata District on the east coast showing pre-tsunami soil at base with sharp contact to overlying tsunami sand with multiple laminations and capped by a thin mud drape.

Figure 2. Coconut tree trunk used as a flow-direction indicator.

Figure 3. Clothes in a mangrove tree at Vaovai used as evidence for measuring minimum flow depth.

Figure 4. Satitoa, Aleipata District showing vegetation debris rampart composed mostly of tree trunks and branches at the limit of inundation.

Figure 5. Boulder field and sand sheet at Satitoa, Aleipata District. In the background, the seawall behaved as a source for boulders.

PRELIMINARY RESULTS

Figure 6 shows areas traveled and study sites on Upolu for the Geology Team and Figure 7 shows the three sites where extensive surveys were carried out. Appendix II is an MS Excel spreadsheet (incomplete) showing where various types of data were collected. The spreadsheet includes data for boulder measurements, trenches, samples, and water levels. Initials in the spreadsheet database refer to: MB (Mark Buckley) SE (Samuel Etienne), LS (Luke Strotz) and BR (Bruce Richmond). More data will be compiled for a final version of the database. Example topographic profiles in trench sites are shown in figures 8 and 9. Table 1 is a listing of boulder measurements (incomplete) and Figure 10 is a plot showing boulder volume and long-axis orientation for the study site at Satitoa, Aleipata. These figures, tables, and spreadsheet are not a complete listing of all data collected but are meant to show examples of the data collected during the field survey. A more complete compilation will be completed and forwarded to the ITST Samoa for transmission to the Government of Samoa.

Figure 6. Map showing areas traveled (green lines) based on hand-held GPS track logs and areas where mesurements and observations were gathered (white dots). Base map is a Google Earth image.

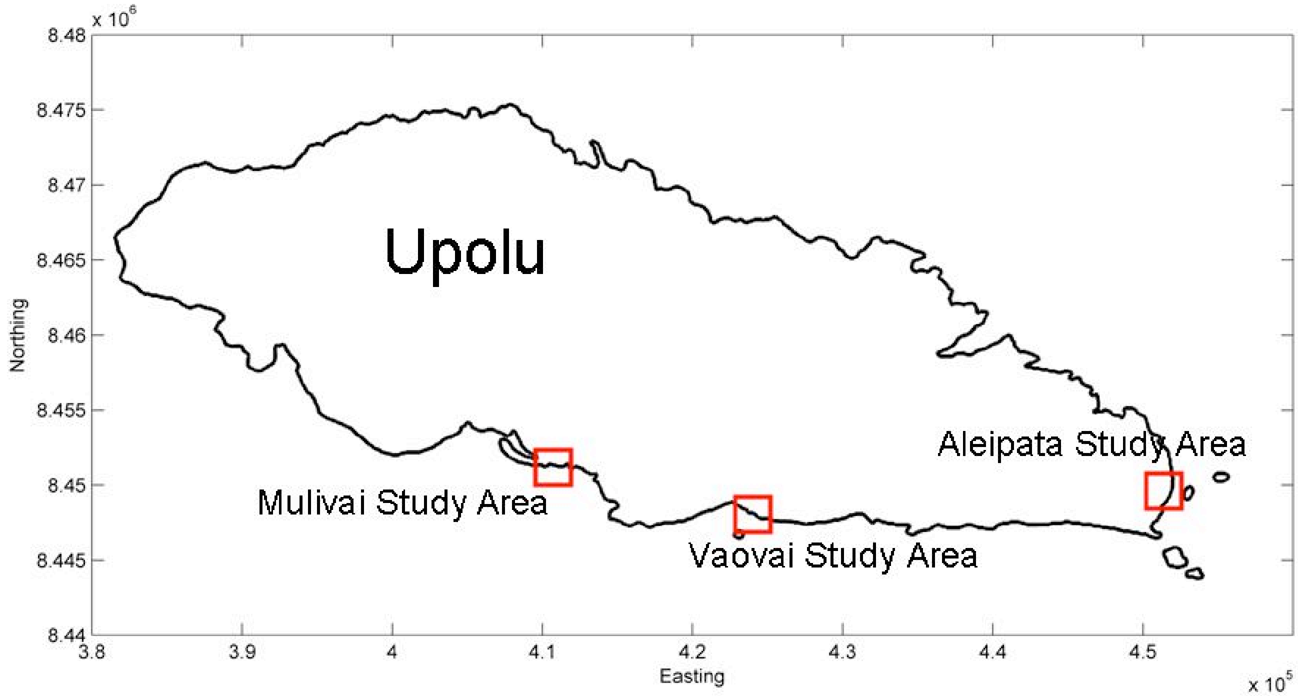

Figure 7. Map showing the location of the Aleipata, Vaovai, and Mulivai detailed study sites.