# TsuInfo Alert

prepared by the Washington State Department of Natural Resources on behalf of the

*National Tsunami Hazard Mitigation Program*

a state/federal partnership funded through the National Oceanic and Atmospheric Administration (NOAA)


**Contents**

**Volume 5, Number 4, August 2003**



## TSUNAMI PROGRAM NEWS

**Report from Oregon,** by Mark Darienzo (July 10, 2003)

Two tsunami programs in Oregon received 2003 Western States Seismic Policy Council (WSSPC) Awards in Excellence for Response Plans/Materials. The paragraphs below were those submitted to WSSPC in support of the nomination.

1. The State of Oregon Tsunami Evacuation Map Program

Tsunamis are rare but can be quite destructive. The worst-case scenario for Oregon is a tsunami generated off our coast from a Cascadia subduction zone earthquake. People have between 15-30 minutes to evacuate to safe ground once the earthquake shaking stops. It is critical that residents and tourists know where the safe areas are, the best routes to take to reach the safe zones, and where they can assembly for assistance. Thus the need for tsunami evacuation maps that show safe zones, evacuation routes and assembly areas in a manner that is easy for residents and tourists to understand. These maps will therefore save lives. Seventeen tsunami evacuation maps have been developed so far that cover twenty-eight incorporated and unincorporated communities on the Oregon coast. The maps are a coordinated effort among state and local government agencies. All the maps are computer generated with a consistent format. The maps also include background text on the hazard and what people can do to protect themselves They are based on simple inundation maps produced for the entire Oregon coast or detailed inundation maps produced for a few communities. All communities on the Oregon coast will eventually have an evacuation map. The decision to develop consistent computer-generated maps for all communities began in April 2000. However, the idea for computer-generated maps began with a National Tsunami Hazard Mitigation Program subgrant to the Umpqua Region Council of Governments in 1999 to develop a computer-generated tsunami evacuation map for Douglas County coastal communities.

2. Cannon Beach Rural Fire Protection District Tsunami Warning and Evacuation Program

The Cannon Beach Fire District (CBFD) is a popular tourist area. During the summer thousands of tourists are visiting on any given day. Cannon Beach suffered much damage to buildings and bridges from the 1964 Alaska earthquake tsunami. Over the last 15 years, CBFD has taken the lead in developing tsunami warning and evacuation plans for their community. They developed one of the first evacuation maps in Oregon and installed several tsunami hazard and evacuation route signs. Their new fire station was deliberately located outside the tsunami inundation zone. They developed a sophisticated tsunami warning system made up of several elements that include 1) sirens with voice capability, 2) Emergency Management Weather Information Network (EMWIN), 3) NOAA Weather Radios, 4) emergency vehicles, and 5) and other elements. The system was established through local initiative with funds coming exclusively from the community. It's known as the Community Warning System (COWS). Because of all these efforts, CBFD was the first community in Oregon to be designated as TsunamiReady.

**Report from Washington, "Radio on a Stick"**

Ocean Shores, the first TsunamiReady community in the nation, is now home to a wind-powered tsunami warning

*(continued, p. 3)*

# *TsuInfo Alert*

is prepared by the Washington State Department of Natural Resources
on behalf of the National Tsunami Hazard Mitigation Program,
a State/Federal Partnership funded through the National Oceanic and Atmospheric Administration (NOAA).

It is assembled by
Lee Walkling, Library Information Specialist and
Connie J. Manson, Senior Library Information Specialist,
and is published bi-monthly by the
Washington Department of Natural Resources, Division of Geology and Earth Resources.

This publication is free upon request and is available in print (by surface mail),
electronically (by e-mail), and at http://www.wa.gov/dnr/htdocs/ger/tsuinfo/index.html

Participants in the TsuInfo program can request copies of reports listed in this issue from:
Library
Washington Department of Natural Resources
Division of Geology and Earth Resources
P.O. Box 47007
Olympia, WA 98504-7007
ph: 360/902-1472 or 360/902-1473
fax: 360/902-1785
e-mail: lee.walkling@wadnr.gov or connie.manson@wadnr.gov



WASHINGTON STATE DEPARTMENT OF
**Natural Resources**
**Doug Sutherland** - Commissioner of Public Lands

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

*(continued, from p. 1)*

device which broadcasts warnings over a loud speaker and flashes a blue light. The speakers, the blue light and a National Oceanic and Atmospheric Administration (NOAA) weather radio are fastened to a 40-foot pole near the Shilo Inn at Chance A La Mer beach.

According to George Crawford (Washington State's earthquake program manager), Ocean Shores was selected for the pilot program because of its long coast line, the proximity of hotels and the city center to the ocean, and the town's previous tsunami mitigation efforts. "The whole community is beach," he said. "That whole community is threatened. There's a lot of hotels and motels. Seconds matter there. They don't have any high ground so every second counts for them." (Aberdeen Daily World, June 29, 2003, reported by Kaitlin Manry)

NOAA donated the equipment, state and contract employees installed it, and the Ocean Shores Police Department conducted tests. Ocean Shores' "Radio on a Stick" could be the first of many such warning towers.

**Report from Alaska**

The new West Coast and Alaska Tsunami Warning Center building is finished and we have moved into it. The above picture is an artist's rendering of the new building. From: http://wcatwc.gov/ (At this page, you can also experience a virtual earthquake!)

**June 23, 2003 Alaska Earthquake Triggers Tsunami Warning**

www.aeic.alaska.edu/Seis//Input/mitch/frame2html/frame2html/results//20030623121235_.pdf

http://neic.usgs.gov/neis/bulletin/neic_vjan.html

Newspapers reported a 7.1 earthquake shaking the ocean floor, approximately 65 miles southeast of Buldir Island (Rat Island region), in the Aleutians on June 23, 2003. A tsunami warning was issued for part of the Aleutians and a tsunami watch was issued along the coast to Kodiak Island. This warning was cancelled when the Adak gauge indicated that no tsunami had been generated.

**Tsunami Field Trip at WSSPC Annual Conference (Portland, Oregon)**

September 21, Mark Darienzo will lead a field trip to Cannon Beach and Seaside, two coastal communities in Oregon with very different tsunami warning and evacuation issues.

Prehistoric tsunami deposits in a marsh near downtown Cannon Beach will be visited prior to a stop at the Cannon Beach Rural Fire Protection District office and a stop at a elementary school in the inundation zone. Cannon Beach Rural Fire Protection District has been active in tsunami preparedness and mitigation for many years and was recently designated a TsunamiReady community by the National Weather Service.

Seaside demonstrates evacuation problems: two waterways, the Necanicum River and Newanna Creek are close to and parallel to the shoreline. The bridges that cross the river and creek are therefore critical evacuation routes. Stops include the First Street Bridge, the Lewis & Clark expedition salt cairn, and a house flooded by the 1964 Alaska tsunami. The owner, Tom Horning, who experienced the tsunami is still living in the house and will talk about his experience.

For more information: www.wsspc.org/events/ac2003

## HAZARD MITIGATION NEWS

**News from NOAA**

The National Oceanic and Atmospheric Agency's (NOAA) National Ocean Service has recently launched a web portal that should be of interest to DR subscribers. The portal provides information for coastal areas in an easy to use "one stop" web-based database. The site allows users to obtain real-time coastal observations and NOAA forecasts for major U.S. estuaries and seaports, the Great Lakes, and the coastal ocean.

The map-based portal, called "nowCOAST" provides spatially-referenced links to information from meteorological, oceanographic, and river observing networks operated by federal and state agencies and educational institutions. It also provides links to forecast point guidance from many National Weather Service (NWS) atmospheric and oceanographic forecast models and to NWS' county weather forecasts and marine forecasts.

The site may be accessed at http://nauticalcharts.noaa.gov/csdl/op/nowcoast.htm (click on "webportal" on the Office of Coast Survey page). For more details about the project or the presentation, contact John G. W. Kelley, Marine Modeling and Analysis Programs, Coast Survey Development Lab, NOAA/ National Ocean Service, Silver Spring, MD; (301) 713-2809; e-mail: John.Kelley@noaa.gov.

*from:* Disaster Research 391, June 27, 2003

**Grant Awarded**

"Research Experience for Undergraduates: Inter-disciplinary Approach to Coastal Processes and Hazard Mitigation," funded by the National Science Foundation ($287,722 for 36 months), was awarded to principal investigators: Daniel T. Cox, Cherri M. Pancake, and Merrick C. Haller, Department of Civil, Construction, and Environmental Engineering, 202 Apperson Hall, Oregon State University, Corvallis, OR 97331-2302; e-mail: dtc@engr.orst.edu.

This award funds a three-year project for 10 undergraduate students a year to undertake research in coastal processes and hazard mitigation. The 10-week summer program will draw from the academic disciplines of coastal engineering, physical oceanography, and computer science, and will focus on coastal processes and the mitigation of natural hazards, particularly those caused by tsunamis and coastal storms. To foster academic growth, the program will implement team research and promote critical thinking through seminars on topics such as ethics and sustainable development.

*from:* Natural Hazards Observer, v. XXVII, no. 6, July 2003, p. 15

*(Editors' note*: The 2003 deadlines have passed for these next two, which gives you extra time for the 2004 cycle!)

**School-based Emergency Response and Crisis Management Grants**

The U.S. Department of Education (DOE) is accepting proposals for local educational agencies to improve and strengthen emergency response and crisis management plans, including training school personnel, students, and parents in emergency response procedures, and coordinating with local law enforcement, public safety, health and mental health agencies. It is estimated that 150 awards will be awarded for a period of up to 18 months.

Applications are due June 30, 2003. Complete details, including eligibility and other requirements, are available from Connie Ann Deshpande or Jennifer Medearis, DOE, 400 Maryland Avenue SW, Room 3E332, Washington, DC 20202; (202) 401-2140; e-mail: connie.deshpande@ed.gov; jennifer.medearis@ed.gov; http://www.ed.gov/legislation/FedRegister/announcements/index.html (listed under May 16, 2003). *from:* Disaster Research 389, May 30, 2003

**Following in Her Footsteps Will be...**

Here at the Hazards Center we are proud to announce that nominations are currently being accepted for the 2003 Mary Fran Myers Award. The award is administered by the Gender and Disaster Network, an educational project initiated by women and men interested in gender relations in disaster contexts. The Network invites nominations of individuals who should be recognized for "efforts to advance women's careers in emergency management and the academy and for promoting gendered disaster research."

The Mary Fran Myers Award was so-named in order to recognize Mary Fran's sustained efforts to launch a worldwide network among disaster professionals and promote research on gender issues in disaster research in emergency management and higher education. The award was established in 2002 in recognition of the fact that vulnerability to disasters and mass emergencies is influenced by social, cultural, and economic structures that marginalize women and girls.

Nomination materials, including a description of how the nominee fits the award criteria, a resume of the nominee which reflects their commitment over time to gendered research and the promotion of women's involvement in the field, and no more than two letters of support, must be received by June 20, 2003. Complete information is available from Brenda D. Phillips, Institute for Emergency Preparedness, Jacksonville State University, 700 Pelham Road North Jacksonville AL 36265; (256) 782-8053; e-mail: Brenda@jsucc.jsu.edu; http://online.northumbria.ac.uk/geography_research/gdn/maryfranmyersaward.html. Information about the Gender and Disaster Network is available at http://online.northumbria.ac.uk/geography_research/gdn/index.html *from:* Disaster Research 389, May 30, 2003

**IUGG TSUNAMI COMMISSION BUSINESS MEETING**

Emerald Room A at the Royton Hotel, Sapporo, Japan, Thursday, July 10, 2003

**Annotated Agenda**

1. Chairman's report on the activities of the Commission in 2001-2003 (V. Gusiakov).

The Chairman will report on the activities of the Commission since its last meeting in Seattle in 2001 that include sponsoring the tsunami related meetings, conferences and workshops and publications of their proceedings, coordination of tsunami related projects, interaction with the IOC/UNESCO and the IUGG official bodies, supporting information and data exchange.

2. Progress reports on the IUGG/TC sponsored projects

-HTDB/PAC (V. Gusiakov)

The HTDB/PAC (Historical Tsunami Database for the Pacific) project is the joint IUGG/TC - ICG/ITSU initiative directed to the development of the comprehensive tsunami database in the standardized format covering the whole period of historical observations in the Pacific (from 47 D.C to the present time). The first stage of the project was completed in 2001 and resulted in the CD-ROM *Tsunamis in the Pacific*, *47 D.C. - 2000 A.D*. Dr.V.Gusiakov, the HTDB/PAC Project Coordinator, will report on the present status and further development of the project. Special attention will be given to reporting the data on recent tsunamis, many of them (15 of 85 events occurred within the Pacific in the last decade) are still kept in the database with validity 2 (as questionable events).

--TIME (F. Imamura)

The TIME (Tsunami Inundation Modeling Exchange) project was launched in 1995 to transfer tsunami modeling technology to developing countries. Since then, the TIME software package has been transferred to more than 15 countries and experts from these countries have been trained in the package application. Dr. F. Imamura, the leader of the Tohoku Tsunami Group, will comment on the present status of the TIME project.

3. Publication of Proceedings of the Sapporo Symposium (K. Satake)

Following the long-term commission tradition, the biannual tsunami symposia are followed by publication of the volume of selected papers. We will decide on how and where the proceedings of the Sapporo symposium can be published and select the editor (volunteers are welcome).

4. Tsunamis from Asteroid/Comets Impact (V. Gusiakov)

Dr. V. Gusiakov will report on his participation at the ICSU-sponsored meeting on the Asteroid/Comets Impact to the Society that was held in Paris last April. Objectives of the Paris meeting were to establish an active collaboration among the participating scientific Unions to prepare an ICSU proposal on the asteroid/comets hazard study. This proposal for the Category I Grant for the 2004 ICSU Grant Programme has been prepared and presented to the ICSU Committee on Scientific Planning and Review (CSPR) for reviewing. Proposal is centered on conducting a multi-disciplinary workshop to be held in April-May of 2004 somewhere in Europe. The main purpose of the workshop will be to bring together the key researches in a variety of disciplines (astronomy, geology, geophysics, geography, economics, psychology, risk management) as well as representatives of leading inter-governmental agencies to consider what is known and what are the major open questions regarding how comet/asteroid impacts may influence human society in the near future. Its output is seen as a balanced report that reflects a multi-union position statement on the subject of comet-asteroid impacts and their possible hazard for society. The risk of tsunami from an oceanic impact is one the main items considered in the project proposal. The

members of the commission are invited to suggest how the IUGG Tsunami Commission could participate in this activity.

5. The 2005 Tsunami Symposium (V. Gusiakov, K. Satake)

In years between the IUGG General Assemblies the symposium is conducted as an independent meeting or in association with the General Assembly of one of our co-sponsoring Associations (IASPEI, IAPSO, IAVCEI). In Sapporo we will have to decide on the place of the biennial tsunami research symposium in 2005. In case, we decide to have an independent meeting, there is an offer to host the 2005 symposium in Greece. The proposed time is the last week of June, place - Crete Island (Chania or Heraklion), leading institution - the Institute of Geodynamics, National Observatory of Athens, 1-day field trip is planned for visiting paleotsunami sites on the north coast of Crete followed by an optional 2-3 day trip to the Thera Island (Santorini).

6. Election of new Commission members

According to the Commission's rules, candidates can be nominated only by a present member of the Commission from the same country, or any member for a country which does not have a current member. The Commission member proposing a candidate for membership should present a short summary (a page or a paragraph) of a candidate's contribution in the tsunami field. The total membership of the Commission should be kept at the nearly constant level (currently, 29 members, the list of which can be found at http: //omzg.sscc.ru/tsulab/IUGGTCmembers.html), so that countries with an adequate membership should nominate new members only when they have lost a former member or there is a definite need for an additional member. Failure to participate in the three consecutive Commission business meetings will result in the loss of membership. Among the present Commission membership, R. Braddock (Australia) missed the meetings in Birmingham and Seattle meetings and, in case of his no-show in Sapporo, will be deleted from the Commission. So far, two new candidates were nominated: V. Titov from USA (by E. Bernard) and G. Downes from New Zealand (by J. Preuss).

7. Election of new Commission Officers

In Sapporo, the terms of all commission officers except one of the Vice-Chairs (K. Satake) will be over. The present Chair (Viacheslav Gusiakov), Vice-Chair (Stefano Tinti) and Secretary (Jim Lander) will retire. Therefore, we need nominations for the new commission officers. Note that nominees must be selected from the Tsunami Commission membership and should be willing to serve for the next four years.

After some preliminary discussion, the Tsunami Commission executive committee proposes the following slot of candidates: Chair - Dr. Kenji Satake (Japan); Vice-Chair, Dr. Frank Gonzalez (USA); Vice-Chair - Dr. Gerassimos Papadopoulos (Greece); Secretary - Dr. Fumihiko Imamura (Japan).

All the candidates expressed their agreement to serve for the next four years. According to the IUGG procedure, officers of a Commission may serve the second term provided that they are re-elected.

8. An open discussion for any members to make comments or to raise questions

Under this agenda item, the commission members are invited to make comments or raise questions concerning any aspects of the commission activities in the past, present and future.

**STATE EMERGENCY MANAGEMENT OFFICES**

Alaska Division of Emergency Services
Dept. of Military & Veterans Affairs
P.O. Box 5750
Fort Richardson, AK 99505-5750
(907) 428-7039; Fax (907) 428-7009
http://www.ak-prepared.com/

California Office of Emergency Services
P. O. Box 419047
Rancho Cordova, CA 95741-9047
(916) 845-8911, Fax (916) 845-8910
http://www.oes.ca.gov/

Hawaii State Civil Defense
Dept. of Defense
3949 Diamond Head Road
Honolulu, HI 96816-4495
(808) 734-2161; Fax (808)733-4287
E-Mail: rprice@pdc.org http://iao.pdc.org

Oregon Division of Emergency Management
595 Cottage Street, NE
Salem, OR 97310
(503) 378-2911 ext 225, Fax (503) 588-1378
http://www.osp.state.or.us/oem/oem.htm

Washington State Military Dept.
Emergency Management Division
Camp Murray, WA 98430-5122
(253) 512-7067, Fax (253) 512-7207
http://www.wa.gov/mil/wsem/

Provincial Emergency Program
455 Boleskin Road
Victoria, BC V8Z 1E7
British Columbia, Canada
(250) 952-4913
Fax (250) 952-4888 http//www.pep.bc.ca

## MEGA TSUNAMI HAZARDS

The Tsunami Society, Media Committee Evaluation, January 15, 2003

From: http://www.drgeorgepc.com/TsunamiMegaThreatEval.html Reprinted with permission from Dr. George Pararas-Carayannis.

The mission of the Tsunami Society includes "the dissemination of knowledge about tsunamis to scientists, officials, and the public." We have established a committee of private, university, and government scientists to accomplish part of this goal by correcting misleading or invalid information released to the public about this hazard. We can supply valid, correct and important information; advice to the public; and the names of reputable scientists active in the field of tsunami [research], who can provide such information.

Most recently, the Discovery Channel has replayed a program alleging potential destruction of coastal areas of the Atlantic by tsunami waves which might be generated in the near future by a volcanic collapse in the Canary Islands. Other reports have involved a smaller but similar catastrophe from Kilauea volcano on the island of Hawai'i. They like to call these occurrences "mega tsunamis". We would like to halt the scaremongering from these unfounded reports. We wish to provide the media with factual information so that the public can be properly informed about actual hazards of tsunamis and their mitigation.

Here is a set of facts, agreed upon by committee members, about the claims in these reports:

--- While the active volcano of Cumbre Vieja on Las Palma is expected to erupt again, it will not send a large part of the island into the ocean, although small landslides may occur. The Discovery program does not bring out in the interviews that such volcanic collapses are extremely rare events, separated in geologic time by thousands or even millions of years.

--- No such event – a mega tsunami – has occurred in either the Atlantic or Pacific oceans in recorded history. NONE.

--- The colossal collapses of Krakatau or Santorini (the two most similar known happenings) generated catastrophic waves in the immediate area but hazardous waves did not propagate to distant shores. Carefully performed numerical and experimental model experiments on such events and of the postulated Las Palma event verify that the relatively short waves from these all, although intense, occurrences do not travel as do tsunami waves from a major earthquake.

--- The U.S. volcano observatory, situated on Kilauea, near the current eruption, states that there is no likelihood of that part of the island breaking off into the ocean.

These considerations have been published in journals and discussed at conferences sponsored by the Tsunami Society.

Some papers on this subject include:

Pararas-Carayannis, George, 2002, Evaluation of the threat of mega tsunami generation from postulated massive slope failures of island stratovolcanoes on La Palma, Canary Islands, and on the island of Hawaii: Science of Tsunami Hazards, v. 20, no. 5, p. 251-277. (Available at http://www.sthjournal.org)

Mader, C. L., 2001, Modeling the La Palma landslide tsunami: Science of Tsunami Hazards, v. 19, no. 3, p. 160-180. (Available at http://www.sthjournal.org)

Moore, J. G.; Clague, D. A., 1992, Volcano growth and evolution of the Island of Hawaii: Geological Society of America Bulletin, v. 104, no. 11, p. 1471-1482, with Supplemental Data 92-34.

Committee members for this report include:

Mr. George Curtis, Hilo, HI (Committee Chairman) 808 963-6670

Mr. Tad Murty, Ottawa, Canada 613 731-8900

Dr. Laura Kong, Honolulu, HI 808 532-6422

Dr. George Pararas-Carayannis, Honolulu, HI 808 943-1150

Dr. Charles L. Mader, Los Alamos, NM 808 396-9855

and all can comment on this or other tsunami matters.

For information regarding the Tsunami Society and its publications, scientific papers on tsunamis, visit: http://sthjournal.org/

**KRAKATAU/KRAKATOA/KRAKATOU**
**120th Anniversary Accounts**

*Editors' note:* On August 26, 1883, the Krakatau volcano erupted explosively, creating one of the deadliest tsunamis in human history. Waves were more than 100 feet high and more than 36,000 people perished. The following materials are presented in recognition of the 120th anniversary of that event.

***Eyewitness Accounts***

**An Elderly Dutch Pilot**

**"**An elderly Dutch pilot, employed in guiding ships through the Straits, gave this account of his experience."(p. 73-74).

*I have lived in Anjer all my life, and little thought the old town would have been destroyed in the way it has. I am getting on in years, and quite expected to have laid my bones in the little cemetery near the shore, but not even that has escaped, and some of the bodies have actually been washed out of the graves and carried out to sea. The whole town has been swept away, and I have lost everything except my life. The wonder is that I escaped at all. I can never be too thankful for such a miraculous escape as I had.*

*The eruption began on the Sunday afternoon [ ed. note: August 26, 1883]. We did not take much notice at first, until the reports grew very loud. Then we noticed that Krakatoa was completely enveloped in smoke. Afterwards came on the thick darkness, so black and intense that I could not see my hand before my eyes. It was about this time that a message came from Batavia [ed. note: Jakarta] inquiring as to the explosive shocks, and the last telegram sent off from us was telling you about the darkness and smoke. Towards night everything became worse. The reports became deafening, the natives cowered down panic-stricken, and a red fiery glare was visible in the sky above the burning mountain. Although Krakatoa was twenty-five miles away, the concussion and vibration from the constantly repeated shocks was most terrifying. Many of the houses shook so much that we feared every minute would bring them down. There was little sleep for any of us that dreadful night. Before daybreak on Monday, on going out of doors, I found the shower of ashes had commenced, and this gradually increased in force until at length large pieces of pumice-stone kept falling around. About six a.m. I was walking along the beach. There was no sign of the sun, as usual, and the sky had a dull, depressing look. Some of the darkness of the previous day had cleared off, but it was not very light even then. Looking out to sea I noticed a dark black object through the gloom, travelling towards the shore.*

*At first sight it seemed like a low range of hills rising out of the water, but I knew there was nothing of the kind in that park of the Soenda [Sunda] Strait. A second glance--and a very hurried one it was--convinced me that it was a lofty ridge of water many feet high, and worse still, that it would soon break upon the coast near the town. There was no time to give any warning, and so I turned and ran for my life. My running days have long gone by, but you may be sure that I did my best. In a few minutes I heard the water with a loud roar break upon the shore. Everything was engulfed. Another glance around showed the houses being swept away and the trees thrown down on every side. Breathless and exhausted I still pressed on. As I heard the rushing waters behind me, I knew that it was a race for life. Struggling on, a few yards more brought me to some rising ground, and here the torrent of water overtook me. I gave up all for lost, as I saw with dismay how high the wave still was. I was soon taken off my feet and borne inland by the force of the resistless mass. I remember nothing more until a violent blow aroused me. Some hard firm substance seemed within my reach, and clutching it I found I had gained a place of safety. The waters swept past, and I found myself clinging to a cocoanut palm-tree. Most of the trees near the town were uprooted and thrown down for miles, but this one fortunately had escaped and myself with it.*


**Figure 1.** Regional map of the Krakatau area.

*The huge wave rolled on, gradually decreasing in height and strength until the mountain slopes at the back of Anjer were reached, and then, its fury spent, the waters gradually receded and flowed back into the sea. The sight of those receding waters haunts me still. As I clung to the palm-tree, wet and exhausted, there floated past the dead bodies of many a friend and neighbor. Only a mere handful of the population escaped. Houses and streets were completely destroyed, and scarcely a trace remains of where the once busy, thriving town originally stood. Unless you go yourself to see the ruin you will never believe how completely the place has been swept away. Dead bodies, fallen*

*trees, wrecked houses, an immense muddy morass and great pools of water, are all that is left of the town where my life has been spent. My home and all my belongings of course perished--even the clothes I am wearing are borrowed--but I am thankful enough to have escaped with my life, and to be none the worse for all that I have passed through."*

(*from:* Simkin, Tom; Fiske, R. S., 1983, Krakatau 1883--The volcanic eruption and its effects: Smithsonian Institution Press, 464 p. reprinted with permission)

**Report from Captain T. H. Lindemann, of the ship *Governor General Loudon*, anchored at Telok Betong** (p. 90-91)

*Monday, August 27th. Finding that at midnight on the evening of our arrival [Aug. 26, 7:30 p.m.] there was still no boat come off to us from the shore, and as the weather was now much calmer, I sent the first mate in the gig with a crew of six men to find out what was the reason of this. About 1 a.m. he returned, and stated that it had been impossible to land on account of the heavy current and surf; also that the harbour pier-head stood partly under water.*

**Figure 2.** Dutch steamship *Berouw*, stranded 1.5 miles inland by tsunami, 60 feet above sea level (or 30 feet, depending upon which source you believe).

*The Government steamer Berouw, which lay anchored near the pier-head, hailed the mate as he was returning on board, and the people on board her then stated to him that it was impossible to land anywhere, and that a boat which had put off from the shore had already been wrecked. That by 6 p.m. on Sunday evening it had already begun to be stormy, and that the stormy weather had been accompanied by a current which swept round and round (apparently a sort of whirlpool). When the mate had come on board, we resolved to await daylight before taking any further steps; however, for the sake of security, we steamed several ships' lengths outwards, because the sound of a ship's bell which seemed to be approaching us made us suspect that the ship must be adrift, and wishing therefore to avoid a collision we re-anchored in nine fathoms with thirty fathoms shackle outside the hawsepipe. We kept the ordinary sea-watch, and afterwards heard nothing more of the bell. When day broke, it appeared to us to be still a matter of danger to send a boat ashore; and we also discovered that a revenue cutter was foul of a sailing-vessel which lay in the roadstead, and that the Berouw was stranded. However, owing to the violent winds and currents, we did not dare to send a boat to her assistance.*

*About 7 a.m. we saw some very high seas, presumably an upheaval of the sea, approaching us up the roadstead. These seas poured themselves out upon the shore and flowed inland, so that we presumed that the inhabitants who dwelt near the shore must be drowned. The signal beacon was altogether carried away, and the Berouw then lay high upon the shore among the cocoanut trees. Also the revenue cutter lay aground, and some native boats which had been lying in the neighborhood at anchor were no more to be seen.*

*Since it was very dangerous to stay where we were, and since if we stayed we could render no assistance, we concluded to proceed to Anjer under steam, and there to give information of what had taken place, weighed anchor at 7:30 a.m., and following the direction of the bay steered thereupon southwards. At 10 a.m. we were obliged to come to anchor in the bay in 15 fathoms of water because the ash rain kept continually growing thicker and thicker, and pumice-stone also began to be rained, of which some pieces were several inches thick. The air grew steadily darker and darker, and at 10:30 a.m. we were in total darkness, just the same as on a very dark night. The wind was from the westward, and began to increase till it reached the force of a hurricane. So we let down both anchors and kept the screw turning slowly at half speed in order to ride over the terribly high seas which kept suddenly striking us presumably in consequence of a "sea quake," and made us dread being buried under them.*

*Awnings and curtains from forward right up the mainmast, three boat covers, and the uppermost awning of the quarter deck were blown away in a moment. Some objects on desk which had been lashed got loose and were carried overboard; the upper deck hatchways and those on the main deck were closed tightly, and the passengers for the most part were sent below. Heavy storms. The lightning struck the mainmast conductor six or seven times, but no damage. The rain of pumice-stones changed to a violent mud rain, and this mud rain was so heavy that in the space of ten minutes the mud lay half a foot deep.*

*Kept steaming with the head of the ship as far as possible seawards for half an hour when the sea began to abate, and at noon the wind dropped away entirely. Then we stopped the engine. The darkness however remained as before, as did also the mud rain."*

(*from:* Simkin, Tom; Fiske, R. S., 1983, Krakatau 1883--The volcanic eruption and its effects: Smithsonian Institution Press, 464 p. reprinted with permission)

**Public Works Engineer N. H. van Sandick, a passenger on the *Loudon*, is a little less constrained in his account** (p. 93-96; abridged)

*"On Aug 26, 1883, the steamer Governor General Loudon, Captain Lindemann, left in the morning from Batavia, destination Kron, Benkoelen, Padang, and Atjeh [Sumatra]. Among the passengers all categories were represented. The majority however consisted of 300 exiles. For the uninformed, be it remarked that with this term are meant persons who have been condemned to forced labor in or outside the chain. Locally they are called "chain boys"; and, especially in the outer colonies, they perform valuable services in the execution of public works, military expeditions, etc.*

*In the afternoon at 3 o'clock the Loudon dropped anchor in the roadstead of Anjer. There 100 Bantammers, which were hired as coolies for the building of a lighthouse on the island of Bodjo [off the west coast of central Sumatra], came aboard. The weather then was beautiful. The white plastered houses of Anjer glittered in the sunshine near the seashore, in the background the mountains, and in front of it the deep blue sea. Clearly the lighthouses of Java's Fourth Point silhouetted itself against the sky. The Dutch flag on the grounds of the Assistant Resident flapped happily; every house could be distinguished and subconsciously the thoughts wander back to the first arrival in the Indies from Europe. Anjer is then the first place which brings welcome greetings from a distance.*

*If we, who were aboard the Loudon in the roads of Anjer, would have declared that the last day of Anjer's existence had already begun, we definitely would have been considered deranged.*

*When our coolies were aboard, the Loudon set course past Dwars-in-Weg and Varkenshoek into the Bay of Lampong toward Telok Betong. To portside we saw in the distance the island of Krakatau, known for its first volcanic eruption several months ago [ed note: May 1883]. Krakatau is an old acquaintance of the Loudon. When, after the first eruption, a pleasure trip was made to see the volcano, the Loudon brought passengers to the island for 25 guilders each. Many landed that time and climbed the volcano; and all experienced a festive and pleasant day.*

*The volcano on Krakatau gave us a free performance. Although we were far away from the island, we saw a high column of black smoke rise above the island; the column widened toward the top to a cloud. Also there was a continual ash fall. Toward evening, at 7 o'clock, we were in the Bay of Lampong, in the roads of Telok Betong, where anchor was dropped and it soon became night.*

*The ashfall increased steadily, while the sea was stormy. The Loudon telegraphed to shore for a sloop to land the passengers, but neither sloop nor load proa arrived. The Loudon itself lowered a boat to make connection with shore. However it was impossible to land, since there was a high surf at the coast, so the boat returned without accomplishing its purpose.*

*The harbor light on the light tower continued to burn, although something unusual seemed to occur: now and then alarm signals were observed from the proas laying in the roadstead. Instead of the ash, we received meanwhile a rain of pumice. Fortunately, the night had passed and it became light, so that we could see Telok Betong. While all of Anjer is located near the seashore, at Telok Betong the military encampment and the house of the Resident are built on a hill farther away from the coast. The largest part of Telok Betong, however, is located near the seashore. The European houses, some covered with tiles, some with atap [palm thatch], could be distinguished from the native houses, which on Sumatra completely differ in building style from the Javanese houses seen at Anjer…*

*However, the last hour of Telok Betong had already sounded. The government steamer Berouw and the cruise boat had already been beached by the sea during the night and the harbor light continued to burn, although the sun already had risen above the houses.*

*Suddenly, at about 7 a.m., a tremendous wave came moving in from the sea, which literally blocked the view and moved with tremendous speed. The Loudon steamed forward in such a way that she headed right into the wave. One moment...the wave had reached us. The ship made a tremendous tumbling; however, the wave was passed and the Loudon was saved. The wave now reached Telok Betong and raced inland. Three more similar colossal waves followed, which destroyed all of Telok Betong right before our eyes. The light tower could be seen to tumble; the houses disappeared; the steamer Berouw was lifted and got stuck, apparently at the height of the cocoanut trees; and everything had become sea in front of our eyes, where a few minutes ago Telok Betong beach had been. The impressiveness of this spectacle is difficult to describe. The unexpectedness of what is seen and the tremendous dimensions of destruction, in front of one's eyes make it difficult to describe what has been viewed. The best comparison is a sudden change of scenery, which in fairy tales occurs by a fairy's magic wand, but on a colossal scale and with the conscious knowledge that it is reality, and that thousands of people have perished in an indivisible moment, that destruction without its equal has been wrought, and that the observer is in threatening danger of life. Taking all these things together the impression caused by such a natural scene can possibly be described, but it stops short of reality….*

*Meanwhile we steamed forward and soon the roads of Telok Betong were lost from view, and we hoped soon to be out of the Bay of Lampong. But we would not get away that easily. It became darker and darker, so that already at 10 a.m. there was almost Egyptian darkness. This darkness was complete. Usually even on a dark night one can still distinguish some outlines of, for instance, white objects. However, here a complete absence of light prevailed. The sun climbed higher and higher, but none of her rays reached us. Even on the horizon not the faintest light could be seen and not a star appeared in the sky.*

*This darkness continued for 18 hours. It is self-evident that the Loudon during this pole-night had to "winter over" in the bay. Meanwhile a dense mud rain fell, covering the deck more than half a meter thick and penetrating everywhere, which was especially bothersome to the crew, whose eyes, ears, and noses were liberally filled with a material which made breathing difficult. Off and on again, ash and pumice fell. The compass showed the strangest deviations. Fierce sea currents were observed in diverging directions. The barometer meanwhile read very high, which certainly was difficult to explain. Breathing, however, was not only made difficult by ash, mud, and pumice particles, but the atmosphere itself had also changed. A devilish smell of sulphurous acid spread. Some felt buzzing in the ears, others a feeling of pressing on the chest and sleepiness. In short, the circumstances left something to be desired, since it would have been quite natural if we all had choked to death.*

*However, the Loudon was exposed to entirely different dangers. After the darkness had fallen for some time the sea became stormy. The wind increased and became a flying hurricane. Following, there were a series of sea tremors. These evidenced themselves by very high waves, which formed suddenly. A few of these hit the Loudon sideways, so that she was lifted up and leaned sideways to the extent that danger of capsizing threatened. The ship then made motions, so that everything rolled over and resembled being in the Gulf of Biscay. Also during these tremors lightning hit the mast up to seven times, moving first along the lightning rod and then after that, still above the ship, jumping over to the water with a demonical, snapping noise. At such a moment, everything was suddenly clearly lit, showing how everything had been tinted ash gray by the mud rain, making one impulsively think of a ghost ship."*

*(from: Simkin, Tom; Fiske, R. S., 1983, Krakatau 1883--The volcanic eruption and its effects: Smithsonian Institution Press, 464 p. reprinted with permission)*

**Telegram from Lloyd's of London Agent Mccoll in the Week Following the Eruption/Tsunami**

*We shall probably not be in possession of full particulars for some days yet, as telegraph lines are damaged and roads destroyed, but so far we can give the following particulars. The island of Krakatoa, the summit of which peak was 2,600 feet above water level, has totally disappeared beneath the sea…and the sea bottom in the Straits of Sunda has completely changed. In fact the Admiral Commanding-in-Chief has issued a circular stating that until new soundings have been taken the navigation of the Straits of Sunda is likely to be extremely dangerous. Anjer and lighthouse and the other lights of southwest Java have all been destroyed. The subsidences and upheavals we have alluded to caused a large wave about 100 feet in height to sweep down on the southwest coast of Java and south of Sumatra. This was swept in for a great distance, thereby doing great injury both to life and property. We are here only twelve miles away from one of the points on which the wave spent its fury. The whole coastline to the southwest has changed its configuration. The inhabitants of the island of Onrust were only saved from the flood which swept over the island by taking refuge on board two steamers. At Merak government establishment the inhabitants took refuge on a knoll, fifty feet high, but were all swept off and drowned, with the exception of one European and two Malays, who were saved. Mauk and Kramat, on the west side of Batavia roads, have been laid waste, and about 300 lives lost. In Tjeringin only one house has been left standing. Both the native and European officials have perished. A rain of mud also fell at the above place, which is situated opposite to where Krakatoa once lay. Anjer seems to have been completely destroyed. Lloyd's sub-agent there wires from Serang: "All gone. Plenty lives lost."*

*from:* Winchester, Simon, 2003, Krakatoa, the day the world exploded: HarperCollins, p. 257-258.

***And, Krakatau Today***

*dateline:* Krakatau, Sunda Strait, Indonesia, 6.10 S, 105.42 E; summit elev. 813 m, All times are local (=UTC+7 hours)

During 9 September through at least late December 2002, seismicity at Krakatau was dominated by A- and B-type volcanic earthquakes (table 2). Throughout the report period, clouds obscured the view of the summit. Krakatau remained at Alert Level 2.

| Date (2002) | A-type volcanic | B-type volcanic | Tectonic |
|---|---|---|---|
| 09 Sep-15 Sep | 2 | 6 | 3 |
| 30 Sep-06 Oct | 8 | 31 | 6 |
| 07 Oct-13 Oct | 30 | 109 | 6 |
| 14 Oct-20 Oct | 18 | 64 | 3 |
| 21 Oct-27 Oct | 7 | 55 | 5 |
| 28 Oct-03 Nov | 8 | 54 | 11 |
| 04 Nov-10 Nov | 28 | 56 | 5 |
| 11 Nov-18 Nov | 2 | 31 | 5 |
| 02 Dec-08 Dec | 16 | 50 | 5 |
| 09 Dec-15 Dec | 13 | 53 | 13 |
| 16 Dec-22 Dec | 6 | 32 | 1 |
| 23 Dec-29 Dec | 11 | 59 | 2 |

Table 2. Earthquakes registered at Krakatau during 9 September-29 December 2002. No data were available during 16-29 September. Courtesy VSI.

Background. Renowned Krakatau volcano lies in the Sunda Strait between Java and Sumatra. Collapse of the ancestral Krakatau edifice, perhaps in 416 AD, formed a 7-km-wide caldera. Remnants of this ancestral volcano are preserved in Verlaten and Lang Islands; subsequently Rakata, Danan, and Perbuwatan volcanoes were formed, coalescing to create the pre-1883 Krakatau Island. Caldera collapse during the catastrophic 1883 eruption destroyed Danan and Perbuwatan volcanoes, and left only a remnant of Rakata volcano. This eruption, the 2nd largest in Indonesia during historical time, caused more than 36,000 fatalities, most as a result of devastating tsunamis that swept the adjacent coastlines of Sumatra and Java. Pyroclastic surges traveled 40 km across

the Sunda Strait and reached the Sumatra coast. After a quiescence of less than a half century, the post-collapse cone of Anak Krakatau (Child of Krakatau) was constructed within the 1883 caldera at a point between the former cones of Danan and Perbuwatan. Anak Krakatau has been the site of frequent eruptions since 1927.

Information Contact: Volcanological Survey of Indonesia (VSI); dali@vsi.dpe.go.id; http://www.vsi.dpe.go.id.

*from:* Bulletin of the Global Volcanism Network, v. 27, no. 12, December 2002, p. 7-8.

***More about Krakatau***

**Krakatau Workshops and Conferences**:

International Seminar/Workshop on Tsunami. "In Memoriam: 120 Years Of Krakatau Eruption-Tsunami and Lessons Learned From Large Tsunami,"August 26th-29th 2003, Jakarta and Anyer.

Opening remarks and seminar in Jakarta, August 26, 2003. Seminar and workshop in Anyer, August 27 and 28, 2003.

Tour to Krakatau volcano complex, August 29, 2003. To remember the great eruption of Krakatau 120 years ago in August 27th 1883 and to awaken the people around the tsunami and earthquake prone area to the possibility of upcoming tsunami disaster, Meteorological and Geophysical Agency (BMG) and Department of Marine Affairs and Fishery (DKP) of Indonesia will organize seminar and workshop in Indonesia. This occasion is in cooperation with ICG/ITSU, IUGG Tsunami commission and several related government institutions in Indonesia. (For more information, go to http://www.bmg.go.id/krakatau/)

**Krakatau Websites:**

http://www.volcanolive.com/krakatau1883.html
chronology of events in 1883

http://www.volcano.si.edu/world/region06/krakatau/krakatau/var.htm

Gives the history of Krakatau and its eruptions, from 416 AD to 2002. Includes charts, maps and photos.

http://www.geology.sdsu.edu/how_volcanoes_work/Krakatau.html

Thorough descriptions of the volcanic eruption and resultant tsunamis.

http://www.volcano.si.edu

Homepage for the Smithsonian's Global Volcanism Program. Includes links to Volcanoes of the World, Volcanic Activity Reports, Frequently Asked Questions and Volcano Links.

http://www.volcano.si.edu/world/volcano.cfm?vnum=0602-00=

Krakatau page, with photo.

**Krakatua Suggested Readings:**


Maclairn, Christopher, 2001, In the shadow of Krakatoa: Xlibris Corporation, 303 p.

Simkin, T.; Fiske, R. S., Krakatau 1883--The volcanic eruption and its effects: Smithsonian Institution Press, 1983.
*Includes a detailed 27-page chronology of events, great maps, charts, geologic reports from the late 1800's, current geologic reports, and eyewitness accounts. Was written for the 100th anniversary of Krakatau's eruption.*

Thornton, I. W. B., 1996, 1996, Krakatau--The destruction and reassembly of an island ecosystem: Harvard University Press, 346 p.

Winchester, Simon, 2003, Krakatoa--The day the world exploded: HarperCollins, 416 p.


**ANOTHER TSUNAMI TSONG!**

(Repr. From International Tsunami Information Center Newsletter, !5 Sept. 1972, p. 1)

*To the tune of "I've Been Working on the Railroad")*

I've been working on the breakwater all the live long day
I've been working on the breakwater just to keep the tsunamis away
Can't you hear the earthquake rumbling, all the buildings crumbling,
Can't you see the water rising, might wash the town away
Tsunami don't you rise, tsunami don't you rise,
Tsunami don't you wash the town away.
You bring in the research projects,
You bring in the research grants,
You bring in the research projects, we'll keep our jobs always.

**THE 13 NOVEMBER 1985 DISASTER AT NEVADO DEL RUIZ, COLOMBIA**

Excerpt from: *Lahars: Classification, Dynamics, and Human Impacts*, by Shizuo Nishizawa, 2000, University of Utah Master of Science thesis, p. 80-87

Reprinted with permission

*Editors' note*: More than 20,000 people perished from the lahar generated by the eruption of Nevado del Ruiz volcano. In reading this account, we were struck by the tragic failures in emergency management and so wanted to share it with *TsuInfo Alert* readers.

In November, 1984, almost a century-long peaceful dormancy at Nevado del Ruiz volcano, Columbia, ended with the beginning of a series of earthquakes and increased fumarolic activity at the summit. As the volcano's anomalous activity continued, a civic committee was formed in late January in Manizales, a city of 350,000, in Caldas province, which is located just west of the volcano (Hall, 1990, 1992; Voight, 1990). During February, at the request of that committee, Colombia's National Institute of Geology and Mines or Geology and Mines Bureau (INGEOMINAS) conducted the first investigation at the summit, while the first article on the unrest at the Ruiz appeared in the newspaper in Manizales.

As both fumarolic and seismic activities were at abnormal levels, INGEOMINAS and Colombian Civil Defense requested aid from the United Nations Office of the Disaster Relief Organization (UNDRO) in March. In the same month, the UNDRO team swiftly concluded that the abnormal activity at the Ruiz corresponded to typical precursory events for eruption (Voight, 1990). Although it also recommended that INGEOMINAS establish a monitoring network and prepare hazard maps, the total absence of volcanic expertise in Colombia at the time, lack of funds in the international organizations, and bureaucratic red tape at various levels of government, all delayed setting up the monitoring network, which was supposed to consist of 4 portable seismographs, until late July. Even then, a lack of telemetry for these seismographs prevented instant readout and interpretation. The data was sent to Bogota by mail for analysis. As a result, the first written seismic report did not even come out until just before November 13 (Hall, 1992). Furthermore, when the Swiss Seismological Service provided three additional seismographs, disillusioned with the unwillingness of government in Bogota to work on the situation, the committee in Manizales opted to work independently instead of sharing data with INGEOMINAS (Hall, 1992). Thus, overall monitoring efforts prior to the eruption might be best described as fragmented or marginal; they never became coordinated and effective.

Likewise, much needed international aid never became a concerted effort. Although a variety of countries such as Italy, Switzerland, France, Costa Rica, Ecuador, New Zealand, and the United States did offer technical assistance, each visit to Nevado del Ruiz usually took a couple of weeks consisting of collecting samples followed by the typical recommendation statements for INGEOMINAS to establish better monitoring networks. The gas samples, for example, were sent back to the home countries for analysis; it was only 12 days before the eruption, when an Italian team, in Italy, confirmed the magmatic origin of the gas sampled at Ruiz. In another case, the results of chemical analyses of water from the crater, conducted by a New Zealand team, were not available before the eruption (Voight, 1990; Hall, 1992).

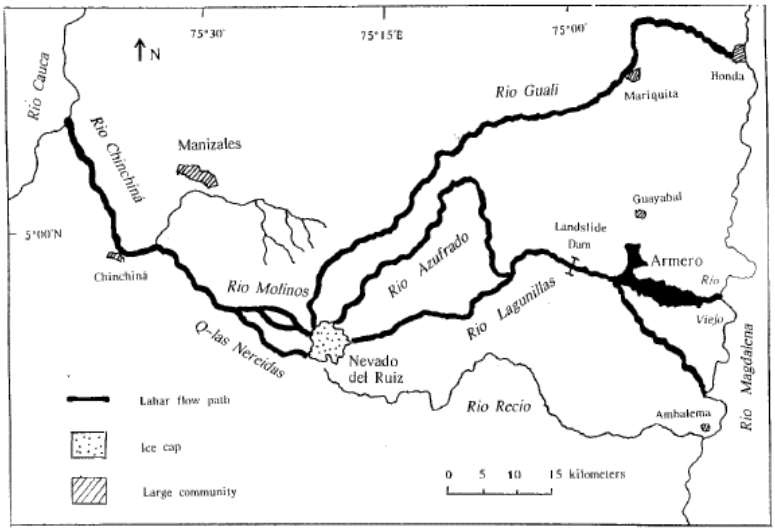


Figure 4. Lahars of the 1985 Nevado del Ruiz eruption, adapted from Pierson and others (1990, Fig. 1., p. 18).

Furthermore, for over 4 months, the U.S. Geological Survey (USGS) had been unable to respond to the INGEOMINAS' plea for technical assistance because of its dispute over budgetary constraints with the U.S. Office of Foreign Disaster Assistance (OFDA). On November 6, when two USGS seismologists with a single telemetered seismograph were ready to leave for Colombia after the lengthy interagency cost negotiations, Colombian government troops stormed the Palace of Justice, which had been seized by leftist guerillas, in Bogota. This botched assault not only left 100 dead, including 11 supreme court justices, but also led the U.S. State Department and OFDA to decide not to send any U.S. government personnel to Colombia (Voight, 1990, 1996).

**Two Provinces with Different Cultural Backgrounds**

Two provinces, aforementioned Caldas to the west and Tolima which includes Armero to the east, are located on the opposite sides of the Ruiz volcano. Being closer to the nation's capital, the province of Tolima has depended upon Bogota for its commerce, culture, and news sources. Caldas, on the other hand, being isolated from Bogota and other cities by the mountains, has been known to be "more independent and dynamic" (Hall, 1992, p. 48). As the quick formation of the civic committee and newspaper coverage in response to the beginning of the Ruiz unrest indicate, the leadership by local government and concerned citizens in Manizales, a capital of Caldas, had always shown "greater initiative" for mobilizing interest, volcanic studies, public awareness, emergency preparedness, and outside assistance (Hall, 1992, p. 48). In addition with a higher average education level and better developed electrification than Tolima, the people in Caldas were in much better position to access and understand information concerning the abnormal Ruiz activity through both printed and electronic news media. A local newspaper, *La Partia*, for example, had provided extensive coverage on the Ruiz situation in more than 60 articles prior to the eruption (Hall, 1992).

Because the province of Tolima, not having developed a strong local news service, had depended solely on two daily newspapers from Bogota that ran only marginal coverage on the unrest at Nevado del Ruiz, mostly downplaying the immediate danger, the governments and public in Tolima were "poorly informed of the volcano's unusual activity, skeptical of any possible danger, and basically remained unconcerned and uninvolved in hazard mitigation efforts" (Hall, 1992, p. 49).

"Very attentive" attitudes of Caldas and Manizales were, however, always met with indifference by the national and other provincial governments (Hall, 1992, p. 49). For instance, in the middle of September, a proposal by the governor of Caldas to combine emergency efforts of the four provinces surrounding the Ruiz had received no enthusiasm from the other three provinces (Hall, 1992). Therefore, mistrust in the way the government in Bogota handled the situation had increasingly grown in Caldas, leading to some of the independent efforts by Manizales and Caldas, as their own seismic monitoring showed.

In response to the great willingness of the local governments and public in Caldas to prepare for the emergency situations, virtually all initiatives and international assistance had centered around Manizales from the beginning. In fact, placing so much emphasis on the mitigation efforts in Manizales and the communities on the west side of the mountain might have, in a way, created the atmosphere in which many overlooked the potentially greater risk on the opposite side of the Ruiz volcano.

**Running Out of Time**

On September 11, 1985, Nevado del Ruiz produced the first phreatic eruption since the unrest began. A small scale ash fall and a moderate size lahar, which traveled 27 km, reconfirmed that the threats of eruption were real (Voight, 1990). While the Caldas civil defense office began the volcano awareness programs at elementary and high schools and distributed hand-outs explaining what to do in case of eruption, even previously uninvolved officials in Tolima expressed concern for the effects of lahars on a natural dam which had existed in the Lagunillas River upstream of Armero for some time (Hall, 1992).

As the news media carried two opposing views regarding the potential of stronger magmatic (eruption and lahars), thereby confusing the public, INGEOMINAS at an October 7 press conference presented the first hazard map, which accurately depicted the areas at risk of lahars (Hall, 1992). With the map, INGEOMINAS officials acknowledged that in event of eruption there would a hundred percent probability of lahars, which would be triggered by melting of the Ruiz summit ice cap to pose great threats to Armero, Mariquita, Honda, Ambalema, and the lower reaches of the Chinchina River---the exact communities that suffered from the lahars on November 13 (Hall, 1992, p. 111). Nevertheless, only 10 copies of the map were distributed at the time, while the newspapers published the map with major errors on the next day; the areas at risk of lahars were labeled as those at risk of pyroclastic flows (Voight, 1996). Despite that, for a moment, it appeared that the governments and people as a whole finally began engaging in serious hazard mitigation efforts; this was when the "countercurrents" started to arise (Voight, 1996, p. 730).

During crisis situations, there are people who are "exposed to direct or indirect losses or mitigation costs from a hazardous event or its perception" (Voight, 1996, p. 747). Those so called "stakeholders" may be property owners, real estate or financial institutions, planners, insurers, and policy makers (Voight, 1996, p. 747). In most cases, they employ political influence to retard the hazard mitigation process and openly demonstrate their skepticism and hostility towards it.

Around the time when the first hazard map came out, the Archbishop of Manizales accused the news media of spreading "volcanic terrorism" (Hall, 1990, p. 111). In addi-

tion, the chamber of commerce in Manizales expressed the fear that the volcano reports on news media would cause economic losses and the volcano hazard map could create real estate devaluation (Voight, 1990). The hazard map was also criticized by some government officials in Bogota for "being too alarming" (Voight, 1996, p. 730-731). The skeptical and reluctant Bogota government eventually ordered INGEOMINAS to recheck and resubmit the map, thereby effectively "tabling" the map for another month (Voight, 1996,p. 730-731). As skepticism still dominated the province of Tolima, the time had run out for Armero.

**November 13**

A couple of hours after the phreatic eruption of the Ruiz at 15:06, a previously scheduled Regional Emergency Committee meeting was held in the capital of Tolima, Ibagu. Although an alert was issued by the Committee, the report that conditions returned to normal at 19:30 prevented any formal decision for evacuation from being made (Voight, 1996). The Committee adjourned shortly after. When the magmatic eruption phase began after 21:08, the Civil Defense Director of Caldas in Manizales immediately issued a red alert in his own voice to urge evacuation of residents along the Caldas riverbank communities. As the alert continued to be aired on radio for an hour, multiple pulses of lahars were rushing down the river valleys. After coming from Molinas and Nereidas channels, the flows entered the Chinchina River and traveled more than 70 km to the Cauca River. The lahars struck the riverbank village of Chinchina at 22:40 (Voight, 1996). Although the general alert is believed to have saved hundreds of lives, 1,921 were killed on the west side of Nevado del Ruiz.

On the east side, around 22:00, now realizing that the climatic eruption was in progress, the officials in the Tolima capital attempted to contact Armero, which was engulfed in a heavy ash laden storm at the time (Voight, 1990, 1996). In addition, the civil defense radios of at least three municipalities warned Armero of the oncoming lahars (Voight, 1996). Although it is not clear that authorities in Armero actually received any of those messages, all survivors' accounts agree that the general evacuation order was never issued in Armero. Some survivors remembered that the radio repeatedly announced to stay calm, with assurances from a mayor and priest, while others report that one of the firemen tried to warn people by blowing a whistle and setting off alarms on the streets, even though the residents did not want to come out because of the heavy rain. Some families were able to survive simply because their relatives upstream warned them by phone. When the first wave of lahars reached Armero at 23:35, the still skeptical mayor was on ham radio talking about this doubts regarding the validity of the eruption and lahar hazards (Voight, 1996).

As discussed in the previous chapter, multiple lahars struck Armero in the next 1.5 hours, burying the town and its 21,000 residents. The still-soft muddy surface of the lahar deposits allowed only 65 of 1,000 to 2,000 still trapped alive to be rescued by noon the next day (Voight, 1996).

**Aftermath**

Immediately following this disaster, the international scientific communities had set up sophisticated monitoring networks on Nevado del Ruiz consisting of telemetered seismographs and lahar sensors. A warning system using sirens was also introduced in combination with a public education campaign in the areas right after November 13. Yet, drills in December, 1985 and January, 1986, revealed that siren systems did not work even with public education--very few residents evacuated (Voight, 1996). Besides reconfirming that the specific verbal command has to be accompanied with sirens in warning systems, as Voight (1996) points out, these disappointing results may imply that even a combination of public awareness programs and siren warning systems in place would not have been sufficient to convince the majority of Armero residents to evacuate at midnight in the midst of the storm on that night. In his concluding remark to summarize the Armero disaster, Voight (1990, p. 185) warns how easily the fundamental problems of common human behavior can cause failures in any hazard mitigation effort and bring about dire consequences: the catastrophe at "Armero was caused, purely and simply, by cumulative human error - by misjudgment, indecision, and bureaucratic shortsightedness," not by excessive technological deficiency, "nor by any overwhelming eruption of unprecedented character, nor by an improbable run of bad luck."

**References**


Hall, M. L., 1990, Chronology of the principal scientific and governmental actions leading up to the November 13, 1985 eruption of Nevado del Ruiz, Colombia: Journal of Volcanology and Geothermal Research, v. 42, no. 1-2, p. 101-115.

Hall, M. L., 1992, The 1985 Nevado del Ruiz eruption--Scientific, social, and governmental response and interaction before the event. *In* McCall, G. J. H., Laming, D. D. C., Scott, S. C., editors, Geohazards—Natural and man-made: Chapman & Hall, p. 43-52.

Pierson, T. C.; Janda, R. J.; Thouret, J.-C.; Borrero, C. A., 1990, Perturbation and melting of snow and ice by the 13 November 1985 eruption of Nevado del Ruiz, Columbia, and consequent mobilization, flow and deposition of lahars: Journal of Volcanology and Geothermal Research, v. 41, no. 1-2, p. 17-66.

Voight, Barry, 1990, The 1985 Nevado del Ruiz volcano catastrophe—Anatomy and retrospection: Journal of Volcanology and Geothermal Research, v. 42, no. 1-2, p. 151-188.

Voight, Barry, 1996, The management of volcano emergencies—Nevado del Ruiz. *In* Scarpa, Roberto; Tilling, R. I., editors, Monitoring and mitigation of volcano hazards: Springer-Verlag, p. 719-769.

## WEBSITES

http://nauticalcharts.noaa.gov/csdl/op/nowcoast.htm
(See "News from NOAA," p. 4 above.)

http://www.ess.washington.edu/tsunami/
Hosted by the Department of Earth and Space Sciences, University of Washington, last updated June 8, 2000. Provides links to the Alaska Tsunami Warning Center, Physics of Tsunamis, A Survey of Great Tsunamis, Tsunami Warning System, and Tsunami Hazard Mitigation web pages.

http://ioc.unesco.org/itsu/
The joint website of ITIC and IOC/ITSU ("a tsunami information data portal") is now available for browsing. No password is needed. The website provides information for both tsunami scientists and the public.

http://ingrid.ldeo.columbia.edu
This web site from the International Research Institute for Climate Protection at Columbia University includes a broad collection of earth science data on atmospheric and oceanic conditions.

http://www.meted.ucar.edu/topics_emt.php
The COMET Program (mentioned many times previously in Hazard Center publications) has remodeled its education and training web site, "MetEd." The new site also contains free self-paced distance learning materials for emergency managers and community decision makers.

http://www.csc.noaa.gov/text/grant.html
This web site provides coastal managers with information on grant opportunities offered by the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center and other relevant organizations. The site also provides links to grant-writing resources, including articles, tutorials, and tips to help navigate through the grant-writing process. *from:* Disaster Research 390, June 13, 2003

## PUBLICATIONS

**All-Hands Community Electronic Newsletter**

The "All Hands Community," a virtual, growing, and user-supported community of emergency and continuity professionals, announces the first edition of its electronic newsletter. All-Hands was started with the goal of making it easy to post articles, share files, and communicate with others in the emergency management and business continuity professions. Newsletter issues will contain links to recently added web site resources, along with relevant articles and news. The newsletter will never feature advertisements, only content straight from the community. This service is available free upon registering as a member of the All-Hands Community at http://www.all-hands.net/pn/.
*from:* Disaster Research 391 June 27, 2003

**Strategies for Coordinating Disaster Responses**

When disaster strikes, people respond. Initial response involves the rapid mobilization of a local core of trained individuals such as fire, police, and emergency medical services personnel, who are collectively known as "first responders." Upon arrival at the scene, first responders often confront a variety of unofficial helpers–people who are trying to help their neighbors and friends, or who are there simply to offer assistance. In addition, the flow of communication between personnel, agencies, and the public quickly becomes complex.

The Hazard Center's newest monograph, *Strategies for Coordinating Disaster Responses* (Monograph 61, Program on Environment and Behavior, 2003, 242 p.) by Thomas E. Drabek, explores how the presence and effectiveness of emergency managers can help shape overall emergency response and recovery to a given event. Emergency managers are called upon to facilitate the smooth functioning of all responders, activities, and jurisdictions, and to create a seamless atmosphere of swift and effective response. This task is not easy, nor is it well understood.

The author uses extensive interviews with over 150 emergency managers, agency executives, and emergency management team members, all of whom have participated in a large disaster response, to shed some light on the structures and strategies used to initiate and maintain multi-agency coordination during disaster. The goal of the study was to document the strategies used by local emergency managers to enhance coordination among the core agencies with which they worked during disaster response. The key lesson from the data is that many emergency managers must learn to operate under the auspices of a new paradigm and a different perspective. They must learn to think strategically.

Monograph 61 may be purchased for $20.00 plus $4.50 shipping from the Publications Administrator, Natural Hazards Center, University of Colorado, 482 UCB Boulder, CO 80309-0482; (303) 492-6819; fax: (303) 792-2151; e-mail: *janet.kroeckel@colorado.edu*.
*from:* Natural Hazards Observer, v. XXVII, no. 6, July 2003, p. 4

**Evaluation of Tsunami Risk to Southern California Coastal Cities: The 2002 NEHRP Professional Fellowship Report.**

This report focuses on the potential occurrence and damage effects of tsunamis generated by major offshore earthquake sources along the California coast. Topics covered include estimating tsunami amplitude, run-up, inundation, and overall occurrence probability. The authors model the Santa Catalina Island platform along two major fault sections and create a simulated 7.6 magnitude earthquake to explore the potential impacts of wave propagation effects. Because of high human population and the value of coastal property, ports, and urban infrastructure, there is potential for great loss from these infrequent offshore events.

The authors are Mark R. Legg, Jose C. Borrero, and Costas E. Synolakis. 2003. 43 p. Free. Available from the

Earthquake Engineering Research Institute (EERI), 499 14th Street Suite 320, Oakland CA 94612-1934; (510) 451-0905; http://www.eeri.org/tsunami_risk/FinlRept.pdf.

*from:* Natural Hazards Observer, v. XXVII, no. 6, July 2003, p. 19

**Emergency Management Plan for Public and Private Schools (K-12) on CD-ROM**.

School systems and other academic institutions conduct emergency response operations differently than corporations or other for-profit organizations. School-based factors include the presence of large numbers of children, as well as the educational purpose of the institution. This CD-ROM is aimed at helping administrators, teachers, and others design emergency management plans using templates for use in a K-12 school environment. Planning templates help users create plans at the school system level, and include suggestions for developing emergency plans targeted to a wide range of school-specific situations, including emergency lockdown procedures. Sections include information on how to organize district-wide emergency management teams, design and activate effective plans, and collect and use information.

Author: Douglas Henderson. 2002. $15.00, plus $7.00 shipping. For ordering information, contact Rothstein Associates Inc., 4 Arapaho Road, Brookfield, CT 06804-3104; (203)740-7444; http://www.rothstein.com/data/dr700.htm.

*from:* Natural Hazards Observer, v. XXVII, no. 6, July 2003, p. 19

**CD-ROM Version of The Disaster Recovery Yellow Pages (2003)**

The publishers of the hard copy *Disaster Recovery Yellow Pages* have issued a PC-based CD-ROM version of their disaster source book designed to help users locate recovery services information and resources throughout North America. Categories covered include drying and dehumidification of paper and microfilm records, trauma counselors, emergency computer network rental information, restoration services, training, business continuity, and more. Yearly CD-ROM updates will be available. $98.00, plus $3.00 shipping. Available from the Systems Audit Group Inc., 25 Ellison Road, Newton, MA 02459; (617) 332-3496; http://www.disaster-help.com/order.html.

*from:* Natural Hazards Observer, v. XXVII, no. 6, July 2003, p. 19

## TSUNAMI ANIMATIONS ON THE WEB

*Note:* QuickTime movies are very large and may take a few minutes to download. Movies are a non-standard part of the internet and may not load for all viewers.

**http://walrus.wr.usgs.gov/tsunami/**

Hypothetical Tsunami along the Pacific Northwest Coast: Phase 1
- QuickTime 64kB
- Animated GIF 110kB

Hypothetical Tsunami along the Pacific Northwest Coast: Phase 2
- Low Resolution (QuickTime) 4.5 MB
- High Resolution (QuickTime) 8.5 MB

1998 Papua New Guinea Tsunami: Earthquake Source
- Low Resolution (QuickTime) 0.6 MB
- Low Resolution (aGIF) 1.4 MB
- Medium Resolution (QuickTime) 1.4 MB
- High Resolution (QuickTime) 13 MB

Animation of the Tsunami from the 1906 San Francisco Earthquake
- Small Scale (QuickTime) 10MB
- Large Scale (QuickTime) 17MB

Preliminary Animation of the 23 June 2001 Peru Tsunami
- Medium Resolution (QuickTime) 9.7 MB
- High Resolution (QuickTime) 19.4 MB

**More tsunami videos/animations:**

http://weather.about.com/gi/dynamic/offsite.htm?site=http%3A%2F%2Fwww.usc.edu%2Fdept%2Ftsunamis%2Fvideo%2F

http://www.pbs.org/wnet/savageearth/animations/tsunami/main.html

http://www.usc.edu/dept/tsunamis/

**Tsunami modeling simulations:**

http://bullard.esc.cam.ac.uk/~taylor/Tsunami.html

http://www.pmel.noaa.gov/tsunami/research.html

http://walrus.wr.usgs.gov/tsunami/GIFanimation.html

http://newport.pmel.noaa.gov/time/animations2.html (SW Washington coast)

http://newport.pmel.noaa.gov/time/anims/ghasper.html (Grays Harbor, WA)

http://courses.dce.harvard.edu/~environment/kst/hokkaido-tsunami-animation.html (Japan Sea)

## ONLINE TSUNAMI PHOTOS

**Detection Buoys**
http://www.pmel.noaa.gov/tsunami-hazard/deploy.html
http://www.fema.gov/kids/p_tsun.htm

**Pacific Tsunami Museum Photo Archives**
http://www.tsunami.org/

**Slidesets**
http://www.ngdc.noaa.gov/seg/hazard/slideset/tsunamis
http://www.ngdc.noaa.gov/seg/image/geohazards_v3/document/739001.htm (geologic hazards photos, volume 3, Landslides, tsunamis, and volcanoes)

**West Coast & Alaska Tsunami Warning Center**
http://wcatwc.gov/tpic.htm

### By Country

**Canada**
*Tsunami damage in British Columbia (1964):*
http://www.usc.edu/dept/tsunamis/alaska/1964/webpages/1964canadaphoto_1.html
http://www.geocities.com/drgeorgepc/Tsunami1964PrWilliam.html
*Images of tsunami effects in Port Alberni, BC. The tsunami was generated by the Great Alaska Earthquake of March 27, 1964.*
http://www.pep.bc.ca/hazard_preparedness/tsunami_preparedness.html

**Papua New Guinea**
http://www.nda.ac.jp/cc/users/fujima/png/photo-index.html
*1998.7.17 PNG TSUNAMI Survey Photo*

**Russia**
Set 1: http://www.ngdc.noaa.gov/seg/hazard/slideset/37/37_slides.html
Set 2: http://www.ngdc.noaa.gov/seg/hazard/slideset/40/40_slides.html
*Shikotan, Kuril Islands Earthquake & Tsunami, October 4, 1994*

**United States: Alaska**
http://www.geophys.washington.edu/tsunami/general/historic/aleutian57.html
*1957 Aleutian tsunami*

**United States: Hawaii**
http://wwwhvo.wr.usgs.gov/earthquakes/destruct/1975Nov29/30424303_008_caption.html
*1975 Hawaiian tsunami photo and account*

http://soconnell.web.wesleyan.edu/courses/ees106/lecture_notes/lecture15A-106/tsld036.htm
*1960 Chilean TsunamiBDowntown Hilo [Hawaii]*

http://wwwhvo.wr.usgs.gov/earthquakes/destruct/1975Nov29/30424303_011_caption.html
*Tsunami at Keauhou Landing, Hawai'i on Nov. 29, 1975*

**Miscellany**
http://nisee.berkeley.edu/images/servlet/KozakBrowse?eq=5341
*Kozak collection: engravings*

## NEW TSUNAMI MITIGATION MATERIALS ADDED TO THE LIBRARY

June 1 to July 31, 2003

> ***Note:*** These, and all our tsunami materials, are included in our on-line catalog at **http://www.wa.gov/dnr/htdocs/ger/washbib.htm**

***Note:*** The articles from the *International Tsunami Information Center Newsletter* are all available at http://www.prh.noaa.gov/itic/library/pubs/newsletters/nl_home.html

**Alaska**


Fedotov, S. A., 1970, On the earthquake and tsunami in the Bering Sea on November 23, 1969; translated by S. L. Soloviev: International Tsunami Information Center Newsletter, v. 3, no. 2, p. 5-6.

Johnson, J. M.; Satake, Kenji, 1997, Asperity distribution of Alaskan-Aleutian earthquakes--Implications for seismic and tsunami hazards. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 67-81.

Okal, E. A.; Plafker, George; Synolakis, C. E.; Borrero, J.C., 2003, Near-field survey of the 1946 Aleutian tsunami on Unimak and Sanak Islands: Seismological Society of America Bulletin, v. 93, no. 3, p. 1226-1234.


**British Columbia**


Dohler, G. C., 1969, Tsunami warning gauges--Tofino and Victoria: International Tsunami Information Center Newsletter, v. 2, no. 2, p. 3-4.

**California**

Preuss, Jane, 1997, Local responses to the October 4, 1994 tsunami warning--Washington, Oregon, California. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction-- Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 35-45.

**Hawaii**

Bernard, E. N., 1973, Long wave response of a multiple island system--Modeling the Hawaiian Islands [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 2.

McGehee, D. D.; McKinney, J. P., 1997, Tsunami detection and warning capability using nearshore submerged pressure transducers--Case study of the 4 October 1994 Shikotan tsunami. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 133-143.

**Oregon**

Preuss, Jane, 1997, Local responses to the October 4, 1994 tsunami warning--Washington, Oregon, California. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 35-45.

**Washington**

Preuss, Jane, 1997, Local responses to the October 4, 1994 tsunami warning--Washington, Oregon, California. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 35-45.

**Algeria**

European Mediterranean Seismological Centre, 2003, Algerian earthquake: Tsunami Newsletter, v. 35, no. 3, p. 2.

**Chile, Peru, and South America**

Hwang, L.-S.; Butler, H. L.; Divoky, D. J., 1973, Numerical modeling of Chilean tsunami of 1960 [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 7.

Iida, Kumizi, 1973, Seismological aspects of Chilean tsunamis [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 6.

Murphy, L. M.; Spaeth, M. G., 1973, Pacific Tsunami Warning System and possible tsunami protection measures in South America [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 9.

Murty, T. S.; Wigen, S. O.; Arora, R., 1973, On some features of tsunamis on the Pacific coast of South and North America [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 8.

Pararas-Carayannis, George, 1968, The tsunami of October 17, 1966 in Peru: International Tsunami Information Center Newsletter, v. 1, no. 1, March 5, 1968, p. 2.

Pararas-Carayannis, George, 1968, Unusual waves in Chile, July 25-26: International Tsunami Information Center Newsletter, v. 1, no. 2, p. 2-3.

Pararas-Carayannis, George, 1973, The source mechanism of the earthquakes and tsunamis of October 17, 1966 in Peru [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 7.

**Japan**

Go, C. N.; Leonidova, N. L.; Leonov, N. N., 1973, Some data on the August 1, 1940 tsunami in the Japanese Sea [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 13.

Shuto, Nobuo, 1997, A natural warning of tsunami arrival. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 157-173.

Tatehata, Hidee, 1997, The new Tsunami Warning System of the Japan Meteorological Agency. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 175-188.

Yamashita, T.; Takabayashi, T.; Tsuchiya, Yoshito, 1997, Numerical simulation of 1993 July 12 tsunami near Hokkaido--Its propagation and flooding onto Aonae district, Okushiri Island. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 83-97

**Pacific Ocean (ocean-wide)**

Gusiakov, V. K.; Marchuk, A. G.; Osipova, A. V., 1997, Expert tsunami database for the Pacific--Motivation, design, and proof-of-concept demonstration. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 21-34.

Miller, G. R., 1968, Tsunami travel time charts: International Tsunami Information Center Newsletter, v. 1, no. 1, March 5, 1968, p. 3-[7].

Miller, G. R.; Pararas-Carayannis, George, 1969, Tsunami travel time charts: International Tsunami Information Center Newsletter, v. 2, no. 2, p. 4-6.

Murphy, L. M.; Spaeth, M. G., 1973, Pacific Tsunami Warning System and possible tsunami protection measures in South America [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 9.

Solov'ev, S. L., 1973, Earthquake and tsunami recurrence in the Pacific Ocean [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 9.

**Papua New Guinea and Java**

Beyond Productions, 2000, Tsunami chasers: TLVC Video, 1 videocassette, 52 min.

Maramai, Alessandra; Tinti, Stefano, 1997, Coastal effects and damage due to the 3rd June, 1994 Java tsunami. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction --Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 1-20.

**Portugal**

Moreira, V. S., 1973, Tsunamis, extension of faulting and focal mechanaism [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 6.

**Russia and the Northwest Pacific Ocean**

Balakina, L. M., 1973, Tsunamis and focal mechanism of earthquakes in the north-western part of the Pacific Ocean [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 10.

Grigorash, Z. K., 1973, The review of some distant tsunami mareograms in the Black Sea currents [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 13.

Grigorash, Z. K.; Korneva, L.A., 1969, Tsunamis in the Black Sea: International Tsunami Information Center Newsletter, v. 2, no. 1, p. 1-2.

Grigorash, Z. K.; Korneva, L. A. 1970, New data about the Black Sea tsunami of December 26, 1939: International Tsunami Information Center Newsletter, v. 3, no. 3, p. 1-4.

Ivashchenko, A. I., 1973, On the recurrence of strong tsunamis in the north-western part of the Pacific for the recent 50 years [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 12.

Lapshin, S. S., 1973, Tsunamis at the Pacific coast of the Kurile Islands in 1968 [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 13.

Leonov, N. N.; Oskorbin, N. A.; Shchetnikov, N. A.; Go, C. N.; Boychuk, A. N.; Poplavskaya, L. N., 1973, Great earthquakes and tsunamis in the Little Kurile Islands area area, 1961-1969 [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 13.

Soloviev, S. L., 1969, A conference on tsunami problerm at USSR: International Tsunami Information Center Newsletter, v. 2, no. 1, p. 1-5.

Soloviev, S. L.; Nekrasov, A. V.; Bukhteev, V. G.; Pyaskovsky, P. B., 1973, The preliminary results of tsunami zonation of the Soviet Pacific coast [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 8.

Zbuk, F. D.; Solov'ev, S. L., 1973, Possibility of recording of hydroacoustical waves of Pacific earthquakes on seismic stations of the USSR [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 12.

**Tsunami Modeling**

Bernard, E. N., 1973, Long wave response of a multiple island system--Modeling the Hawaiian Islands [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 2.

Bernstein, V. A., 1973, On the boundary effects iin regions of bottom steps at long gravity wave propation in a rotating basin [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 10.

Bernstein, V. A., 1973, Tsunami in a shelf zone--Characteristics and registration problem [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 11.

Bernstein, V. A.; Maramzin, V. Y., 1973, Calculation of tsunami run-up as a function of inclination and roughness of the bottom [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 11.

Braddock, R. D., 1969, Tsunami propagation: International Tsunami Information Center Newsletter, v. 3, no. 1, p. 6-8.

Chen, M. H. T., 1973, Tsunami propation and response to coastal areas [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p.

Hwang, L.-S.; Butler, H. L.; Divoky, D. J., 1973, Numerical modeling of Chilean tsunami of 1960 [abstract]: International Tsuami Information Center Newsletter, v. 6, no. 1, p. 7.

Iida, Kumizi, 1973, Seismological aspects of Chilean tsunamis [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 6.

Kaystrenko, V. M., 1973, Inverse problem for tsunami source determination [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 10.

Kononkova, G. E.; Reihrudel, A. E., 1973, Model investigation of solitary tsunami waves run-up onto the coast [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 11.

Mader, C. L., 1973, Numerical tsunami simulation [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 4.

Makarov, V.A.; Buchtaev, V. G.; Usankina, G. E., 1973, Tsunami waves from initial disburgances of different form (investigation on and electrical model) [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 11.

Meerson, A. E., 1973, On taking ocean bathymetry into account when computing arrival times and amplitudes of tsunami waves [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 11.

Murty, T. S.; Polavarapu, R. J., 1973, Atmospheric acoustic and internal gravity waves and their relevance to tsunami prediction [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 5.

Nekrasov, A. V.; Pyaskovsky, R. V.; Buchtaev, V. G., 1973, Investigation of propagation and transformation of tsunami waves by the calculation method [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 10.

Nepop, K. I., 1973, On the long-time tsunami prediction [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 12.

Pararas-Carayannis, George, 1973, The source mechanism of the earthquakes and tsunamis of October 17, 1966 in Peru [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 7.

Spielvogel, L. Q., 1973, Existence of steady flows [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 2

Vo't, S. S.; Sebekin, B. I., 1973, Some problems of the theory of tsunami wave propagation [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 10.

Yamashita, T.; Takabayashi, T.; Tsuchiya, Yoshito, 1997, Numerical simulation of 1993 July 12 tsunami near Hokkaido--Its propagation and flooding onto Aonae district, Okushiri Island. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 83-97

Zhak, V. M.; Velikanov, A. M.; Sapozhnikov, I. N., 1973, Distant recorder of sea level [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 11.

**Tsunami Research (General)**

Folger, Tim, 1994, Waves of destruction: Discover, v. 15, no. 4, p. 66-73.

Liu, P. L.-F.,, 2000, Tsunami--Understanding the giant wave: Cornell University, 1 compact disk.

U.S. National Oceanic and Atmospheric Administration; and others, 2001, Tsunami--The great waves: U.S. National Oceanic and Atmospheric Administration, accessed Dec. 10, 2001 at http://205.156.54.206/om/brochures/tsunami.htm.

**Tsunami Warning Systems**

Dohler, G. C., 1969, Tsunami warning gauges--Tofino and Victor-

ia: International Tsunami Information Center Newsletter, v. 2, no. 2, p. 3-4.

McGehee, D. D.; McKinney, J. P., 1997, Tsunami detection and warning capability using nearshore submerged pressure transducers--Case study of the 4 October 1994 Shikotan tsunami. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 133-143.

Murphy, L. M.; Spaeth, M. G., 1973, Pacific Tsunami Warning System and possible tsunami protection measures in South America [abstract]: International Tsunami Information Center Newsletter, v. 6, no. 1, p. 9.

Shuto, Nobuo, 1997, A natural warning of tsunami arrival. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 157-173.

Tatehata, Hidee, 1997, The new Tsunami Warning System of the Japan Meteorological Agency. *In* Hebenstreit, G. T., editor, Perspectives on tsunami hazard reduction--Observations, theory and planning: Kluwer Academic Publishers Advances in Natural and Technological Hazards Research, v. 9, p. 175-188.

## CONFERENCES/WORKSHOPS

September 20-24, 2003

Toward Earthquake Loss Reduction: Developing Effective Communication, Realistic Strategies, and Successful Mitigation Actions for Your Community. Sponsor: Western States Seismic Policy Council (WSSPC). Portland, Oregon: September 20-24, 2003. This conference will focus on the efforts of those who have effectively reduced earthquake risk through the successful use of laws, local ordinances, construction projects, homes, and schools. Understanding how these successes were accomplished will help attendees better affect risk reduction in their areas of responsibility. Information is available from WSSP AC2003, 125 California Avenue, Suite D201, #1, Palo Alto, CA 94306; e-mail: wsspc@wsspc.org; http://www.wsspc.org/events/ac2003.

September 21-24, 2003

Fall World 2003. Sponsor: Disaster Recovery Journal (DRJ). San Diego, CA: This conference is geared toward business continuity planners and other emergency managers. Contact: DRJ, P.O. Box 510110, St. Louis, MO 63151; (314) 894-7474; e-mail: mercedes@drj.com; http://www.drj.com.

September 25-27, 2003

Tsunamis in the South Pacific: Research Toward Preparedness and Mitigation. Sponsor: Natural Hazards Centre, International Tsunami Commission, the International Coordination Group for the Tsunami Warning System in the Pacific. Wellington, New Zealand: September 25- 27, 2003. The workshop will discuss a wide spectrum of tsunami research related to understanding tsunami hazards, and developing tsunami warning and mitigation measures. It is aimed at a wide community of researchers, emergency managers, decision makers, and other practitioners dealing with assessment and mitigation of tsunami hazard. Complete information may be obtained from "Tsunamis in the South Pacific," C/-Absolutely Organised, P.O. Box 41-016, Eastbourne, Wellington, New Zealand; e-mail: organiser@conferences.co.nz; http://www.naturalhazards.net.nz/tsunami/.

October 27-29, 2003

Emergency Preparedness: Improving the Odds. Sponsor: Pacific Northwest Preparedness Society. Vancouver, British Columbia. Conference goals are to raise the global level of emergency preparedness through promoting awareness, providing information and solutions to problems, sharing experiences, showcasing technologies, and creating networking opportunities. For more information contact the Center for Policy Research on Science and Technology, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6; 604-665-6097; e-mail: info@epconference.ca; http://www.epconference.ca/. *from:* Disaster Research 390, June 13, 2003

November 12-13, 2003

2003 IBHS Annual Congress "Taking the Lead in Property Loss Reduction." Sponsor: Institute for Business and Home Safety. Orlando, Florida: November 12-13, 2003. This congress on natural hazard loss reduction brings professionals in the insurance industry, emergency management, government agencies and academic institutions together to discuss the latest developments in natural hazard mitigation. For conference details, contact IBHS, 4775 East Fowler Avenue, Tampa, FL 33617; (813) 286-3400; http://www.ibhs.org/congress/.

*from:* Disaster Research 391 June 27, 2003

## VIDEO RESERVATIONS

Place a check mark (T) beside the video(s) you want to reserve; write the date of the program behind the title.

Mail to TsuInfo Alert Video Reservations, Lee Walkling, Division of Geology and Earth Resources Library, PO Box 47007, Olympia, WA 98504-7007; or email lee.walkling@wadnr.gov

***NEW!!*** ___ Tsunami Chasers. Beyond Productions for the Discovery Channel. 52 minutes.

___Earthquake…Drop, Cover & Hold; Washington Emergency Management Division. 1998. 5 min.

___Tsunami Evacuation PSA; DIS Interactive Technologies for WA Emergency Management Division. 2000. 30 seconds.

___Cascadia: The Hidden Fire–An Earthquake Survival Guide; Global Net Productions, 2001. 9.5 minutes. A promo for a documentary about the Cascadia subduction zone and the preparedness its existence demands of Alaska, Oregon and Washington states. Includes mention of tsunamis. (The full documentary is scheduled for broadcasting on a PBS station in April 2002.)

___Not Business as Usual: Emergency Planning for Small Businesses, sponsored by CREW (Cascadia Regional Earthquake Workgroup), 2001. 10 min. Discusses disaster preparedness and business continuity. Although it was made for Utah, the multi-hazard issues remain valid for everyone. Websites are included at the end of the video for further information and for the source of a manual for emergency preparedness for businesses.

___Adventures of Disaster Dudes (14 min.)
Preparedness for preteens

___The Alaska Earthquake, 1964 (20 min.)
Includes data on the tsunamis generated by that event

___Cannon Beach Fire District Community Warning System (COWS) (21 min.) Explains why Cannon Beach chose their particular system

___Disasters are Preventable (22 min.)
Ways to reduce losses from various kinds of disasters through preparedness and prevention.

___Disaster Mitigation Campaign (15 min.)
American Red Cross; 2000 TV spots. Hurricanes, high winds, floods, earthquakes

___Forum: Earthquakes & Tsunamis (2 hrs.)
CVTV-23, Vancouver, WA (January 24, 2000). 2 lectures: Brian Atwater describes the detective work and sources of information about the Jan. 1700 Cascadia earthquake and tsunami; Walter C. Dudley talks about Hawaiian tsunamis and the development of warning systems.

___Killer Wave: Power of the Tsunami (60 min.)
National Geographic video.

___Mitigation: Making Families and Communities Safer (13 min.)
American Red Cross

___Numerical Model Aonae Tsunami–7-12-93 (animation by Dr. Vasily Titov) and Tsunami Early Warning by Glenn Farley, KING 5 News (The Glenn Farley portion cannot be rebroadcast.)

___The Prediction Problem (58 min.)
Episode 3 of the PBS series "Fire on the Rim." Explores earthquakes and tsunamis around the Pacific Rim

___Protecting Our Kids from Disasters (15 min.)
Gives good instructions to help parents and volunteers make effective but low-cost, non-structural changes to child care facilities, in preparation for natural disasters. The Institute provides a booklet to use with the video. Does NOT address problems specifically caused by tsunamis.

___The Quake Hunters (45 min.)
A good mystery story, explaining how a 300-year old Cascadia earthquake was finally dated by finding records in Japan about a rogue tsunami in January 1700

___Raging Planet; Tidal Wave (50 min.) Produced for the Discovery Channel in 1997, this video shows a Japanese city that builds walls against tsunamis, talks with scientists about tsunami prediction, and has incredible survival stories.

___Raging Sea: KGMB-TV Tsunami Special. (23.5 min.)
Aired 4-17-99, discussing tsunami preparedness in Hawaii.

___The Restless Planet (60 min.) An episode of "Savage Earth" series. About earthquakes, with examples from Japan, Mexico, and the 1989 Loma Prieta earthquake in California.

___Tsunami and Earthquake Video (60 min.)
Includes "Tsunami: How Occur, How Protect," "Learning from Earthquakes," and "Computer modeling of alternative source scenarios."

___ Tsunami: Killer Wave, Born of Fire (10 min.)
NOAA/PMEL. Features tsunami destruction and fires on Okushiri Island, Japan; good graphics, explanations, and safety information. Narrated by Dr. Eddie Bernard, (with Japanese subtitles).

___Tsunami: Surviving the Killer Waves (13 min.)
Two versions, one with breaks inserted for discussion time.

____USGS Earthquake Videotapes "Pacific Northwest"
USGS Open-File Report 94-179-E

___Understanding Volcanic Hazards (25 min.)
Includes information about volcano-induced tsunamis and landslides.

___The Wave: a Japanese Folktale (9 min.) Animated film to help start discussions of tsunami preparedness for children.

___Waves of Destruction (60 min.) An episode of the "Savage Earth" series. Tsunamis around the Pacific Rim.

___Who Wants to be Disaster Smart? (9 min.)
Washington Military Department/Emergency Management Division. 2000. A game show format, along the lines of *Who Wants to be a Millionaire*?, for teens. Questions cover a range of different hazards.

___The Wild Sea: Enjoy It...Safely (7 min.)
Produced by the Ocean Shores (Washington) Interpretive Center, this video deals with beach safety, including tsunamis.

Check the title(s) you would like and indicate the date of your program. The video(s) will be mailed one week before the program date.

Name: Organization:

Mailing address:

City, State, Zip:

email:

## DIRECTORIES: NATIONAL TSUNAMI HAZARD MITIGATION PROGRAM STEERING GROUP

### FEDERAL

Eddie Bernard, NOAA/PMEL, Chairman,
National Tsunami Hazard Mitigation Pro.
7600 Sand Point Way NE
Seattle, WA 98115-6349
(206) 526-6800; Fax (206) 526-6815
email: Eddie.N.Bernard@.noaa.gov

Frank González, NOAA/PMEL
7600 Sand Point Way NE
Seattle, WA 98115-6349
(206) 526-6803; Fax (206) 526-6485
email: Frank.I.Gonzalez@noaa.gov

Richard Przywarty
NOAA/NWS, Alaska Region
222 W. 7th Ave. #23
Anchorage, AK 99513-7575
907-271-5136; fax 907-271-3711
email: Richard.Przywarty@ noaa.gov

Jeff LaDouce, NOAA/NWS
Pacific Guardian Center
737 Bishop St., Suite 2200
Honolulu, HI 96813-3213
(808) 532-6416; Fax (808) 532-5569
email: Jeff.Ladouce@noaa.gov

Chris Jonientz-Trisler, FEMA, RegionX
130 228th Street SW
Bothell, WA 98021-9796
(425) 487-4645; Fax (425) 487-4613
email: ChrisJonientzTrisler@dhs.gov

Michael Hornick, FEMA, Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607
(510) 627-7260; Fax (510) 627-7147
email: michael.hornick@fema.gov

David Oppenheimer
U.S. Geological Survey
345 Middlefield Road, MS 977
Menlo Park, CA 94025
(650) 329-4792; Fax: (650) 329-4732
email: oppen@usgs.gov

Craig Weaver, U.S. Geological Survey
Box 351650, Univ. of Washington
Seattle, WA 98195-1650
(206) 553-0627; Fax (206) 553-8350
email:craig@geophys.washington.edu

### ALASKA

Roger Hansen
Geophysical Institute, University of Alaska
P.O. Box 757320, 903 Koyukuk Drive
Fairbanks, AK 99775-7320
(907) 474-5533; Fax (907) 474-5618
email: roger@GISEIS.alaska.edu

Rodney Combellick (Alt.)
Alaska Dept. of Natural Resources
Div. of Geological & Geophysical Survey
Fairbanks, AK 99708
Ph: 907-451-5007; fax: 907-451-5050
rod@dnr.state.ak.us

R. Scott Simmons
Alaska Division of Emergency Svcs.
P.O. Box 5750
Suite B-210, Bldg. 49000
Fort Richardson, AK 99505-5750
Ph: 907-428-7016; fax: 907-428-7009
scott_simmons@ak-prepared. com

Ervin Petty (Alt.)
Alaska Division of Emergency Svcs.
P.O. Box 5750
Suite B-210, Bldg. 49000
Fort Richardson, AK 99505-5750
Ph: 907-428-7015; fax:: 907-428-7009
ervin_petty@ak-prepared. com

### CALIFORNIA

Richard Eisner, FAIA; CISN & Earthquake
Governor's Office of Emergency Services
724 Mandana Boulevard
Oakland, CA 94610-2421
(510) 465-4887; fax (510) 663-5339
email: Rich_Eisner@oes.ca.gov

James Davis, State Geologist
California Geological Survey
Dept. of Conservation
801 K Street, MS 12-30
Sacramento, CA 95814-3531
Ph: 916-445-1923; fax: 916-445-5718
jdavis@consrv.ca.gov

### HAWAII

Brian Yanagi, Earthquake Program Man.
Civil Defense Division
3949 Diamond Head Road
Honolulu, HI 96816-4495
(808) 733-4300, ext.552; Fax (808)737-8197
email: byanagi@scd.state.hi.us

Dr. Laura S. L. Kong, Director
International Tsunami Information Center
737 Bishop Street, Suite 2200
Honolulu, Hi 96813-3213
email: Laura.Kong@noaa.gov

Glenn Bauer, State Geologist
Dept. of Land and Natural Resources
Division of Water Resource Management
P.O. Box 621
Kalanimoku Bldg. Rm 130,
1151 Punchbowl St.
Honolulu, HI 96809
Ph: 808-587-0263; fax: 808-587-0219
glenn_r_bauer@exec.state.hi.us

Sterling Yong, State Floodplain Coordinator
Dept. of Land and Natural Resources
Engineering Division
P.O. Box 621
Kalanimoku Bldg. Rm 130,
1151 Punchbowl St.
Honolulu, HI 96809 Ph: 808-587-0248
FAX: 808-587-0283
e-mail: sterling_sl_yong@exec.state.hi.us

### OREGON

Mark Darienzo
Oregon Emergency Management
595 Cottage Street NE
Salem, OR 97310
(503) 378-2911, ext. 237; Fax (503)588-1378
email: mdarien@oem.state.or.us

George Priest
Oregon Dept. of Geology & Mineral Ind.
800 NE Oregon Street #28
Portland, OR 97232
503-731-4100, Ext. 225; fax 503-731-4066
email: george.priest@dogami.state.or.us
Jonathan C. Allan (Alt.)

Oregon Dept. of Geology & Mineral Industries
Coastal Program Office
Coastal Field Office
313 S.W. 2nd, Suite D
Newport, OR 97365
Ph: 541-574-6658; fax: 541-265-5241
jonathan.allan@dogami.state.or.us

### WASHINGTON

George Crawford
Washington State Military Dept.
Emergency Management Division
Camp Murray, WA 98430-5122
Ph: 253-512-7067; fax: 253-512-7207
g.crawford@emd.wa.gov

Tim Walsh
Division of Geology and Earth Resources
P.O. Box 47007
Olympia, WA 98504-7007
(360) 902-1432; Fax (360) 902-1785
email: tim.walsh@wadnr.gov

# Infrequently Asked Questions
# compiled by Lee Walkling

**Which historic tsunami was caused by a volcano and not an earthquake? (It was the first catastrophe in the world to take place after the establishment of a world-wide network of telegraph cables.)**

August 27, 1883: Indonesia. Krakatau, a volcano in the Sunda Straits, exploded with a gigantic roar audible 3,000 miles away. The explosions blew 20 cubic kilometers of rock into the sky. Undersea cracks allowed massive amounts of seawater into a white-hot magma chamber. When the water turned to steam, the explosion caused tsunamis that caused most of the more than 36,000 deaths on nearby Sumatra and Java. Ironically, history's most deadly tsunami was caused by a volcano, not an earthquake.

**Was Krakatau the world's largest volcanic eruption?**

"Geological evidence from around the world admits of a number of bigger and more devastating volcanoes, true. Krakatoa is reckoned today to be only the fifth most explosive one in the planet's certain geological history – Mounts Toba and Tambora in the East Indies, Taupo in New Zealand, and Katmai in Alaska are all thought to have been very much larger, at least in terms of the amount of material they hurled into the sky and the height to which all that material is thought to have soared."

*from:* Winchester, Simon, 2003, Krakatoa, the day the earth exploded: HarperCollins, p. 4-5.

**A new volcanic island is replacing Krakatau. What is its name?**

The eruption and collapse of the caldera in 1883 produced one of the largest explosions on Earth in recorded time (VEI=6) and destroyed much of Krakatau island, leaving only a remnant. Since 1927, small eruptions have been frequent and have constructed a new island, Anak Krakatau (Child of Krakatau).

*from:* http://volcano.und.nodak.edu/vwdocs/volc_images/southeast_asia/indonesia/krakatau.html

**Even though Krakatau's eruption and tsunami were witnessed and documented, why is it so difficult to construct a chronology of events?**

"…these events took place before the invention of time zones, either in the East Indies or anywhere else in the world. Taken together with the dubious accuracy of many of the mechanical clocks of the day, the absence of the coordinating abilities of radio, which had of course not quite yet been invented, and the wide range of anecdotal reports from frequently panicky eyewitnesses, this makes it tricky, if not entirely impossible, to construct a firm chronology of what took place in the aftermath of the eruptions."

*from:* Winchester, Simon, 2003, Krakatoa, the day the earth exploded: HarperCollins, p. 247

.


Library
Department of Natural Resources
Division of Geology and Earth Resources
P.O. Box 47007
Olympia, WA 98504-7007