Fieldconference and workshop

Java 2007

IGCP 490 The role of Holocene environmental catastrophes in human history

What is the aim of IGCP 490?

The project addresses the following fundamental issues:

- **Chronology of Catastrophes**

The project focuses on natural events that have affected the planet since the beginning of the Holocene, excluding therefore the influence of the glacial-interglacial cycles. This period includes several abrupt climatic changes, large volcanic eruptions, numerous great earthquakes (and clusters of them), several ecosystem collapses and a few large cosmogenic impacts. For the Holocene, our high-resolution geologic data records can be correlated with archaeological, historical or meteorological data, which makes it possible to gain a broader understanding of the effects of environmental catastrophes. Three timescales will be considered: 1) the entire Holocene (11500 calendar years), for which major extreme events are mostly captured in sedimentary records; 2) the last 5000-4000 years, for which we have good written documents; and 3) the last few centuries, for which there are contemporaneous instrumental records.

Reliable dating of past environmental change is at the core of this project. The ’suck in and smear’ tendency for well-dated event horizons to draw in more loosely constrained ’events’ from further afield ensures that many local crises are inferred to be regional catastrophes. High-resolution geochronology needs to be at the heart of geo-catastrophe research, in (1) identifying event chronologies, (2) establishing robust trans-continental correlations, and (3) estimating the onset time and residence time for past environmental disturbance.

- **Causes and mechanisms of past environmental catastrophes**

What are the real capabilities of the mechanisms that are implicated in past environmental catastrophes? What are the frequency-magnitude relations of catastrophe-triggering phenomena and is there a periodicity in their actions? New research is uncovering the rhythmns at which cometary material strike the Earth, whilst at the same time there are signs that destructive earthquake and volcanic activity may be strongly clustered in time and space. In addition, given that geophysical agents of change may be intimately coupled with global climatic fluctuations, the competing mechanisms of catastrophe are difficult to disentangle.

- **Impacts on past civilisations and ecosystems**

Declines or terminations of many past societies or ecosystems may arise from a combination of different factors that may be related to or independent on each other. For example, a rapid climatic change can be the result of a change in solar activity or a volcanic eruption or a meteorite impact, or it can be the result of an accumulated effect of more than one of these factors. An ecosystem or civilisation that is already under stress because of a climatic deterioration may not be able to survive the added dust effects of a medium-size volcano eruption, even though larger previous eruptions may have had little detrimental impact. The convergent-catastrophe hypothesis means that the impacts are likely to have been insidious, leaving behind a complex and variable signal in our geological, palaeoecological and human record. Reading that signal will be one of the key challenges of this project.

- **Mechanisms of recovery**

Importantly, the project will examine how quickly (and by what means) ecosystems and civilisations are able to recover from catastrophic events as this has direct application for planners. Did the recovery take place by adjustment to the new conditions? Did the recovery take place by return to the pre-catastrophic situation? Did no recovery take place? Alternatively, what of the known environmental events that had no significant impact on human history or ecosystems. With the growing recognition that major natural events can have abrupt global impacts, this project is a timely opportunity to assess the sensitivity of modern society to extreme natural threats.

Disentangling cause and effect across these four overlapping themes will rely on the integration of various high-quality, high-resolution environmental datasets and the cross-disciplinary exchange of information between earth science, ecology and human history. This, in turn, requires the establishment of an interdisciplinary research culture. Presently, there is no national or international research body dealing with this topic.

Reference
Leroy S. A. G., 2006. From natural hazard to environmental catastrophe, past and present. Quaternary International. 158-1: 4-12

Abstracts

Eddy GAFFAR, gaffar@geotek.lipi.go.id
Research Centre for Geotechnology, Indonesian Institute of Sciences, Building 70, Jl. Sangkuriang, Bandung 40135, Indonesia.

Determine of Past History of Earthquake and Tsunami Along the Sumatra Coast: Preliminary Result

The December 26th 2004, Mw 9.3 subduction earthquake off northern Sumatra was second or third largest ever recorded. The collected data has conducted in the Indonesian EEZ Ocean, western of Sumatra by R/V Roger Ravelle on May – June 2007. There are bathimetry and coring samples data. This research will apply submarine paleoseismologic techniques to the turbidite history along the Indonesian convergent marine. The margin exhibits strong parallel to the Cascadia margin, where turbidite paleoseismologisy has proved successful by researcher from Oregon State University, United States of America. Core samples have taken from about 100 locations. We got cores with variation as piston cores, Kasten cores, multi core and gravity cores. This result just Preliminary Result and the research program will continue until 2009 as joint research between Oregon State University with Agency of Assessment of Application of Technology (Indonesian Government).

Hendra GUNAWAN, hendra@vsi.esdm.go.id
Hendra GUNAWAN1, Andri HENDRIANA2, Cahya PATRIA1, Rachmat SULE2, Malte Ibs-von SEHT3, Anne HOFFMANN3, Rudolf Kniess RATHE3
1 : PVMBG, 2 : ITB, 3 : BGR
Center for Volcanology and Geological Hazard Mitigation
Office : Jl. Dipenogoro no. 57. Bandung-Indonesia
website : vsi.esdm.go.id

Seismic Waveform Modelling of Krakatau Complex: Observation of seismic data and some preliminary results

Since its birth in 1929 to 1996 has erupted at least 78 times showing an explosive or efusive activity. Anak Krakatau is a volcano island, lies in the center of the Krakatau Volcanic Complex with estimated height in 1996 of about 300 m above sea level. It is constructed of alternating layers of lava and pyroclastic deposits that formed since 1930. The Krakatau Volcanic complex consists of Rakata, Sertung, Panjang and Anak Krakatau Island. The first three islands are remnant of the caldera collapse of the supposed Ancient Krakatau, and Rakata island itself is volcano that grow up together with Danan and Perbuwatan volcanoes before the cataclysmic eruption of 1883. A temporary analog seismic stations were installed in 1981-1983 on the body of anak krakatau, the aim of this campaign was to locate the source of volcano earthquakes, frequency of occurrence and seismic wave signatures. The recorded seismic events were more than 100 events per month or 1-30 events per day (maximum > 100 events/ day). In November 1992 until may 1997 Krakatau has had erupted with ash column rose about 100-400 m. 3

temporary digital seismic stations were installed for about a couple of months in 1997, during the eruption volcano earthquake were dominated by explosions quake. In June 1997 when the volcano activity was cooling down, the recorded seismic were dominated by type A volcanic quake. In mid 2005, BGR and PVMBG had a joint cooperation to monitor the volcano by using a modern monitoring system under the named “Krakatau Monitoring Parameter” (KRAKMON). At least there are 9 temporary seismic stations and 3 permanent seismic stations were installed. On the seismic data processing we stressed on modeling wave propagation and travel time tomographic method were done and we are still working on it. Unfortunately the seismic stations were not enough to make an ideal modeling of tomographic method, so it is only valid to the cell inside the model that are traversed by seismic rays. Some synthetic seismograms were generated, in which their location of source-receiver pairs in the model must have the same location as in the field. Based on this limited result a priori information, e.g. models delivered from Haryono et.al (1990) and Dahrin (1993) must be taken into account. A modelling wave propagation can provide a very useful tools in order to understand hazards induced by volcano eruption.

Lina HANDAYANI, lina@geotek.lipi.go.id
Research Centre for Geotechnology, Indonesian Institute of Sciences, Building 70, Jl. Sangkuriang, Bandung 40135, Indonesia.

Earthquake and Tsunami Hazard Study of Banten area (West Java)

Sunda Strait forearc region (the area from the Sunda Strait to the trench at its southwest) has a relatively lower seismicity than the high seismicity area of Sumatra forearc and Java forearc region. However, the infrequent earthquake does not mean that the area is free of the shaking. Earthquakes at the Sunda Strait are mostly due to the extension of the area, as the focal mechanisms of the past earthquakes showed thrust systems. The epicenters generally are shallow, less than 60 km depth. Just last year, on July 19, 2006, an earthquake occurred west of South Banten (at Sunda Strait, near the Ujung Kulon) with a magnitude of 6.1 Mw and the epicenter of the earthquake was 40 km depth.

With the recent development of the Banten region with new industries and housings, it is very important to study the effect of earthquake hazard of this area. Since most of the earthquakes are shallow, added with the possible tsunami from the Krakatau eruption, tsunami hazard also should be considered. Therefore, we need to develop a zonation map for earthquake and tsunami hazard of the Banten region.

Wahyoe HANTORO, hantoro@geotek.lipi.go.id
Wahyoe S. Hantoro, Hamzah Latief, Susilohadi, Azalea Hidayat, Anouk Suminar, Aditya Gusman, Airlangga A.Y.
Research Centre for Geotechnology, Indonesian Institute of Sciences, Building 70, Jl. Sangkuriang, Bandung 40135, Indonesia.

Volcanic Tsunami Hazard of Krakatau: Run up and travel time model for its mitigation in Sunda Strait

Sunda Strait physiographically separates Sumatra and Java, but geologically too as in the middle of this strait, an active magma body reaches surface, arises young volcano named Krakatau. Its big eruption on 1883 produced such material ejection to the atmosphere, followed a series of explosion till the biggest one that induced a large caldera collapse. This collapse generated sudden huge mass water displacement, induced high bulge of sea water swell that propagated under the velocity of >60 km/hrs and swept the coastal area around Sunda Strait, left the devastation and dead people.

Now days, the coastal area of the Sunda Strait develop rapidly. An heavy industrial zone and its harbor facility develops in north part of Banten area (Merak & Cilegon). To the south, along the coast, the area gradually changes to human settlement, tourist area, marine-culture to natural conservation in the southern tip of West Java. Lampung area, the west side of the strait, part of the Sumatra Island, shows similar rapid development, where human settlement and its activity grows rapidly along coastal zone.

Based on the distribution of tsunami relict that left by 1883's eruption in this area and the run up model that had been developed, the coastal area that had been flooded by tsunami can be identified and mapped. Without natural coastal protection, large managed area in Panimbang had been destroyed by tsunami, but the wave seems to be reduced by dense coastal baringtonian and mangrove forest at Panaitan's conservation park in Ujung Kulon. In that island, wave was considerably reduced as it had been broken by barrier reef and or fringing reef before it run into the upper coastal area.

To protect the area, wave breaker zone is proposed to be developed in land and in the shallow off shore. Ridges, trees and coral reef are the potential risk reducer to protect coastal zone from the tsunami's threat.

Patricia ILA'AVA, pilaava@upng.ac.pg
Rabaul Volcano Observatory, Rabaul, PNG

Hazard mapping based on modelling of tsunami inundation of the Vanimo coastline in Sandaun Province, Papua New Guinea

Papua New Guinea's (PNG) northern coastline has a long history of both documented and undocumented tsunamis. There is, therefore, an urgent need for scientific research into the potential for tsunami hazards on this coastline. Ideally, this would be complemented by a solid understanding of the vulnerability of the communities located along the coast.

Vanimo is an ideal candidate for tsunami inundation modelling for several reasons. Firstly, it is the Sandaun Provincial Government's administrative headquarters. Secondly, it is located within 100 km of Sissano Lagoon, the area that was most devastated by the well-documented 1998 Aitape event. Finally, the New Guinea Trench, a northwest-southeast trending subduction zone, lies within 50 km of Vanimo, so warning systems would be ineffective for near-source tsunamis triggered at the trench.

The Australian National University and Geoscience Australia jointly developed a hydrodynamic modelling package called ANUGA. ANUGA will be used to model several scenarios of tsunami inundation at Vanimo. Subsequently, hazard maps of the Vanimo area will be constructed from the models for use by the authorities and relevant stakeholders. This project is intended as a pilot for further work in inundation modelling of tsunamis and tsunami hazard mapping for all vulnerable coastlines of PNG.

Simon JUSSERET, simon.jusseret@student.uclouvain.be
Department of Archaeology, Université catholique de Louvain, Belgium

The evolution and consequences of geo-environmental constraints in Minoan society (3000-1200 B.C.): towards the development of an interdisciplinary methodology adapted to the Cretan Bronze Age.

The object of this research is to approach an ancient society using techniques of geoarchaeology, a discipline born out of the union between earth sciences and archaeology. For a long time confined to the narrow domain of landscape analysis, geoarchaeology has nowadays largely proved its worth in the study of ancient societies.

Since the early twentieth century, the island of Crete has witnessed a multitude of archaeological excavations. This fieldwork has provided archaeologists with important keys to understanding the anthropogenic formation processes of the archaeological sites. But Minoan civilisation remains enigmatic and mysterious in various domains: we face undeciphered writing systems, continuing ignorance of economic and socio-political organization, a lack of knowledge on the precise functions of the central court buildings (the so-called “Minoan palaces”), etc. Among all those uncertainties, the consequence of changes in the geo-environment (i.e. sea- and groundwater-level changes, earthquakes, tsunami, volcanic eruption) on Minoan society is not the least. The proposed PhD thesis will try to fill this gap through the construction of a methodology applicable to all Cretan coastal sites where major Minoan settlements have been discovered. The proposed work aims to reconstitute and assess the societal consequences of geo-environmental processes, combining currently used techniques in earth sciences (geomorphological analysis, sedimentological coring, geophysical surveys) with those of archaeology (stratigraphical analysis, pottery dating, exploitation of technical characteristics of Minoan wells).

Suzanne LEROY, suzanne.leroy@brunel.ac.uk
Institute for the Environment, Brunel University, Uxbridge UB8 3PH, UK

Rapid environmental changes and civilisation collapse: can we learn from them

In trying to measure the changes of our present environment, we use a series of monitoring schemes. However these instrumental records are often based on data ranging over the last 100-200 years only. If we want to set up preparedness measures, we need to know the full range of possible changes. Hence it becomes crucial to look back in time and see how rapidly, even catastrophically, the environment can change and affect societies.

Some societies have collapsed; others have revived. Three factors need to be considered when analysing disasters and human recovery:

- the temporal scale: how suddenly and for how long? (longer than the food storage capacity),
- the spatial scale: the overall area affected (large area leaving nowhere to escape)and the proportion of the settlement
- the cultural response: the flexibility of the society (freedom to innovate)and its previous fragility.

Geo-scientists and Historians contribute by examining together how people have responded to those changes. Some societies have gone on doing exactly the same things without learning from the experience; others have modified their behaviours and successfully adapted to changes. If we turn to recent examples of environmental catastrophes, we do not seem to learn from them in most cases. In Istanbul after the Izmit 1999 earthquake and with the very high probability of an earthquake before long, the 12 million inhabitant city is still expanding and too often without the respect of anti-seismic building regulation. After the earthquake and the tsunami of the Indian Ocean in 2005, international help aims at rebuilding villages and replanting fields exactly where they were.

What are the mechanisms through which a society learns from the disasters of past catastrophes? Ancient societies could declare a land impure and create a myth that would keep people away. In the XXIst century, we must try to find modern solutions with politicians closely working with scientists. Maybe solutions such as the creation of nature parks and the voluntary movement of people (through forcing by insurance cover costs) could be examined and would be beneficial in the long run.

Charlotte MILLER, chazluvsu@hotmail.com
Institute for the Environment, Brunel University, Uxbridge UB8 3PH, UK

Linking the Tamanrasset river system palaeovalleys to the deep sea Cap Timiris Canyon in Mauritania.

Sediment cores will be taken in the Banc d,Arguin region close to Cap Timiris, Mauritania. These cores taken will be crucial in reconstructing the palaeonenvironements of Mauritania and will also be key in determining when the Tamanrasset river system was last active. The Tamanrasset River is an example of an abandoned river system which is not discharging under present day climatic conditions (Wien *et al.*, 2002). When active, the river system would have been discharging off the Mauritanian coast at Cap Timiris into the Atlantic Ocean. It is believed that its existence was linked to the first half of the Holocene when the climate was wetter and the Sahara green.

Numerous sample cores will be taken offshore in the Banc d,Arguin region penetrating a few metres into the subsurface. The location of the samples taken will be measured through the use of GPS as well as positions been taken relative to known topographic features on land. A series of cores taken in 2004 do not reach the river sediment but will be useful to get familiarise with the type of sediment and the type of proxies to be applied to the longer new cores.

Analysis will assess the source of the sediment whether terrigenous or non-terrigenous (Koopmann *et al.*, 1979). Currently there is very little fluvial input onto the Mauritanian margin and most sediment has been transported by wind offshore coming from the Saharan Desert (Holz *et al*. 2004). If I can date when river deposits were being transported into the Banc d,Arguin then I can state when the Tamanrasset system was last active. The potential dating techniques are OSL with Prof. Ashok Singhvi (India) and radiocarbon dating of organic material.

I will investigate whether the drying up of the Tamanrasset system coincides with major widespread African arid periods for example the last glacial maximum (22-19 ky BP), Younger Dryas (~13-11.5 ky BP), Heinrich 1 event (break up of the northern ice-sheets creating immense discharge of ice-bergs into North Atlantic, slowing thermohaline circulation and cooling global temperatures, centred on 16 ky BP) (DeMenocal., 2001, Williams and Faure., 1983).

The research undertaken in this project will increase our knowledge regarding the palaeoenvironments of coastal Mauritania. Switching off mechanisms will be established and I will assess previous climatic conditions and their causes regarding the drying-up of the Tamanrasset system. My research will positively influence further studies related to assessing geohazards related to turbidite flows and its associated tsunamis.

References

DeMenocal, P.B., (2001). Cultural responses to climate change during the late Holocene. Science. Vol. 292. pp. 667-673.

Holz. C., Stuut. J.-B.W., Henrich. R., (2004). Terrigenous sedimentation processes along the continental margin off NW-Africa: implications from grain-size analysis of seabed sediments. Sedimentology. Vol. 51. pp. 1145-1154.

Koopmann. B.J., Lees. A., Piessens. P., Sarnthein. M., (1979). Skeletal carbonate sands and wind-dervided silty marls off the Saharan coast: Baie du Lévrier, Arguin Platform, Mauritania. "Meteor" Forsch.-Ergebn. Vol. C30.

Wien. K., Holz. C., Kölling. M., Schulz. H.D., (2002). Age models for pelagites and turbidites from the Cap Timiris Canyon off Mauritania. Marine and Petroleum Geology. Vol. 23. pp. 337-252.

Williams. A.J., Faure. H., (1983). The Sahara and the Nile: Quaternary Environments and Prehistoric Occupation in Northern Africa. The Geographical Journal. Vol. 149. pp. 223-225

Cher PETERSON, cherpeterson@hotmail.com
Institute for the Environment, Brunel University, Uxbridge UB8 3PH, UK

Sedimentary and palaeoecological characterisation of tsunami deposits by multi-proxy analysis of the 2004 Sumatra Andaman tsunami

Sediment distribution is a common characteristic of tsunamigenic events. Tsunamis are capable of inundating coastal regions and depositing sediments over vast areas landward of the beach (USGS 2005). The nature of tsunami relic deposits has been documented in scientific literature over the last two decades (Scheffers & Kelletat 2004).

Although the geomorphological effects and physical characteristics relating to the impacts of the tsunami and the destruction to caused to the built environment and society have been well documented, few studies have analysed the sedimentological process associated with the 2004 tsunami and its impacts upon the Sri Lankan coastline. Moderate research has been conducted into ancient tsunami deposits in Sri Lanka's geological history- a history, which extends much farther in the past than written records allow for. Identifying a deposit as either a tsunami or storm related deposit is essential for an accurate hazard frequency assessment to try to measure the probability of future events as well as providing a gateway for dissemination (USGS 2005).

This research aims to identify, examine and catalogue preserved sediment deposited around the Sri Lankan coastline by the 2004 tsunami event and describe in depth its sedimentological and palaeoecological attributes, extrapolate new knowledge to older tsunami deposits in Sri Lanka and elsewhere and to identify how the resulting information can be used to help shape and define Sri Lanka's geological records.