6th International Symposium on Submarine Mass Movements and Their Consequences

Monday 23 September 2013 - Wednesday 25 September 2013

GEOMAR East shore

Book of abstracts

Table of contents

01: The Italian experience / 29

Integrated stratigraphic and morphological investigation of the Twin Slide complex offshore southern Sicily

Author: Mr. KUHLMANN, Jannis [1]

Co-Authors: ASIOLI, A. [2]; Prof. STRASSER, Michael [3]; TRINCARDI, F. [4]; Prof. HUHN, Katrin [5]

[1] *MARUM, University of Bremen, Germany*

[2] *Istituto di Geoscienze e Georisorse, CNR-UOS di Padova, Italy*

[3] *ETH Zurich*

[4] *Istituto di Scienze Marine (ISMAR-CNR), Venezia, Italy*

[5] *MARUM, University Bremen*

Corresponding Author: jkuhlmann@marum.de

The Holocene Twin Slides form the most recent of recurrent mass wasting events along the NE portion of Gela Basin within the Sicily Channel, central Mediterranean Sea. Here, we present new evidence on the morphological evolution and stratigraphic context of this coeval slide complex based on deep-drilled sediment sequences providing a >100 ka paleo-oceanographic record. Both Northern (NTS) and Southern Twin Slide (STS) involve two failure stages, a debris avalanche and a translational slide, but are strongly affected by distinct preconditioning factors linked to the older and buried Father Slide. Core-acoustic correlations suggest that sliding occurred along sub-horizontal weak layers reflecting abrupt physical changes in lithology or mechanical properties. Our results show further that headwall failure predominantly took place along sub-vertical normal faults, partly through reactivation of buried Father Slide headscarps.

01: The Italian experience / 8

Mass wasting features on the submarine flanks of Ventotene volcanic edifice (Tyrrhenian Sea, Italy)

Author: Dr. CASALBORE, Daniele [1]

Co-Authors: BOSMAN, Alessandro [2]; MARTORELLI, Eleonora [2]; SPOSATO, Andrea [2]; Prof. CHIOCCI, Francesco Latino [3]

[1] *IGAG-CNR*

[2] *CNR-IGAG, Rome, Italy*

[3] *Sapienza, University of Rome*

Corresponding Author: daniele.casalbore@igag.cnr.it

High-resolution multibeam bathymetry acquired around Ventotene and S. Stefano islands (eastern Pontine Archipelago, Italy) enabled us to map main mass wasting features affecting their submarine portions. Large-scale instability morphological features are absent (apart from a 4x2.5 km caldera in the western sector), whereas 126 landslide scars of hundred-meter of length scale were identified between 130 m and 1150 m of water depth (wd). Two main groups of scars can be distinguished: the first one affects the edge of the insular shelf between 130 and 260 m wd. The second group affects the lower slope and surrounding basins, representing cases of retrogressive failure at the heads of channelized features. The different morphological relief of the scars coupled with the recognition of crescent-shaped bedforms made it possible to distinguish two mass-wasting/erosive stages and consequently to map the more active sectors of the edifice. The future evolution of the mass wasting processes will produce the enlargement of erosive sectors with possible formation of large channels, which will carve wide sectors of the edifice, as suggested by available geological constraints and by comparison with the nearby and older western sector of the Pontine archipelago, where a more mature organization of mass wasting processes is observed. The present study can provide useful insights for hazard assessment and future planning of risk mitigation in such islands that are densely populated and touristically exploited during the summer months.

01: The Italian experience / 111

National scale mapping of continental margins geohazard features: the Italian MaGIC project

Prof. CHIOCCI, Francesco Latino [1]

[1] *Sapienza, University of Rome*

Corresponding Author: francesco.chiocci@uniroma1.it

New mapping techniques allow us to define with unpreceded detail seafloor morphology; scientific literature is flooded with a growing number of researches based on high-resolution bathymetry and/or morphometry depicting new geological features and processes. Such techniques however will give an important, up to essential, contribute to the management of the marine areas by national agencies and local authorities; EU is heading in this direction with recent regulations and laws.
In order to have a functional base for the management, a solid procedure for data acquisition, processing and interpretation is needed, providing homogeneous cartography in all the region. Moreover, the retrieving of all the collected data (mainly from scientific institutes) and their integration with new acquisition is also advisable.
This is exactly the story of the Italian MAGIC (MArine Geohazard along the Italian Coast) project, a just-finished 5 years initiative, funded with 5.25 M€ by the National Civil Defense Department. The project involved the whole Italian marine geology scientific community (3 CNR institutes, 7 universities, OGS-Trieste) and provided 73 sheets of the "Map of Geohazard Features of the Italian Seas" plus a web-GIS database (Infor.Mare) to retrieve in real time all the maps present in scientific literature dealing with the marine geology of the Italian Seas.
Some 39.000 nautical miles of multibeam data have been acquired and integrated with 10.000 from previous surveys. Almost 2/3 of the Italian coasts have been covered by the project as we excluded shallow epicontinental seas (e.g. Northern-central Adriatic, northern Tyrrhenian, Sicily Channel) as in general they host few geohazard features. The depth range we investigated is 50-1000m w.d. even if we reached shallower water at canyon head or everywhere needed and we stop deeper (80-90m) where wide shelves were present.
The setting-up of common procedures for data acquisition, processing, interpretation and cartographic representation has been complex and reiterative due to the need of having a standard methods suitable for the different realms (shelf to slope, volcanic/rocky to sedimentary-covered seafloor, erosion dominated to deposition dominated environments, …) and trying to differentiate between morphological (objective) and genetic (interpretative) representation of the depicted features.
The target has been achieved by the establishment of a complex and comprehensive nomenclature and legend, a four level of interpretation and cartographic representation, ranging in scale from 1:250.000 to 50.000 (mainly) and up to more detailed scales for specific point of interest.
The Magic project has been very successful and the results exceeded the expectation. In fact we were able to: (1) furnish the country of a opertaive tool to identify geohazards and to manage emergencies; (2) highlight the extent (and the speed) of morphogenetic processes in geological active areas such the Italian Seas; (3) create a new generation of marine scientists and a very large database that will boost marine sciences researches for the decades to come.

01: The Italian experience / 7

Coastal and submarine landslides in the tectonically-active Tyrrhenian Calabrian margin (Southern Italy): examples and geohazard implications

Author: Dr. CASALBORE, Daniele [1]

Co-Authors: ALESSANDRO BOSMAN, Alessandro Bosman [2]; Prof. CHIOCCI, Francesco Latino [3]; RIDENTE, Domenico [2]

[1] *IGAG-CNR*

[2] *CNR-IGAG, Rome, Italy*

[3] *Sapienza, University of Rome*

Corresponding Author: daniele.casalbore@igag.cnr.it

High-resolution multibeam bathymetry is used as basis for detecting instability processes on the Tyrrhenian margin offshore Calabria (Italy). Among the many evidence at different spatial scale, we focus on selected cases that may represent a potential geohazard because of their scale, shallow/proximal location and state of activity. These include failures along coastal cliffs and canyon headwalls indenting narrow shelves. Coastal rocky failures impacting shallow water offshore Scilla and Palmi retain significant tsunamigenic potential, as proved by the 1783 Scilla event. Slide scars at canyon headwalls offshore Bagnara Calabra and Gioia Tauro indicate retrogressive failure active at water depth < 10 m, just few hundreds of meters from the coast and the settlements and infrastructures there present. Geohazard related to these features is therefore relevant as testified by the failure induced during construction of the Gioia Tauro harbour in 1977.

01: The Italian experience / 10

Submarine mass-movements along the slopes of the active Ionian continental margins and their consequences for marine geohazards (Mediterranean Sea)

Author: Dr. CERAMICOLA, Silvia [1]

Co-Authors: Dr. PRAEG, Daniel [2]; COSTE, Marianne [3]; FORLIN, Edy [3]; COVA, Andrea [3]; COLIZZA, Ester [4]; CRITELLI, Salvatore [5]

[1] *OGS - Istituto Nazionale di Oceanografia e Geofisica Sperimentale*

[2] *OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale)*

[3] *OGS - Instituto Nazionale di Oceanografia e di Geofisica Sperimentale, Borgo Grotta Gigante 42c, 34010 Trieste*

[4] *DGM, Dipatimento di Matematica e Geoscienze, Università di Trieste*

[5] *Dipartimento di Scienze della Terra, Università della Calabria, Arcavate de Rende*

Corresponding Author: sceramicola@inogs.it

The Ionian margins of Calabria and Apulia (IMCA) have been affected by mass movements of varying style, scale and age. Here we present examples of seabed and subsurface features identified along more than 400km of the IMCA from multibeam seabed imagery and subbottom profiles acquired by OGS since 2005. Four different types of mass movement phenomena are recognized with expression at seabed and in the shallow subsurface: 1) mass transport complexes (MTCs) within intra-slope basins, 2) isolated slide scars along open slopes (ISS), 3) slope-parallel sediment undulations (SPSU) recording block-rotations linked to fluid migration, and 4) headwall and sidewall scarps in submarine canyons (HSC). Preliminary analyses of sedimentary processes suggest that both open-slope failures capable of triggering tsunamis and retrogression of canyon headwalls within 1-3km of the Calabrian coast represent potential geohazards for coastal populations and offshore infrastructures.

01: The Italian experience / 13

Mass transport complexes from contourite and shelf-edge deposits along the South-Western Adriatic Margin (Italy)

Author: Mr. DALLA VALLE, Giacomo [1]

Co-Authors: CAMPIANI, Elisabetta [2]; FOGLINI, Federica [2]; GAMBERI, Fabiano [2]; TRINCARDI, Fabio [3]

[1] *ISMAR CNR*

[2] *Istituto di Scienze Marine (ISMAR-CNR), Bologna Italy*

[3] *Istituto di Scienze Marine (ISMAR-CNR), Venezia, Italy*

Corresponding Author: giacomo.dalla.valle@bo.ismar.cnr.it

Seismic data and multi-beam bathymetry reveal the occurrence of several exposed or shallowly buried Mass Transport Complexes (MTCs) in the South-Western Adriatic margin (SWAM), which represents the outer sector of the Albanides-Dinarides foreland basin. MTCs are spatially diffused along the SWAM and characterized by high variability in size, morphology and internal geometry. MTCs are derived from the mobilisation of both contourite drift deposits and shelf-margin progradational deposits. The most prominent MTC of the SWAM is the Gondola Slide (GS), a large, deep-seated (~ 250 m) MTC located near the Gondola-Dauno fault zone (GDFZ), involving around 30 km3 of shelf and slope sediments. In the northern sector of the margin, the Vieste Slide (VS) affects a low gradient upper slope sector, which is extensively dominated by contourite drifts and sediment waves. Seismic correlation shows that the first and main failure events of GS and VS were contemporaneous and impacted the entire margin (more than 2000 km2), and probably were trigger by large earthquake, while later events in both GS and VS appear more localised and asynchronous indicating, probably, slope readjustments governed by local stratigraphic factors.

01: The Italian experience / 18

Evidence for submarine landslides offshore Mt. Etna, Italy

Author: Mr. GROSS, Felix [1]

Co-Authors: Prof. KRASTEL, Sebastian [2]; Prof. CHIOCCI, Francesco Latino [3]; RIDENTE, Dominico [4]; Dr. BIALAS, Joerg [1]; Mrs. SCHWAB, Julia [1]; BEIER, Julio [5]; CUKUR, Deniz [6]; WINKELMANN, Daniel [6]

[1] *GEOMAR*

[2] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

[3] *Sapienza, University of Rome*

[4] *IGAG-CNR, National Research Council, Rome, Italy*

[5] *Institute of Geosciences, Christian-Albrechts Universit¨at zu Kiel, Kiel, Germany*

[6] *GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany*

Corresponding Author: fgross@geomar.de

Mt. Etna is the largest and one of the best-studied volcanoes in Europe. It represents a highly active basaltic volcano on top of the active Apennine thrust belt. The instability of its eastern flank has been described as an important preconditioning factor for the occurrence of submarine mass wasting events. In order to better understand the processes that may cause submarine slope failures, a new dataset including seismic, hydroacoustic and core data was collected during RV Meteor cruise M86/2 from December 2011 to January 2012. Seismic profiles and sediment cores reveal repeated mass transport deposits (MTD), indicating a long history of landslides in the working area. Some of the sampled MTDs and their surrounding strata contain volcaniclastic debris, indicating that slope failures may be controlled by volcanic and non-volcanic processes. Several tephra layers directly cover MTDs, which is regarded as an indicator for the possibility that several flank failures occur immediately before or very early during an eruption.

02: Pore Fluids & Weak Layers / 33

Baiyun Slide and its relation to fluid migration in the northern slope of Southern China Sea

Author: Mr. LI, Wei [1]

Co-Authors: WU, Shiguo [2]; WANG, Xiujuan [2]; ZHAO, Fang [2]; DAWEI, Wang [2]; MI, Lijun [3]; LI, Qingping [4]

[1] *Institute of Oceanology, Chinese Academy of Sciences*

[2] *Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China*

[3] *Department of Exploration, CNOOC, Beijing 100010, China*

[4] *CNOOC Research Centre, Beijing 100029, China*

Corresponding Author: iocasliwei@gmail.com

A large-scale submarine landslide (Baiyun Slide) covering an area of 10,000 km2 was identified from the multibeam bathymetric data, high-resolution 2D and 3D seismic data acquired in the Baiyun Sag, Pearl River Mouth Basin, northern South China Sea (SCS). Numerous polygonal faults are also found below the translational domain of the Baiyun Slide. Enhanced reflections, bright spots and pull-down reflection have been illustrated from the 2D and 3D seismic data, indicating the presence of gas. The headwall scarps of the slide are located stratigraphically above the sediments where the amplitude anomalies are identified. The focused fluid flow maybe leak from the gas reservoir and migrate upward into the base of the Baiyun Slide. Though the triggering mechanism of the Baiyun Slide is still poorly known, the fluid trapped below the slide will reduce the strength of the sediments and trigger the slope failure. We propose a conceptual model of the relationship between fluid migration and slope stability.

02: Pore Fluids & Weak Layers / 36

Weak layers: their definition and classification from a geotechnical perspective

Author: Prof. LOCAT, Jacques [1]

Co-Authors: LEROUEIL, Serge [2]; LOCAT, Ariane [2]; LEE, Homa [3]

[1] *Laval University*

[2] *Laboratoire d'etudes sur les risques naturels, Université Laval, Quebéc, Canada*

[3] *USGS, Menlo Park, CA, USA*

Corresponding Author: jacques.locat@ggl.ulaval.ca

Weak layers play a major role in the development of many large submarine landslides. A definition of a weak layer is proposed here using a geotechnical perspective: a layer (or band) consisting of sediment or rock that has strength potentially or actually sufficiently lower than that of adjacent units (strength contrast) to provide a potential focus for the development of a surface of rupture. Such a layer or a band can follow stratigraphic horizons, but this is not a requirement. From this it is proposed to define two types: inherited and induced weak layers. In addition, weak layers can develop in strain softening sediments where progressive failure can generate a surface of rupture without the need to invoke the role of excess pore pressures.

02: Pore Fluids & Weak Layers / 44

A semi-empirical method to assess flow-slide probability

Author: Dr. VAN DEN HAM, Geeralt [1]

Co-Authors: DE GROOT, Maarten B. [2]; MASTBERGEN, Dick R. [2]

[1] *Deltares*

[2] *Deltares, Delft, The Netherlands*

Corresponding Author: geeralt.vandenham@deltares.nl

Flow-slides in submerged slopes in non-lithified sand and silt-sized sediments form a major threat for flood defences along (estuary) coastlines and riverbanks in the Netherlands. Flow slide is a complex failure mechanism including both soil mechanical and hydraulic features. Two important sub-mechanisms are static liquefaction and breaching. Both result in a flowing sand-water mixture, that eventually re-sediments under a gentle slope. Therefore, when analyzing historical flow slides it is often not clear to what extent static soil liquefaction and/or breaching played a role.
This paper presents a practical, semi-empirical method for assessing dike failure probability due to flow-sliding. It is based on statistical information about documented historical flow slides, in which the results of complex theoretical models, describing physics of static liquefaction or breach-flow, are incorporated.

02: Pore Fluids & Weak Layers / 45

Field measurements to investigate submerged slope failures

Author: Mr. VAN DUINEN, Alexander [1]

Co-Authors: BEZUIJEN, Adam [2]; Dr. VAN DEN HAM, Geeralt [3]; HOPMAN, Victor [4]

[1] *DELTARES*

[2] *Department of Geo-engineering, Deltares, Delft, The Netherlands*

[3] *Deltares*

[4] *Department of Subsurface and Groundwater Systems, Deltares, Delft, The Netherlands*

Corresponding Author: alexander.vanduinen@deltares.nl

Many flood defences in The Netherlands have been disapproved for flow slides of the Holocene subsoil. Traditionally these flow slides are assumed to be induced by static liquefaction. Only in recent times it has been recognized that flow slides may also concern breach flows, which do not necessarily require loosely packed sand. For both static liquefaction and breach flow the inaccuracy of the currently applied methods to determine in situ density lead to high computed probabilities of failure, which is one of the main problems in the safety assessment of flow slides. In order to reduce this uncertainty, based on a literature study a number of methods were selected and applied on four test locations: two sites where flow slides occurred and two sites where no flow slides occurred, but for which high probabilities on flow slides were calculated based on current Dutch assessment rules for liquefaction and breach flow. For these sites CPT's and electrical resistivity cone tests available from earlier investigations, were extended with seismic CPT's and interpreted for relative density and state parameter. The results of this study lead to the conclusion that some of the historical flow slides in The Netherlands may have been the result of static liquefaction in loosely packed sand. For many other slopes, however, it is more reasonable to assume that the failures must have been breach flows in medium or densely packed layers.

03: Pore Fluids & Microfabrics / 27

Characteristics of magnetic fabrics in mass transport deposits in the Nankai Trough trench slope, Japan

Author: Dr. KITAMURA, Yujin [1]

Co-Authors: Prof. STRASSER, Michael [2]; NOVAK, Beth [3]; KANAMATSU, Toshiya [4]; KAWAMURA, Kiichiro [5]; ZHAO, Xixi [6]

[1] *Department of Earth and Planetary Science, University of Tokyo*

[2] *ETH Zurich*

[3] *Western Washington University, Bellingham, WA, USA*

[4] *Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan*

[5] *Department of Geosphere Sciences, Yamaguchi University, Yamaguchi, Japan*

[6] *Department of Earth and Planetary Sciences, University of California Santa Cruz, USA*

Corresponding Author: ykitamura@eps.s.u-tokyo.ac.jp

Submarine landslides are a potential risk to coastal areas all over the world. Studies of mass transport deposit (MTD) contribute to our understanding of the nature and process of submarine landslides. Scientific drilling provides material containing geological records of past landslide events. However, MTDs may not always be uniquely discernible by visual inspection. We applied magnetic fabric analysis to the drilled cores to examine the potential of magnetic fabrics for use in identifying MTDs. Among the sites drilled in the framework of the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE), in Japan, of the Integrated Ocean Drilling Program (IODP), multiple occurrences of MTDs were observed in the recovered cores. We focused on the slope sediments in the footwall of the megasplay fault at Sites C0008 and C0018. The shape parameter (T) and the orientation of the axes of magnetic ellipsoids are distinctively scattered in MTDs at Site C0018. Downward increments in the lineation parameter (L) near the bottom of the MTDs may result from shear localization near the basal sliding plane. This, in combination with visual observation, suggests cohesive mass flow. By contrast, the results from sediments previously described as mass transport complexes at Site C0008 showed the opposite trend, suggesting a different process during transportation; i.e. the mass transport body evolved to become a complete debris flow. Our results show that magnetic fabric analysis is potent for describing MTDs and their internal structures. This finding may extend the methodology for describing MTDs and add to the discussion of the dynamic formation process.

03: Pore Fluids & Microfabrics / 51

Pore pressure response to unloading, progressive slope failure, and the stratigraphic record

FLEMINGS, Peter [1]

[1] *The University of Texas*

Corresponding Author: pflemings@jsg.utexas.edu

Pore pressure response during slope failure controls the nature of slope failure, its periodic behavior, and the form of the stratigraphic record. During liquefaction failure, large volumes of sediment associated with clay rich deposits undergo contraction and liquefication during shear failure. Episodic, retrogressive, failures are recorded in densified mass transport deposits that record separate viscous flows. During breaching failure, sand rich deposits undergo dilation. Resultant under-pressures generate near vertical and progressive slope failure. Sediment is released as episodic or steady turbidity flows. I present field observations, and laboratory results to describe these processes and I use poromechanical modeling to describe the coupling between unloading and shear failure. I emphasize how pore pressure dissipation at the failure front controls the episodic nature of these failures.

03: Pore Fluids & Microfabrics / 39

Fluid seepage in relation to seabed deformation on the central Nile Deep-Sea Fan: evidence from multibeam and sidescan imagery

Author: PRAEG, Daniel [1]

Co-Authors: Prof. KETZER, João Marcelo [2]; AUGUSTIN, Adolpho Herbert [2]; Prof. MIGEON, Sébastien [3]; CERAMICOLA, Silvia [4]; DANO, Alexandre [3]; DUCASSOU, Emmanuelle [5]; DUPRÉ, Stéphanie [6]; MASCLE, Jean [7]; RODRIGUES, Luiz Frederico [2]

[1] *OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale)*

[2] *CEPAC, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil*

[3] *Géoazur, UMR7329, UNS-UPMC-CNRS-OCA, Valbonne, France*

[4] *OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Trieste, Italy*

[5] *Université Bordeaux 1, UMR5805 EPOC, Talence, France*

[6] *IFREMER, Technopôle Brest-Iroise, Plouzané, France*

[7] *Géoazur, UMR7329, UNS-UPMC-CNRS-OCA, Villefranche/Mer, France*

Corresponding Author: dpraeg@ogs.trieste.it

On the central Nile deep-sea fan, stratified sediments overlying mass-transport deposits (MTDs) are deformed into slope-parallel seabed undulations associated with fluid seepage. The western part of this system, in water depths of 1950-2250m, is examined using multi-frequency data from hull-mounted and deep-towed swath/profiling systems. Sub-bottom profiles show sub-vertical fluid pipes that terminate both at and below seabed, and gas signatures along fault planes bounding the undulations. Fluid seepage is recorded by high- to intermediate-backscatter patches (HBPs, IBPs) that differ in appearance on multibeam imagery (30 kHz, ≤3 m penetration) and sidescan swaths (170/190 kHz, <0.1 m penetration). Comparison of the two suggests a distinction of a) buried carbonates (0.1-3 m), b) broad near-seabed (<0.1 m) carbonate pavements elongate along the undulations, c) sub-circular areas of seabed seepage up to 300 m across. Four of the latter have narrower gas flares at their edges rising 400-800 m above seabed. These results are consistent with an evolving system of narrow fluid conduits that support the growth and burial of carbonate pavements, shifting over millennial timescales along linear zones parallel to fault planes rooted in MTDs. Sediment deformation above MTDs is inferred to provide pathways for fluid escape, but migration of gas-rich fluids from depth is likely to have facilitated slope destabilisation.

03: Pore Fluids & Microfabrics / 5

Elemental distribution and microfabric characterization across a buried slump scar: New insights on the long-term development and reactivation of scar surfaces from a microscopic perspective

Author: Ms. AMSLER, Helen Eri [1]

Co-Authors: REUSSER, Eric [2]; MILLIKEN, Kitty [3]; Prof. STRASSER, Michael [4]

[1] *ETH Zürich, Switzerland*

[2] *ETHZ, Zürich, Switzerland*

[3] *Bureau of Economic Geology, University of Texas at Austin, TX, USA*

[4] *ETH Zurich, Switzerland*

Corresponding Author: eri.amsler@erdw.ethz.ch

This study presents a detailed characterization of the sedimentology, microfabric and elemental distributions across a prominent unconformity drilled at 78 meters below sea floor at Integrated Ocean Drilling Program (IODP) Site C0004 in the Nankai accretionary prism, offshore Japan. This stratigraphic contact has previously been interpreted as buried landslide scar, which likely experienced multiple failure events. Our study aims at testing this hypothesis and at contributing new insights on the long-term development and reactivation of submarine landslide scars from a microscopic perspective. X-ray fluorescence spectroscopy documents increased values of sulfur and iron across the unconformity. Pyrite mineralization occurring in small fractures immediately below the unconformity is identified with energy dispersive X-ray analysis. Cross-cutting relationships between fractures and pyrite minerals, as imaged by X-ray computed tomography and scanning electron microscopy reveals that precipitation has occurred before the formation of the unconformity. A few mm-to-cm above the studied surface and thus within the overlying hemipelagic sediment, preferred mineral alignment along thin deformation bands are observed. Inferred shear bands are hypothesized as incipient evidence for a potential future submarine landslide. Compiled data confirm the hypothesis of recurrent submarine landslides along the same surface.

04: (In)stability of Volcanic Edifices / 108

Instability of oceanic volcanic edifices: examples of sector collapse, debris avalanches, and debris flows from Gran Canaria (Canary Islands)

Author: SCHMINCKE, Hans-Ulrich [1]

Co-Author: SUMITA, Mari [2]

[1] *GEOMAR*

[2] *GEOMAR Kiel*

Corresponding Author: h-u.schmincke@t-online.de

We review different types of mass transfer (landslides, debris avalanches, debris flows, turbidites) generated throughout the evolution of a long-lived volcanic island (Gran Canaria) from its emergence ca. 16 m.y. ago to the present. The choice of Gran Canaria is based on its unique characteristics in that the various types of downslope mass transfer are not only documented by acoustic methods and bathymetry, but also by lithology (ODP Leg 157 drilling and land deposits). The intermittent mass transfer caused by edifice instability and direct volcanic processes (pyroclastic flows) represents by far the greatest contribution of mass to the depot centers peripheral to the island, as contrasted with steady erosion. We speculate on the impact of long-term trade wind directions as major factors in deeply eroding and thus weakening the northern slopes and therefore preferentially localizing sector collapses on the windward sides of the islands.

04: (In)stability of Volcanic Edifices / 107

New insights on submarine flank volcano evolution from geomechanical characterization of marine sediments, west of Martinique Island, Lesser Antilles arc

Author: Mrs. LAFUERZA, Sara [1]

Co-Authors: LE FRIANT, Anne [1]; MANGA, Michael [2]; BOUDON, Georges [1]; VILLEMANT, Benoit [3]; STRONCIK, Nicole [4]; VOIGHT, Barry [5]; HORNBACH, Matt [6]; ISHIZUKA, Osamu [7]

[1] *Institut de Physique du Globe de Paris*

[2] *Department of Earth and Planetary Science, University of California, Berkeley, CA 94720, USA*

[3] *University Pierre et Marie Curie Paris, France*

[4] *Department of Geology and Geophysics, Texas A M, College Station, Texas 77845, USA*

[5] *Geosciences, Penn State University, University Park, PA 16802, USA*

[6] *Department of Earth Sciences, Southern Methodist University, Dallas, Texas 75275, USA*

[7] *Geological Survey of Japan, AIST, Central 7 1-1-1 Higashi, Tsukuba, Ibaraki 305-8567, Japan*

Corresponding Author: lafuerza@ipgp.fr

Onshore-offshore geophysical studies conducted on Martinique have identified major flank collapse events of Montagne Pelée that generated large submarine mass wasting deposits. Here, we evaluate the preconditioning factors involved in the deformation and failure of marine sediments related to volcano-flank collapse events. We use core logging, sedimentological and geotechnical data of the upper 200 meters of core at sites U1397, U1398, U1399 and U1400 drilled during the Integrated Ocean Drilling Program (IODP) expedition 340, west of Martinique. We find that the low hydraulic conductivity of hemipelagic sediment causes low rates of dewatering of turbidites and tephra layers allowing excess pore fluid pressures to persist at depth. Overpressure generation was likely enhanced during major flank collapses, leading to low shear strength and subsequent deformation of large volumes of marine sediments, as found at Site U1400.

04: (In)stability of Volcanic Edifices / 67

The Detection of Volcanic Debris Avalanches (VDAs) Along the Hellenic Volcanic Arc, Through Marine Geophysical Techniques

Author: Dr. NOMIKOU, Paraskevi [1]

Co-Authors: Prof. PAPANIKOLAOU, Dimitris [2]; ALESSANDRO, Tibaldi [3]; Prof. STEVEN, Carey [4]; Mr. ISIDOROS, Livanos [2]; Dr. KATHERINE, Croff Bell [5]; Prof. FEDERIQUE, Pasquare [6]; Dr. GROGORIS, Rousakis [7]

[1] *Universiy of Athens*

[2] *University of Athens*

[3] *University of Milan Bicocca*

[4] *University of Rhode Island*

[5] *Ocean Exploration Trust*

[6] *Insubria University*

[7] *Hellenic Centre for Marine Research*

Corresponding Author: evinom@geol.uoa.gr

Recent marine oceanographic surveys using geophysical techniques have revealed a number of debris avalanche deposits (VDAs) on the external flanks of Antimilos, Santorini and Nisyros volcanoes in the South Aegean Sea. Swath bathymetry and side-scan sonar surveys led to the recognition of characteristic hummocky topography on all of these deposits. On seismic profiles the VDAs are identified by chaotic facies, with incoherent areas bordered by continuous undisturbed seismic reflectors. High-resolution examination of the morphological characteristics of the VDAs was accomplished by using Remotely Operated Vehicles (ROVs), in order to distinguish them from other clastic deposits. In some cases the VDAs can be traced upslope to horseshoe-shaped collapse depressions and represent the expression of the complex evolution of these volcanic edifices. Recognition of VDAs at these volcanic centers has important implications for geohazard assessments as flank collapses have the potential for triggering of large-scale tsunamis. The relationship between the distribution/emplacement mechanisms of the VDA deposits and the source flank collapses remains an area of ongoing research.

05: Fjords & High Latitudes / 21

Submarine mass movements and trigger mechanisms in Byfjorden, western Norway

Author: Dr. HJELSTUEN, Berit Oline [1]

Co-Author: BRENDRYEN, Jo [2]

[1] *University of Bergen*

[2] *Department of Earth Science, University of Bergen, Norway*

Corresponding Author: berit.hjelstuen@geo.uib.no

High-resolution TOPAS seismic profiles, bathymetric records and gravity cores from Byfjorden, surrounding the city of Bergen on the west coast of Norway, have been analysed in order to identify mass failures and their trigger mechanisms during the last 15,000 years. The seismic profiles show that Byfjorden comprises four 20-50 m deep sediment basins. These basins are characterised by glacimarine and hemipelagic acoustically laminated successions and acoustically transparent lens-shaped features, interpreted to be slide debrites. The gravity cores, taken from the sediment basin close to Bergen Harbour, penetrate the upper 2.4 m of the sediment infill in Byfjorden and reveal a 1.5 m thick turbidite above a larger-scale slide debrite. The turbidite is radiocarbon dated to c. 1180 cal yrs BP, noting that such an age also has been assigned as a minimum age for a turbidite identified in the neighbouring Fensfjorden system. These turbidites are considerably younger than turbidites found in other western Norwegian fjord systems, which commonly cluster around 8200, 2800 and 2100 cal yrs BP. We suggest an earthquake as trigger mechanism for the 1180 cal yrs BP event, whereas the larger-sized slide debrites identified may be related to changes in depositional environments due to the last withdrawal of the Fennoscandian Ice Sheet in the Weichselian.

05: Fjords & High Latitudes / 22

Imaging active mass-wasting and sediment flows on a fjord delta, Squamish, British Columbia

Author: Dr. HUGHES CLARKE, John [1]

Co-Authors: VIDIERA MARQUES, Carlos R. [2]; DANAR PRATOMO, Danar Pratomo [2]

[1] *University of Brunswick*

[2] *University of New Brunswick, Canada*

Corresponding Author: jhc@omg.unb.ca

An active fjord head delta in Squamish British Columbia, was selected as the location for a repetitive multibeam survey program to monitor temporal evolution of the prodelta morphology. Daily resurveys in 2011 established the style and extent of submarine mass movements, their typical periodicity and the conditions associated with the most active periods. This has now been followed by an hourly resurvey program in 2012 during those most active periods to actually witness the progression of activity immediately preceding, during and subsequent to a singular event.

The delta front in depths of 20-50m is often the apparent start point for trains of sequential erosive and depositional events associated with upslope bedform migration along prodelta channels. Heavy targets on the channel floors were monitored in 2011 and indicated rare, abrupt down channel displacements of a few hundred metres, indicating that a small subset of events involved bulk translation of the seabed. In 2011, a bottom-mounted ADCP beyond one channel mouth recorded clear turbidity current events for a subset of the channel bedform migration periods.

In 2012, using multibeam water column imaging and a rapidly dipping towed optical backscatter probe, the evolution of a descending suspended sediment plume below the overlying river plume was monitored on an hourly basis. Towards low water, that descending plume was seen to occasionally feed a near seabed higher suspended sediment layer. On the development of this layer, the water column imaging revealed a thin basal flow that lasted about an hour and corresponded directly with the period of migration of the channel floor bedforms. Delta-lip failures are associated with the upslope end of about half of the bedform trains suggesting an alternate initiating mechanism.

05: Fjords & High Latitudes / 109

Submarine landslides affecting the Jan Mayen micro-continent, Norwegian-Greenland Sea

Author: Dr. LABERG, Jan Sverre [1]

Co-Authors: KAWAMURA, K. [2]; AMUNDSEN, H. [1]; ANDREASSEN, K. [1]; BAETEN, N [1]; FORWICK, M [1]; RYDNINGEN, T. A. [1]; VORREN, T. O. [1]

[1] *Department of Geology, University of Tromsø, Norway*

[2] *Graduate School of Science and Engineering, Yamaguchi University, Japan*

Corresponding Author: jan.laberg@uit.no

The Jan Mayen micro-continent is located in the Norwegian-Greenland Sea. It forms an up to 30 km wide and relatively flat-topped submarine ridge which narrows and deepens towards the south. The ridge rises 1500 – 2000 m above the surrounding sea-floor and has a length of some 150 km. Its northern termination is defined by the Jan Mayen Fracture Zone that is part of the mid-Atlantic spreading ridge system. Here, both submarine and sub-aerial (on the island Jan Mayen) volcanism occur. Based on newly acquired swath bathymetry data covering most of the ridge, the eastern and western slope morphologies were studied. Preliminary analyses show that the slope includes a number of smaller slide scars (up to some km wide) as well as one up to 50 km wide scar located on the eastern slope. The morphology of the larger slide scar is “fresh” and includes an irregular headwall area and channels that can be followed from the headwall at about 800 m water depth and downslope to at least 2500 m water depth. This morphology is distinctly different from that of the large slide scars along the Norwegian continental margin and in the paper factors that may explain this difference will be discussed.

05: Fjords & High Latitudes / 31

The 1930 landslide in Orkdalsfjorden: morphology and failure mechanism

Author: Dr. L'HEUREUX, Jean-Sebastien [1]

Co-Authors: LONGVA, Oddvar [2]; HANSEN, Louise [2]; VANNESTE, Maarten [3]

[1] *Norwegian Geotechnical Institute (NGI)*

[2] *Geological Survey of Norway (NGU), Trondheim, Norway*

[3] *Norwegian Geotechnical Institute (NGI), Oslo, Norway*

Corresponding Author: jsl@ngi.no

The 1930 landslide and associated 15-m high tsunami along the shore of Orkdalsfjorden, mid Norway, killed one person and caused major damage to port facilities. The combination of witness testimony with swath bathymetry data, high resolution seismic reflection data and gravity cores show that the failure propagated rapidly (up to 25 m/s) and progressively over a clay layer in a retrogressive manner. The volume of sediment evacuated downslope of the 8-12 m high and 3 km long headwall amounts 18.5·106 m3 during this event. The transformation of the failed mass into a sediment gravity flow caused subsequent slope failures on the opposite side of the fjord and the breakage of submarine cables at distances of 3 and 18 km away from the initial landslide.

05: Fjords & High Latitudes / 34

Slope instability of glaciated continental margins: Constrains from permeability-compressibility tests and hydrogeological modeling off Storfjorden, NW Barents Sea

Author: Mr. LLOPART, Jaume [1]

Co-Authors: Dr. URGELES, Roger [2]; CAMERLENGHI, A. [3]; LUCCHI, R. G. [3]; DE MOL, B. [4]; REBESCO, M. [3]; PEDROSA, M T [5]

[1] *ICM-CSIC*

[2] *Institute of Marine Sciences (CSIC)*

[3] *Geophysics Research Section, Istituto Nazionale di Oceanografia e Geofisica Sperimentale-OGS, Trieste, Italy*

[4] *Dept. Geoci`encies Marines, Institut de Ci`encies del Mar (CSIC), Barcelona, Spain*

[5] *Instituto Andaluz de Ciencias de la Tierra-IACT, Granada, Spain*

Corresponding Author: jaume.llopart@gmail.com

Climate variations control sediment supply to the continental slope as well as glacial advances and retreats, which (a) cause significant stress changes in the sedimentary column and redistribution of interstitial fluids, (b) induce a particular margin stratigraphic pattern and permeability architecture and (c) are at the origin of isostatic adjustments that may reactivate faults. We test this hypothesis using a combination of geophysical and geotechnical data from the Storfjorden Trough Mouth Fan, off southern Svalbard. The results of compressibility and permeability testing are used together with margin stratigraphic models obtained from seismic reflection data, as input for numerical finite elements models to understand focusing of interstitial fluids in glaciated continental margins and influence on timing and location of submarine slope failure. Available results indicate values of overpressure of 0.23-0.5 (slope-shelf) that persists to present-day. This overpressure started to develop in response to onset of Pleistocene glaciations and reduced by half the factor of safety of the continental slope.

06: Mediterranean, Marmara, Black Sea / 25

Regional Slope Stability Assessment along the Caucasian Shelf of the Black Sea

Author: Mr. IONOV, Vsevolod [1]

Co-Authors: KALININ, Ernest [2]; FOMENKO, Igor K. [3]; MIRONYUK, Sergey G. [4]

[1] *Lomonosov Moscow State University, Geological Department, chair of engineering and ecological geology*

[2] *Geological Department, Lomonosov Moscow State University, GSP-1, Leninskie Gory, 119991 Moscow, Russia*

[3] *Gulf Interstate Engineering Company, Moscow, R*

[4] *Peter Gaz LLC, Moscow, Russia*

Corresponding Author: sevaionov@gmail.com

Construction of submarine pipelines across the Caucasian shelf of the Black Sea draws a necessity of a detailed study of submarine landslides, which were discovered during a recent survey. The most probable triggers for landslide generation for the Caucasian shelf include earthquakes, wave loading and human activity. Slope stability assessment of the study area was carried out in order to reveal the most important triggering mechanisms. 1-D slope stability modelling was implemented for the purpose of landslide prediction. Gravity force, seismic loading and storm waves' loading were taken into consideration in the present slope stability assessment. The results indicate that for static conditions, landslides formation would most probably occur within the shelf break area where the surface inclination is ~30°. For the shelf area, landslide formation only occurs with additional triggers, such as seismic or wave loading.

06: Mediterranean, Marmara, Black Sea / 3

Submarine slope stability assessment of the central Mediterranean continental margin: the Gela Basin

Mr. AI, Fei [1]

[1] *Marum, Univesity of Bremen*

Corresponding Author: aifei@uni-bremen.de

This study investigates slope stability for a relatively small scale (5.7 km2, 0.6 km3), 8 kyr old landslide named Northern Twin Slide (NTS) at the slope of the Gela Basin in the Sicily Channel (central Mediterranean). The NTS is characterized by two prominent failure scars, forming two morphological steps of 110 m and 70 m height. Geotechnical data from a drill core upslope the failure scar (GeoB14403) recovered sediments down to ~52 m below seafloor (mbsf). The deposits show low overconsolidation ratio (OCR = 0.24-0.4) and low internal friction angle (20-22°) around 28-45 mbsf, which suggests this mechanically weak interval may act as potential location of instability in a future failure event. Oedometer tests attest the sediments are highly underconsolidated and the average overpressure ratio () is ~0.7. Slope stability analyses carried out for different scenarios indicate that the slope is stable both under static undrained and drained conditions. A relatively small horizontal acceleration of 0.03-0.08 g induced by an earthquake may be sufficient to cause failure. We propose that moderate seismic triggers may have been responsible for the twin slide formation and could also cause mass wasting in the future.

06: Mediterranean, Marmara, Black Sea / 37

The Malta-Sicily Escarpment: Mass movement dynamics in a sediment-undersupplied margin

Author: Dr. MICALLEF, Aaron [1]

Co-Authors: Dr. MOUNTJOY, Joshu [2]; Dr. LE BAS, Timothy [3]; Dr. LO IACONO, Claudio [4]; Dr. GEORGIOPOULOU, Aggeliki [5]; Dr. VEERLE, Huvenne [3]

[1] *University of Malta*

[2] *National Institute of Water and Atmospheric Research, New Zealand*

[3] *National Oceanography Centre, UK*

[4] *National Oceanography Centre, Southampton*

[5] *University College Dublin*

Corresponding Author: micallefaaron@gmail.com

The Malta-Sicily Escarpment (MSE) is a steep carbonate escarpment that appears to have largely remained isolated from inputs of fluvial and littoral sediments since the Messinian Salinity Crisis. Mass movement activity has so far only been inferred from sediment cores at the base of the MSE. In this study we use geophysical and sedimentological data acquired from the upper MSE and outer Malta Plateau to: (i) map and characterise the dominant forms of mass movements, and (ii) determine the nature and origin of these mass movements, and their role in the evolution of the MSE. We document 67 mass movement scars across 370 km2 of seafloor. Slope instability entailed translational slides, spreads and debris flows that mobilised Plio-Pleistocene outer shelf hemipelagic/pelagic sediments or carbonate sequences across the upper continental slope. Slope failure events are caused by loss of support associated with the formation of channels, gullies, canyon heads and fault-related escarpments. Mass movements play a key role in eroding the seafloor and transferring material to the lower MSE. In particular, they control the extent of headward and lateral extension of submarine canyons, facilitate tributary development, remove material from the continental shelf and slope, and feed sediment and drive its transport across the submarine canyon system.

06: Mediterranean, Marmara, Black Sea / 66

Submarine Mass Movements Along a Sediment Starved Margin: The Menorca Channel (Balearic Islands –Western Mediterranean)

Author: Dr. LO IACONO, Claudio [1]

Co-Authors: Dr. URGELES, Roger [2]; Mrs. POLIZZI, Sabrina [3]; Mr. GRINYÓ, Jordi [4]; Dr. DRUET, Maria [5]; Dr. AGATE, Mauro [3]; Prof. GILI, Josep Maria [4]; Dr. ACOSTA, Juan [5]

[1] *National Oceanography Centre, Southampton-UK, Institut de Ciències del Mar (CSIC)-Spain*

[2] *Institut de Ciències del Mar (CSIC), Spain*

[3] *Dipartimento delle Scienze della Terra e del Mare dell'Universitá di Palermo - Italy*

[4] *Institut de Ciències del Mar (CSIC) - Spain*

[5] *Insituto Español de Oceanografia - Spain*

Corresponding Author: cllo@noc.ac.uk

Sediment starved passive margins, particularly those of insular slopes, display significant mass transport activity despite the absence of environmental stresses from high sedimentation rates. The "Menorca Channel" represents the up 90 to 120 m deep shelf sector connecting the Menorca and Mallorca Islands (Balearic Islands – Western Mediterranean). South of the Menorca Channel submarine gravitational processes have been mapped and interpreted from swath-bathymetry, TOPAS parametric echosounder and deep-towed videos. The shelf-break is located at an average depth of 140 m, and sediment instability is a widespread phenomenon. The slope region south the Menorca Channel shows a number of submarine canyons disrupting the outer shelf. The north-easternmost canyon is the more active feature, with an incised axis and scars shaping the flanks up to their edges. Headwall scarps, between 140 and 700 m depth, are up to 20 m high. The shallower scarps producing slab-type failures have carved the outer edges of planar sedimentary bodies interpreted as formed in shallow environments during previous glacial stages. Results show that a variety of sediment instability processes extensively shape the southern upper slope of the Menorca Channel. Submarine canyons develop on the Emile Bodout Escarpment (EBE), a passive tectonic feature which bounds the slope region of the study area. A number of knickpoints within the canyons suggest backward erosion control on mass wasting and, at the same time, that slope failure is one of the main drivers for canyon upslope migration. Steep gradients of the upper slope, the presence of weak layers and the action of major storms during lowstand stages are additional factors likely to influence the distribution and frequency of mass wasting processes in this area.

06: Mediterranean, Marmara, Black Sea / 17

Mass Transport Deposits periodicity related to glacial cycles and marine-lacustrine transitions on a ponded basin of the Sea of Marmara (Turkey) over the last 500 ka

Author: Dr. GRALL, CELINE [1]

Co-Authors: HENRY, Pierre [2]; WESTBROOK, G.K. [3]; ÇAĞATAY, M. N. [4]; THOMAS, Y. [3]; MARSSET, B. [3]; BORSCHNECK, D [2]; SARITAS, H. [5]; CIFÇI, G. [5]; GÉLI, L. [3]

[1] *CEREGE, CNRS, AIx-Marseille University*

[2] *CEREGE, CNRS, Aix Marseille University, Marseille, France*

[3] *IFREMER - French Research Institute for Exploration of the Sea, Marine Geosciences, Plouzané, France*

[4] *EMCOL and Department of Geological Engineering, Istanbul Technical University, Istanbul, Turkey*

[5] *Institute of Marine Sciences and Technology, Dokuz Eylul University, Izmir, Turkey*

Corresponding Author: grall@cerege.fr

The Sea of Marmara (SoM) is affected by large earthquakes occurring on the North Anatolian Fault. Numerous submarine mass movements have occurred and the most recent turbidites in the basins of the SoM have been related to historical earthquakes. Within the SoM, the occurrence of submarine mass movements and their size appears modulated by eustatic changes that can be accompanied by transitions between a salty marine environment and a brackish lake environment. Detailed analysis, using a 3D high-resolution seismic dataset, of stratigraphy over the last 500 ka, within a ponded basin of the Western High, shows that intervals of draped sedimentary reflectors alternate with onlap sequences that followed episodes of rapid sea-level rise, with a periodicity of approximately 100,000 years (corresponding to glacial cycles). Mass Transport Deposits (MTDs) occur within the onlapping sequences. Detail analysis of the youngest large slide, which probably followed the lacustrine transition to during Marine Isotopic Stage 4 is presented; and the possible triggering processes are discussed. The potential triggers of MTDs during this transition, in the context of the SoM are: (i) gas hydrate dissociation by pressure drop; (ii) changes in sediments supply and transport dynamics; (iii) variations in pressure and/or ionic strength in pores. The latter case appears the most suitable hypothesis, as salt diffuses out of the pores of the marine clay-rich sediment dominated by smectite at the beginning of low stand/lacustrine stages. The pore water freshening induces clay swelling, which can potentially drive sediment slope failure.

06: Mediterranean, Marmara, Black Sea / 9

Submarine landslides and contourite drifts along the Pianosa Ridge (Corsica Trough, Mediterranean Sea)

Author: Dr. CATTANEO, Antonio [1]

Co-Authors: JOUET, G. [2]; CHARRIER, S. [3]; THÉREAU, E. [3]; RIBOULOT, V. [3]

[1] *IFREMER*

[2] *IFREMER Plouzané, France*

[3] *IFREMER, Plouzané, France*

Corresponding Author: antonio.cattaneo@ifremer.fr

The Corsica Trough between the island of Corsica and the mainland of Italy is dominated on its western side by turbidite channel-lobe systems fed by high-gradient rivers during glacial epochs, while the eastern side is markedly different. It is flanked by the Pianosa Ridge, a prominent tectonic structure confining the distal reaches of turbidite lobes and it is characterized by the development of contourite drifts with evident seafloor expression. The southern part of the Pianosa Ridge hosts a submarine landslide called 'Pianosa Slump' (PS, 6 km long, 14 km wide). Multichannel Sparker and Chirp profiles reveal the internal geometry of the PS, formed by two sediment bodies of up to 0.85 and 0.34 km3. A buried submarine landslide below the PS shows that mass wasting is a recurrent process in this area. Preliminary results suggest that submarine landslides have volumes and ages comparable with those of turbidite lobes from the Golo turbidite system and contribute actively to their confinement and to basin filling. Relatively steep gradients, rapid contourite drift accumulation during times of sea level lowstands, and fluid escape from distal turbidite sandy lobes are the main factors conducive to seafloor instability.

07: Australia, Latin America / 23

Morphological Expression of Submarine Landslides in the Accretionary Prism of the Carribean Continental Margin of Colombia

Author: Dr. IDÁRRAGA-GARCÍA, Javier [1]

Co-Author: Prof. VARGAS JIMENEZ, Carlos Alberto [2]

[1] *Graduate Program of Geophysics, Universidad Nacional de Colombia*

[2] *Universidad Nacional de Colombia*

Corresponding Author: jidarragag@unal.edu.co

Morphological analyses of ~14500 km2 of high-resolution-bathymetric data in the Caribbean continental margin of Colombia has allowed us to identify submarine landslides in the Sinú Accretionary Prism (SAP) and Magdalena submarine fan (MSF) areas.

In the MSF area most of submarine failures are disintegrative, i.e. with no obvious deposit near or at the base of the scar, and are related to a system of canyons belonging to the Magdalena turbidite system and to an abrupt slope break at the border of the continental shelf. Landslides in the SAP area are mainly associated to the steeper flanks (12-18°) of anticline-related ridges. In many cases, the associated landslide deposits are buried by subsequent sediments related to broad fans formed in the mouth of channels and canyons. The cohesive landslides identified exhibit blocky deposits with rubble masses up to 50 m high and runout distances between 3.6 and 11 km.

Morphometric analyses of scarps allowed us to calculate landslides ages in function of the constant k of diffusivity. Estimations using a k value of 0.015 m2y-1 suggest ages ranging between 13.8 and 9,761.9 ky for the MSF and ages between 12.2 and 1,031.8 ky for the SAP.

07: Australia, Latin America / 28

Mass wasting along Atlantic continental margins: a comparison between NW-Africa and the de la Plata River region (northern Argentina and Uruguay)

Author: Prof. KRASTEL, Sebastian [1]

Co-Authors: LEHR, J. [2]; WINKELMANN, D. [3]; SCHWENK, T. [4]; PREU, B. [4]; Prof. STRASSER, Michael [5]; WYNN, R.B. [6]; Dr. GEORGIOPOULOU, Aggeliki [7]; HANEBUTH, T.J.J. [4]

[1] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

[2] *Institute for Geosciences, Kiel University, Germany*

[3] *GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany*

[4] *MARUM, Bremen, Germany*

[5] *ETH Zurich*

[6] *National Oceanography Centre, Southampton, UK*

[7] *University College Dublin*

Corresponding Author: skrastel@geophysik.uni-kiel.de

The passive continental margins of the Atlantic Ocean are characterized by thick sedimentary successions, which might become unstable resulting in landslides of various sizes. The type of mass-wasting differs between individual margin sections but the reasons for these differences are not well understood. The NW-African continental margin is characterized by several large-scale but infrequent landslides, while the continental margin in the de la Plata River region (northern Argentina and Uruguay) shows widespread small-scale mass transport deposits. These different styles of mass wasting can be explained by different oceanographic and sedimentary settings. The margin off Northwest Africa is characterized by high primary productivity caused by oceanic upwelling as well as locally focused aeolian input resulting in relatively high sedimentation rates. This setting leads to sediment instabilities arising primarily from underconsolidation of deposited sediments and widespread weak layers. In contrast, the modern ocean margin off Uruguay and northern Argentina is characterized by strong contour currents and a high amount of fluvial sediment resulting in widespread contouritic deposits. These contourites are potentially unstable leading to smaller but more frequent landslides.

07: Australia, Latin America / 50

Characterization of submarine landslide complexes offshore Costa Rica: An evolutionary model related to seamount subduction

Author: Dr. HARDERS, Rieka [1]

Co-Authors: RANERO, César R. [2]; WEINREBE, Wilhelm R. [3]

[1] *University of Barcelona*

[2] *Barcelona Center for Subsurface Imaging (Barcelona-CSI), ICM, ICREA at CSIC, Barcelona, Spain*

[3] *GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Germany*

Corresponding Author: rharders@ub.edu

Offshore Costa Rica large seamounts under-thrust the continental convergent margin causing slides of complex morphology. The large dimension of the structures has attracted previous investigations and their basic characteristics are known. However, no detailed mapping of their complex morphology has been reported. Here we present a detailed mapping of the failure-related structures and deposits. We use deep-towed sidescan sonar data, aided by multibeam bathymetry to analyze their geometry, geomorphologic character, backscatter intensity, and spatial distribution. Those observations are used to analyze the relationship between landslide characteristics and abundance, to the changes in the style of deformation caused by the subduction of seamounts to progressively greater depth under the margin.

07: Australia, Latin America / 2

Size-frequency relationship of submarine landslides at convergent plate margins: implications for hazard and risk assessment

Author: Prof. BEHRMANN, Jan [1]

Co-Authors: Dr. VÖLKER, David [2]; GEERSEN, Jacob [3]; Dr. HARDERS, Rieka [4]; WEINREBE, Wilhelm [5]

[1] *GEOMAR Helmholtz Cente fro Ocean Research*

[2] *GEOMAR*

[3] *University of Southampton*

[4] *University of Barcelona*

[5] *GEOMAR Kiel, Germany*

Corresponding Author: jbehrmann@geomar.de

We use complete inventories of submarine landslides from the Middle America (MA) and the Central Chile (CC) trench and forearc systems to analyze the size-frequency relationship of such structures on active continental slopes. The MA forearc is characterized by subduction erosion, and the CC forearc has had an accretionary tectonic history since the Late Neogene. Both are end-member types of convergent margins around the world. Both margin segments have been mapped by high-resolution swath bathymetry at strike lengths of about 1300 km (MA) and 1000 km (CC). The Middle America forearc has 143 discernible slides with sizes ranging from 0.38 km2 to 1426 km2. Offshore Central Chile, the 62 mapped slides are 0.9 km2 to 1285 km2 in size. Slide localization is markedly different at both margin types. While they also vary strongly along strike of the individual margin, depending on forearc slope gradient, kinematic coupling between plates, or topographic structure of the downgoing plate, the size-freqency relationships are remarkably similar. This allows quantification of the incidence of a submarine slide of given size per margin segment. The relationships hold for slide sizes from 10-1000 km2, with the cut-off defined by slide size (smaller slides) and sample size (larger slides). As slide traces of 100 km2 to 300 km2 size are obliterated by tectonic deformation after about 200000 years, recurrence rates for slides of a given size can be estimated. This offers a chance to assess hazard and risk resulting from such events. It is suggested that it takes 20 to 200 plate boundary earthquakes to set off a medium-sized (> 10 km2) or larger slump or slide.

07: Australia, Latin America / 98

Probable Landslide Detachment Surfaces And Post-slide Deposits Sampled In The Yamba Slide Complex, New South Wales, Australia.

Author: Dr. HUBBLE, Thomas [1]

Co-Authors: Ms. CLARKE, Samantha [1]; Ms. YU, Phyllis [2]; Dr. VÖLKER, David [3]

[1] *University of Sidney*

[2] *The University of Sydney*

[3] *GEOMAR*

Corresponding Author: tom.hubble@sydney.edu.au

The Yamba Slide Complex is located on eastern Australia's upper continental slope offshore from the town of Yamba in northern New South Wales. It is a composite submarine landslide feature in which near-surface, slab slides up to sixty meters thick have been detached and removed from the upper portion of a larger rotational slump block approximately 2 km wide, 4 km long and some hundreds of metres thick.

Four cores have been recovered from three sites within the slide complex and one core from the continental slope adjacent to the complex. All four cores present sharp and distinct boundary surfaces separating upper layers of soft, unconsolidated hemipelagic mud from lower layers of denser, moderately consolidated to stiff hemipelagic mud. Sedimentologic descriptions and mini-shear vane data are presented for the four cores and this data is interpreted in the context of the available bathymetric and seismic reflection data as well as the regional geology.

The shortest of the four cores collected from the Yamba Slide Complex presents an interesting transition between the lower stiff hemipelagic muds and the upper unconsolidated mud units. This core was recovered from a site that apparently shed the thickest, translational slab slide removed from the Yamba complex (approximately 60 m). Its transition zone is a ten centimeter thick, upper-fining mud-flake paraconglomerate which presents rounded to sub-rounded, mud-pebble intraclasts imbedded in a mud matrix. This paraconglomerate overlies significantly stiffer material which is presently located at a depth of 1.4 below the seafloor. Mini-shear vane results for these stiff muds are consistent with burial of these lower layer materials at depths of more than forty metres and it is probable that the stiff, hemipelagic mud layers represent in-situ, below-slide-plane materials. The upward-fining paraconglomerate is interpreted to be a post-slide deposit, which was possibly deposited immediately after, and as a consequence of the removal of a translational slab-slide block. The contact between the base of this mud-flake paraconglomerate and the stiff muds is interpreted to be either a surface eroded down through the slab-slide's detachment surface; or the slab-slide's actual detachment surface upon the removed upper block slid donwslope.

All four of the boundary surfaces presented in the three within slide cores and the one slide-adjacent core site taken from the Yamba Slide Complex are suggested to represent submarine landslide detachment surfaces and/or actual slide plane surfaces.

07: Australia, Latin America / 12

Morphology of Australia's eastern continental slope and related tsunami hazard

Author: Ms. CLARKE, Samantha [1]

Co-Authors: Dr. HUBBLE, Thomas [1]; AIREY, David [2]; Ms. YU, Phyllis [3]; BOYD, Ron [4]; KEENE, John [2]; EXON, Neville [5]; GARDNER, James [6]; WARD, Steven [7]

[1] *University of Sydney*

[2] *University of Sydney, Sydney, NSW, Australia*

[3] *The University of Sydney*

[4] *University of Newcastle, NSW, Australia*

[5] *Australian National University, Canberra, ACT, Australia*

[6] *CCOM, University of New Hampshire, Durham, NH, USA*

[7] *University of California, Santa Cruz, CA, USA*

Corresponding Author: samantha.clarke@sydney.edu.au

Morphologic characterisation of five distinct, eastern Australian upper continental slope submarine landslides enabled modelling of their tsunami hazard. Flow depth, run-up and inundation distance has been calculated for each of the five landslides. Future submarine landslides with similar characteristics to these could generate tsunami with maximum flow depths ranging five to ten meters at the coastline, maximum run-up of five meters and maximum inundation distances of one kilometre

07: Australia, Latin America / 46

Age estimation of submarine landslides in the La Aguja Submarine Canyon, Northwestern Colombia

Author: Prof. VARGAS JIMENEZ, Carlos Alberto [1]

Co-Author: Dr. IDÁRRAGA-GARCÍA, Javier [2]

[1] *Universidad Nacional de Colombia*

[2] *Graduate Program of Geophysics, Universidad Nacional de Colombia*

Corresponding Author: cavargasj@unal.edu.co

La Aguja Submarine Canyon (LASC) is a remarkable bathymetric feature that cuts the continental margin of the Colombian Caribbean Coast offshore of the Santa Marta massif. This section of the margin is strongly influenced by two active strike-slip fault systems: the NNW-trending Santa Marta – Bucaramanga Fault (SMBF) and the EW-trending Oca- Fault (OF). Based on 6500 km2 of high resolution multibeam bathymetry and one 2D seismic reflection profile (~60 km), we identified submarine landslides associated with the LASC. Along the canyon we observe channel morphologies high sinuosity, variable widths (between 2 and 8 km), and both U- and V-shaped asymmetric cross sections. The occurrence of mud volcanoes in the surrounding area, some of which stand above the flanks of the canyon, is also common. The available data allowed us to identify 31 submarine landslides on the LASC flanks, between water depths of 1200 m and 3285 m, with slopes ranging between 6.1° and 36.8°. Using numerical solutions of the diffusion equation of these scarps we estimate ages of between <1.0 ka to ~631.6 ka. According to observations, the triggering mechanisms of landslides could be closely related to earthquakes originated in the convergence zone of SMBF and OF, and/or to the flanks instabilities driven by mud diapirism.

07: Australia, Latin America / 41

The tsunami generation potential of Shovel and Bulli Slides in the continental margin SE Australia

Author: Dr. TALUKDER, Asrar [1]

Co-Author: Dr. VÖLKER, David [2]

[1] *CSIRO*

[2] *GEOMAR*

Corresponding Author: asrar.talukder@csiro.au

High-resolution bathymetric maps from offshore SE Australia have shown that the continental margin is characterised by numerous landslides of all sizes and shapes. We have studied two of the larger slides, Shovel Slide and Bulli Slide, located in the upper to mid continental margin offshore New South Wales (NSW), in detail. Morphometric analyses suggest that the slides had the potential to create tsunamis. We have calculated the initial wavelength and maximum amplitudes of those hypothetical tsunamis using the equations of Watts et al. (2003). The calculated initial wave heights above the mass centroid are in the same range of magnitude on the order of 10 to 25 m for both slides. The initial wavelengths vary between 75 and 104 km. If, on the other hand, the slides represent multiple (e.g. retrogressive) events, the tsunamigenic potentials were lower. Sizes, shapes, frequencies and the tsunami potentials of the submarine landslides from offshore NSW suggest that submarine landslides may well provide sources for local tsunamis. Precise dating of the landslide events and modelling of the calculated tsunami run up along the coast are yet to be performed.

08: Fossil Slide Complexes / 65

New Concepts on Mass Wasting Phenomena at Passive and Active Margins of the Alpine Tethys: Famous Classical Outcrops in the Berchtesgaden – Salzburg Alps Revisited. Part A: Jurassic Slide/Debrite Complexes Triggered by Syn-Sedimentary Block Faulting

Author: Prof. HENRICH, Rüdiger [1]

Co-Authors: BAUMANN, Karl-Heinz [2]; BICKERT, Torsten [2]

[1] *University of Bremen - Faculty of Geosciences*

[2] *MARUM and Faculty of Geosciences, University of Bremen, Germany*

Corresponding Author: henrich@uni-bremen.de

Jurassic strata exposed in outcrops along road cuts and trails as well as saw cut wall sections of “technical marmor” quarries at Adnet close to Salzburg and Waidring were studied for their depositional features, their geometries of sediment bodies, syn-depositional deformation and re-deposition structures as well as tectonic features. A spectacular mass wasting complex at Rote Wand/ Mount Steinplatte near Waidring (Austria, Tirol) was studied. Development of this complex indicates that in a first phase downward gliding almost intact slide blocks plugged into the underlying bedded nodular strata. In turn, this slide was immediately overrun by semi-consolidated slumped deposits, which partly disintegrated into pebbly mudstones. On top of the mass sealing by three debris flows is observed.We assume that the emplacement of the slide/slump complex occurred as one single event triggered by syn-sedimentary block faulting at the passive Early Jurassic Alpine margin. Eventually deposition of the first debrite covering the slide/slump complex was also related to this phase. In addition, a broad spectrumofmass wasting deposits is described from Liassic strata on the paleoslope of the drowned Rhaetian reef complex at Adnet and the surrounding basins.

09: Tsunami Models and Geotechnical Testing / 26

Utilizing core penetration tests for landslide evaluation

Mr. JORAT, Mohammed Ehsan [1]

[1] *PhD student*

Corresponding Author: jorat@uni-bremen.de

Pore pressure and shear strength are two important parameters that control the stability of slopes. These parameters can be derived in-situ by cone penetration testing (CPT) with pore pressure measurements. This paper presents the results from three static, vibratory and dissipation CPT profiles deployed into a landslide headwall at Pyes Pa, Bay of Plenty, New Zealand. The landslide strata consist of volcanic ashes and ignimbrites. Studying the stability of slopes in this area using in-situ geotechnical testing is of societal-economic importance since several other landslides within comparable strata caused considerable property damage. Three CPT profiles were collected across the headwall of the slide scar with 2 m spacing in undisturbed sediments using static, vibratory and dissipation test modes. Static CPT results are used to evaluate soil grain size variations, geotechnical parameters of sediments such as shear resistance, probable slip surface and sensitivity of sediments. Liquefaction potential of sediments is assessed using vibratory CPT results. For dissipation tests, the cone remained stationary in the sediment for ~60 minutes to monitor pore pressure dissipation at the depths of 6 m, 9 m and 11 m. With the use of pore pressure dissipation data, values of soil horizontal permeability are calculated. The liquefaction probability from static CPT results is compared to liquefaction potential evaluation from vibratory CPT. Last but not least, an unstable soil layer is defined based on static CPT, vibratory CPT and dissipation results.

09: Tsunami Models and Geotechnical Testing / 20

The state-of-the-art numerical tools for modeling landslide tsunamis: a short review

Author: Dr. HEIDARZADEH, Mohammad [1]

Co-Authors: Prof. KRASTEL, Sebastian [2]; YALCINER, Ahmed [3]

[1] *Kiel University*

[2] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

[3] *Middle East Technical University, Ankara, Turkey*

Corresponding Author: mheidarzadeh@geomar.de

We present a short review of the state-of-the-art numerical tools that have been used for modeling landslide-generated waves. A comparative study is conducted on the physical properties of earthquake- and landslide-generated waves suggesting that both dispersion and nonlinearity effects may be neglected for the former waves whereas they may be considered for the latter ones. We introduce landslide tsunami models and group them into three classes: 1) models treating the moving mass as a fluid, 2) models estimating the initial water surface, and 3) models fed by the transient seafloor deformation. Selection of a particular model from the list of models introduced here depends on: 1) the dimensions of the source, 2) the available computing capacities, 3) availability of fine bathymetric grid, and 4) the purposes of the modeling.

09: Tsunami Models and Geotechnical Testing / 112

Submarine landslide tsunamis – generation mechanisms and hazard assessment

Author: Dr. HARBITZ, Carl Bonnevie [1]

Co-Author: Dr. ELVERHØI, Anders [2]

[1] *NGI*

[2] *UiO, Norway*

Corresponding Author: carl.bonnevie.harbitz@ngi.no

Submarine landslides may occur along any passive or active continental margin and at different water depths. Most landslides that cause tsunamis result in more local effects than comparable earthquake-induced tsunamis, due to different source characteristics. However, enormous submarine landslides exhibiting volumes of several thousands of km3 may cause tsunamis with more widespread effects. Volcanic flank collapses may also cause tsunamis inducing distant destruction, although their tsunamigenic potentials are disputed.

The landslide parameters governing the tsunami generation can all gain extreme values. However, the hazard posed by a landslide is not necessarily proportional to its size. The high mobility of submarine landslides may be explained partly by the large volumes involved and partly by the landslide/water interaction. Material properties, including clay rheology, are of great importance for the dynamics of most events. The quantification of the landslide parameters is complicated by the transformation of the landslide from a huge slab to smaller blocks, then to a highly viscous fluid and – in many cases – to a turbidity current. The stages of flow evolution are connected to different flow regimes that require different modeling approaches. Many submarine landslides develop retrogressively (i.e. they are released progressively upwards from the toe). Depending on the time lags between releases of the individual elements, this process normally reduces the tsunamigenic power. Mechanical analyses of release, disintegration, and flow mechanisms will help understanding the dynamics of past events. Laboratory experiments (and the important discussion on how they relate to the corresponding natural phenomena) are particularly important for submarine landslides that are difficult to observe at full scale.

Wave frequency dispersion, which is normally more pronounced for landslide than for earthquake tsunamis owing to the relatively short length scale of landslide thickness variations relative to the water depth, makes the propagation more complex. Generally, the leading-order wave is reduced due to dispersion. On the other hand, the limited wavelengths of landslide tsunamis favor amplification due to shoaling. Moreover, the landslides are difficult to observe and monitor; hence, they are apparently unpredictable, which in turn makes the tsunami consequences more extreme.

Most tsunami hazard assessments have been scenario-based and focused on earthquake tsunamis. More recently, however, a Probabilistic Tsunami Hazard Assessment (PTHA, largely inherited from Probabilistic Seismic Hazard) approach has been developed. However, insufficient sampling and changing conditions for landslide release are major obstacles in transporting a PTHA approach from earthquake to landslide tsunamis. It is further expected that the landslide tsunami risk is dominated by the large return periods, generally carrying the largest uncertainties. Hence, the more robust Scenario-Based Tsunami Hazard Assessment (SBTHA) approach will probably still be most efficient to use. Advanced numerical models to simulate submarine landslides or tsunamis are already in practical use. Combining models for the evolution of retrogressive landslides with the more sophisticated (dispersive) tsunami propagation models will be a huge step forward in the field of landslide tsunami research.

09: Tsunami Models and Geotechnical Testing / 86

Delta failure events measured on Fraser Delta using scientific cabled observatory

Author: Dr. LINTERN, Gwyn [1]

Co-Author: Dr. HILL, Philip [1]

[1] *Geological Survey of Canada*

Corresponding Author: glintern@nrcan.gc.ca

The slope of the Fraser delta is prone to failure. At least six independent mechanisms have been hypothesized. Modeling by Fisheries and Oceans Canada shows that a large magnitude slide would generate a tsunami large enough to impact lives in communities of Metro Vancouver and damage hundreds of millions of dollars worth of infrastructure. Although slides of this magnitude are mostly hypothetical, there is some evidence that a large one has occurred in the past. There is also ample information about small and medium sized slides which occur on timescales of months to years. These smaller slides are capable of causing millions of dollars of damage to cables, ports and navigational structures.

The Geological Survey of Canada is making use of the Ocean Networks Canada VENUS scientific cable to measure the slides, and more importantly, to measure all of the factors which are hypothesized to cause instability. With the first phase of the planned instrumentation in the water, the Delta Dynamics Laboratory, we have already measured at least two events of sufficient magnitude to cause damage to cables and other small infrastructure. The most recent event sent the large DDL platform tumbling down the delta slope. The second phase of the project comprises the Seismic Liquefaction In Situ Piezometers (SLIPs) which will be deployed, alongside the restored DDL, starting in 2013. This paper describes the failure events we have seen to date, and discusses the forcing factors which led to them. All are being measured and transmitted in real time using VENUS.

09: Tsunami Models and Geotechnical Testing / 32

Modeling submarine landslide-generated waves in Lake Ohrid, Macedonia/Albania

Author: Dr. LINDHORST, Katja [1]

Co-Authors: Prof. KRASTEL, Sebastian [2]; PAPENBERG, Cord [3]; Dr. HEIDARZADEH, Mohammad [4]

[1] *University of Kiel*

[2] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

[3] *Helmholtz Centre for Ocean Research Kiel, GermanyGEOMAR*

[4] *Kiel University*

Corresponding Author: klindhorst@geophysik.uni-kiel.de

We study potential tsunami hazards associated with submarine landslides in Lake Ohrid, Macedonia/Albania. The transboundary Lake Ohrid located on the Balkan Peninsula shared by Macedonia and Albania is considered to be the oldest- continuously existing lake in Europe (2-5 Ma), though the age and the origin are not completely unraveled to date. Previous studies by means of hydroacoustic methods have shown that the western margin of Lake Ohrid has a long history of mass wasting. Based on seismic data, slide deposits are found in different stratigraphic levels as well as on the lake floor where they have affected a large area. This study is focused on the well-studied Udenisht Slide Complex covering an area of 27 km^2 within the southwestern part of Lake Ohrid.The Udenisht slide is by far the largest mass movement with an average thickness of 30 to 40 m and an estimated volume of about 0.11 km^3. It is therefore well within the limits of submarine landslides that are known to be capable of triggering tsunamis. Using numerical modeling, the propagation of a landslide-generated tsunami with an initial wave height of more than 5 m has been calculated. Run-up heights estimated for coastal communities around the lake are moderate in the north (2-3m) can reach up to 10 m directly at the site where the slide initiated. This study is a first generation of landslide tsunami hazard assessment for Lake Ohrid and further detailed modeling is recommended for the region.

09: Tsunami Models and Geotechnical Testing / 49

Advances in Offshore Seismic Slope Stability: A Case History

Author: ZANOLI, Omar [1]

Co-Authors: PIATTI, Claudio [1]; PARKER, Eric J. [1]; ZUCCARINO, Lorenzo [1]

[1] *D'Appolonia S.p.A.*

Corresponding Author: omar.zanoli@dappolonia.it

This paper presents a case history showing how the integration of detailed geophysical and geotechnical data and advanced numerical modeling can overcome the limitations of conventional analysis in predicting seismic stability of deepwater slopes. Submarine landslides represent one of the most critical geohazards for offshore pipelines and deepwater hydrocarbon developments. This is particularly true for seismically active regions where earthquakes are expected to be a triggering mechanism. A typical issue encountered in these cases is the coexistence of several detrimental aspects: poor geomechanical properties of shallow sediments; presence of steep slopes; and/or severe seismic input. The combination of these aspects often makes it difficult to match results of conventional pseudo-static slope stability analysis with field observations. These methods are generally conservative for deepwater conditions and are not able to reproduce observed past failures modes. This case history is of a complex slope system in the Mediterranean Sea. Morphologically the system presents a number of canyons and large-scale landslide features, overlain by a limited number of shallow planar slides. Geochronological testing constrained the large, deep slides to the distant past while confirming the shallow slides as recent phenomena. The use of high quality sampling and advanced laboratory tests provided the necessary input for dynamic nonlinear FEM analyses using OpenSees software. Numerical results based on a set of real time histories confirmed field observations and highlighted the possible formation of seismically triggered shallow slides. The paper describes how geophysical data, accurate soil sampling and advanced laboratory testing together with an advanced numerical model can develop reliable slope stability assessments for projects in difficult environmental conditions.

09: Tsunami Models and Geotechnical Testing / 43

A numerical investigation of sediment destructuring as a potential globally widespread trigger for large submarine landslides on low gradients

Author: Ms. URLAUB, Morelia [1]

Co-Authors: Dr. TALLING, Peter [2]; Dr. ZERVOS, Antonis [3]

[1] *GEOMAR Helmholtz Centre for Ocean Research*

[2] *National Oceanography Centre Southampton*

[3] *Engineering and the Environment, University of Southampton*

Corresponding Author: murlaub@geomar.de

Submarine landslides on open continental slopes can be far larger than any slope failure on land and occur in locations worldwide on gradients of <2°. Significantly elevated pore pressure is necessary to overcome the sediment's shearing resistance on such remarkably low gradients, but the processes causing such overpressure generation are contentious, especially in areas with slow sedimentation rates. Here we propose that the progressive loss of interparticle bonding and fabric could cause such high excess pore pressure. Slow sedimentation may favour the formation of a structural framework in the sediment that is load-bearing until yield stress is reached. The bonds then break down, causing an abrupt porosity decrease and consequently overpressure as pore fluid cannot escape sufficiently rapidly. To test this hypothesis, we implement such a loss of structure into a 2D fully coupled stress-fluid flow Finite Element model of a submerged low angle slope, and simulate consolidation due to slow sedimentation. The results suggest that destructuring could indeed be a critical process for submarine slope stability.

09: Tsunami Models and Geotechnical Testing / 70

Modeling Potential Tsunami Generation by the BIG'95 Landslide

Author: Dr. LØVHOLT, Finn [1]

Co-Authors: Dr. IGLESIAS, Olaia [2]; Dr. LASTRAS, Galderic [2]; Dr. CANALS, Miquel [2]; Dr. PEDERSEN, Geir K. [3]; Dr. HARBITZ, Carl Bonnevie [1]; Dr. VANNESTE, Maarten [1]; Dr. DE BLASIO, Fabio V. [4]; Dr. GLIMSDAL, Sylfest [1]; Dr. URGELES, Roger [5]

[1] *NGI*

[2] *University of Barcelona*

[3] *University of Oslo*

[4] *Universita di Roma "Sapienza", Rome, Italy*

[5] *CSIC*

Corresponding Author: carl.bonnevie.harbitz@ngi.no

The BIG'95 landslide was emplaced 11,500 years ago and is one of the largest known submarine landslides in the Mediterranean Sea. The simulated landslide dynamics matches the observed run-out and deposited thickness. Water elevation simulated by using a dispersive tsunami model exceed 10 m close to the landslide area and at the nearest shorelines. Modeling further indicates that the tsunami probably had widespread consequences in the Mediterranean. Compared to previous studies, this new simulation provides larger waves. There is, however, still a need to better constrain the landslide dynamics in order to illuminate the uncertainties related to the tsunamigenic power of this, and other, submarine landslides.

10: North America / 59

Creeping deformation mechanisms for mixed hydrate-sediment submarine landslides.

Author: Dr. MOUNTJOY, Joshu [1]

Co-Authors: Dr. PECHER, Ingo [2]; Dr. HENRYS, Stuart [3]; Dr. CRUTCHLEY, Gareth [3]; Dr. BARNES, Philip [4]; Dr. PLAZA-FAVEROLA, Andrea [5]

[1] *NIWA*

[2] *University of Auckland. Private Bag 92019, Auckland 1142, New Zealand*

[3] *GNS Science. PO Box 30-368, Lower Hutt 5040, New Zealand*

[4] *National Institute of Water and Atmospheric Research. Private Bag 14901, Wellington, New Zealand.*

[5] *GNS Science. PO Box 30-368, Lower Hutt 5040, New Zealand (now at University of Tromsø, Dramsveien 201, N-9037 Tromsø, Norway)*

Corresponding Author: joshu.mountjoy@niwa.co.nz

Globally widespread gas hydrates are proposed to stabilize the seafloor by increasing sediment peak shear strength; while seafloor failure localises at the base of the gas hydrate stability field (BGHS). The primary mechanism by which gas hydrates are proposed to induce slope failure is by temperature or pressure controlled dissociation of hydrate to free gas resulting in a significant pore pressure increase at the BGHS. Direct evidence for this process is lacking however, and the interaction between gas hydrate and seafloor stability remains poorly understood. We present a hypothesis that, contrary to conventional views, gas hydrate can itself destabilize the seafloor. Morphological (Kongsberg-Simrad EM300 and EM302 multibeam) and high-resolution multichannel seismic refection data from a 100 km2 submarine landslide complex in ~450 m water depth, 20 km off the east coast of New Zealand indicate flow-like deformation within gas hydrate-bearing sediments. Extension dominated creep deformation occurs immediately downslope of where the BGHS projects to the seafloor, suggesting involvement of gas hydrates.
We propose two mechanisms to explain how the shallow gas hydrate system could control these landslides. 1) Overpressure and/or temperature fluctuations below low-permeability gas hydrate-bearing sediments causes hydrofracturing where the BGHS approaches the landslide base, both weakening sediments and creating a valve for transferring excess pore pressure into the upper landslide body. Overpressure in sediment may also migrate laterally into sequences underlying debris up-slope of the BGHS, 2) Gas hydrate-bearing sediment exhibits time-dependent plastic deformation enabling glacial-style deformation. This second hypothesis is supported by recent laboratory observations of time-dependent behaviour of gas-hydrate-bearing sands. Given the ubiquitous occurrence of gas hydrates on continental slopes, our results may require a re-evaluation of slope stability following future climate-forced variation in bottom water temperatures.

10: North America / 35

A geomorphological analysis of the Veatch slide complex off Massachusetts, U.S.A.

Author: Prof. LOCAT, Jacques [1]

Co-Authors: Dr. CHAYTOR, Jason [2]; TEN BRINK, Uri [3]

[1] *Laval University*

[2] *U.S. Geological Survey*

[3] *USGS, Woods Hole, USA*

Corresponding Author: jacques.locat@ggl.ulaval.ca

A geomorphological analysis of the Veatch slide complex is presented here indicting the presence of at least two major slides presenting different morphological characteristics and involving different type of sediments (in terms of strength and grain size). These slides took place after the erosion of the Veatch Canyon which had been the locus of many bank failures. It is shown that a more refined morphological analysis of similar landslide areas may lead to the definition of a greater number of slides and a greater role of channels both leading to a more complex interpretation on their mobility.

10: North America / 16

Comparison of mass wasting processes on the slopes of the Rockall Trough, Northeast Atlantic

Author: Dr. GEORGIOPOULOU, Aggeliki [1]

Co-Authors: BENETTI, Sara [2]; SHANNON, Patrick M. [3]; SACCHETTI, Fabio [2]; HAUGHTON, Peter D.W. [3]; COMAS-BRU, Laia [4]; Prof. KRASTEL, Sebastian [5]

[1] *University College Dublin*

[2] *University of Ulster, Coleraine, Northern Ireland, UK*

[3] *University College Dublin, Ireland*

[4] *University College Dublin, Dublin, Ireland*

[5] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

Corresponding Author: aggie.georg@ucd.ie

The deep-water, sediment-starved Rockall Trough separates the western Irish shelf from the Rockall Bank. Both margins have narrow, steep slopes that connect the continental shelf with the deeper basin but differ in their underlying geological controls and sediment transport processes. We compare and contrast the opposing margins of the Rockall Trough and review the size, depth distribution and degree of mass wasting processes and associated geohazard risk on each margin.

Rapid contourite buildup, shallow underlying abrupt basement topography and slope oversteepening due to erosion at the base of the western margin have led to large slope failures such as the Rockall Bank Slide Complex.

In contrast, the eastern margin of the Rockall Trough marked the westernmost extent of the British Irish Ice Sheet, reflected on the shelf by the presence of end moraines. Sediment was delivered by meltwater discharged from the ice sheet which locally reached the shelf edge. In conjunction with the effect of erosion from bottom currents and localised slope failures, the waning of the ice sheet led to the formation of numerous canyons incising this slope.

Slope failures on the eastern margin were relatively small and sediment was progressively evacuated towards the deeper basin through canyons. In contrast, mass wasting on the western margin involved larger sediment volumes. Processes resulting in mass wasting on the western margin are likely to be still active. In contrast, the eastern margin that was glacially nourished is likely to be less active with only minor mass wasting resulting from contour current scour and local canyon margin collapse.

11: Indian Ocean and Asian Pacific / 81

Seabed features of undersea volcanic ridge in the Andaman Sea - Signatures of pyroclastic flow

Dr. SAHA, Bijan Kumar [1]

[1] *School of Oceanographic Studies, Jadavpur University, Kolkata*

Corresponding Author: sahabijankr@yahoo.co.in

The Barren and the Western ridge, in a subduction related setting, forms a part of inner volcanic arc in the Andaman Sea. Barren Island is the sub-aerial expression of the Barren volcanic ridge. Bathymetric survey has delineated the submarine extension of Barren ridge as well as another 55 km long Para longitudinal submarine volcanic ridge, 16 to 18 km west of Barren Island. Both the ridges might have been formed during late to post Pleistocene volcanism. But the recent cycles of volcanic eruptions are restricted to Barren Island only. There are no signatures of recent eruptions on the Western ridge. The basaltic fragments, recovered from the Western ridge are having biogenic growth on the surface.

The Western ridge has come out from about 1500m water depths with peaks at 600 and 437m water depths. The eastern slope is steeper and may be due to large scale lateral collapses, followed by modern sedimentation. Western flank is gentle. The top part of the ridge is mostly veneered by sand/ silty sands. Silty sediments cover its flank. There are four to five down depth layers of sand size pyroclastic materials, ranging from 40 to 80 wt %, consisting of volcanic glass, plagioclase feldspars, hypersthenes along the western slope. These sub seabed layers vary in number and thickness (3 to 11cm) and spread over in different domains at varying water depths with higher concentrations in the central sector mostly down to 80-110 cm sediment columns. Presence of smectite and absence of other clay minerals in the sediments in the core are significant. On the contrary, these types of layers are absent in the outer flank of Barren ridge. Flow of pyroclastic materials during different periods might have resulted in depositions of these buried multiple layers combined with other sediments along the slope of the ridge.

11: Indian Ocean and Asian Pacific / 30

Contrasting development of the latest Quaternary slope failures and mass-transport deposits in the Ulleung Basin, East Sea (Japan Sea)

Author: Dr. LEE, Sang Hoon [1]

Co-Authors: BAHK, Jang-Jun [2]; KIM, Han Joon [3]; KIM, Gil-Young [4]; KIM, Seong-Pil [4]; JEONG, Sueng-Won [4]; PARK, Sung-Sik [5]

[1] *Korea Institute of Ocean Science and Technology*

[2] *Korea Institute of Geoscience and Mineral Resources, Daejeon 305-330, South Korea*

[3] *Korea Institute of Ocean Science and Technology, Ansan, South Korea*

[4] *Korea Institute of Geoscience and Mineral Resources, Daejeon, South Korea*

[5] *Kyungpook National University, Daegu, South Korea*

Corresponding Author: sanglee@kordi.re.kr

In order to understand how the variations in shelf morphology and sediment supply to the shelf within a basin can change the occurrence styles of slope failures and mass-transport deposits (MTDs), this paper details dimensions and morphology of the latest Quaternary slope failures and MTDs on the western and southern margins of the Ulleung Basin. On the western margin, the slides and slumps have relatively small dimensions with a few small, scoop-shaped scars and gullies deeper than 700 m water depth. The downslope mass-flow deposits occur as small, solitary lobes restricted at the base-of-slope. On the western margin, the small sediment input to the shelf and the prominent Hupo Bank and Hupo Trough blocking sediment delivery to the slope probably caused relatively low accumulation of muddy sediments in the slope, most likely resulting in the small dimensions of slope failures, and the restricted occurrence of small MTDs at the base-of-slope. In contrast, the southern margin is characterized by large dimensions of gullied scars with huge slides and slumps deeper than 250 m water depth. These catastrophic failures evolved into extensive mass flows, which travelled downslope for several tens of kilometers. On the southern margin, the flat, broad shelf and the high sediment supply to the shelf during the last glacial period probably caused relatively high accumulation of mixed muddy and sandy sediments in the upper slope. These conditions could have promoted large-scale slope failures along the entire upper slope, forming the extensive occurrence of MTDs in the middle to lower slopes. This study provides an example that the variations in shelf morphology and sediment supply to the shelf within a basin can affect the styles of slope failures and MTDs by controlling sediment input and sediment types to the slope.

11: Indian Ocean and Asian Pacific / 15

Evidence for Mass Transport Deposits at the IODP JFAST-Site in the Japan Trench

Author: Dr. FINK, Hiske [1]

Co-Authors: Prof. STRASSER, Michael [2]; Dr. RÖMER, Miriam [3]; Dr. KÖLLING, Martin [3]; Dr. IKEHARA, Ken [4]; Dr. KANAMATSU, Toshiya [5]; DINTEN, Dominik [6]; KIOKA, Arata [7]; Dr. FUJIWARA, Toshiya [5]; Dr. KAWAMURA, Kiichiro [8]; Dr. KODAIRA, Shuichi [5]; Prof. WEFER, Gerold [3]

[1] *MARUM - Center for Marine Environmental Sciences, University of Bremen*

[2] *ETH Zurich*

[3] *MARUM – Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany*

[4] *Geological Survey of Japan, AIST*

[5] *IFREE, JAMSTEC, Yokosuka, Japan*

[6] *ETH Zurich, Switzerland*

[7] *AORI, Tokyo University, Tokyo, Japan*

[8] *Departement of Geosphere Science, Yamaguchi University, Yamaguchi, Japan*

Corresponding Author: hfink@marum.de

Several studies indicate that the 2011 Tohoku-Oki earthquake (Mw 9.0) off the Pacific coast of Japan has induced slip to the trench and triggered landslides in the Japan Trench. In order to better understand these processes, detailed mapping and shallow-coring landslides at the trench as well as Integrated Ocean Drilling Program (IODP) deep drilling to recover the plate boundary décollement (Japan Trench Fast Earthquake Drilling Project, JFAST) have been conducted. In this study we report sediment core data from the rapid response R/V SONNE cruise (SO219A) to the Japan Trench, evidencing a mass transport deposit (MTD) in the uppermost section later drilled at this JFAST-site during IODP Expedition 343. A 8.7 m long gravity core (GeoB16423-1) recovered from ~7000 m water depth reveals a 8 m sequence of semi-consolidated mud clast breccias embedded in a distorted chaotic sediment matrix. The MTD is covered by a thin veneer of 50 cm hemipelagic, bioturbated diatomaceous mud. This stratigraphic boundary can be clearly distinguished by using physical properties data from Multi Sensor Core Logging and from fall-cone penetrometer shear strength measurements. The geochemical analysis of the pore-water shows undisturbed linear profiles measured from the seafloor downcore across the stratigraphic contact between overlying younger background-sediment and MTD below. This indicates that the investigated section has not been affected by a recent sediment destabilization in the course of the giant Tohoku-Oki earthquake event. Instead, we report an older landslide which occurred between 700 and 10,000 years ago, implying that submarine mass movements are dominant processes along the Japan Trench. However, they occur on local sites and not during each megathrust earthquake.

11: Indian Ocean and Asian Pacific / 48

Along-strike migration of intermittent submarine slope failures at subduction margins: geological evidence from the Chikura Group, central Japan

Author: Dr. YAMAMOTO, Yuzuru [1]

Co-Author: KAWAKAMI, Shunsuke [2]

[1] *IFREE, JAMSTEC*

[2] *Asahi Geo Survey Co., Ltd, Tokyo, Japan*

Corresponding Author: yuzuru-y@jamstec.go.jp

Ancient submarine slope failures are exposed in the Plio–Pleistocene trench–slope basin sediments of the Chikura Group. Based on the lateral tracing of a key tephra bed ("HF") and the sedimentology and geological structure at seven exposures of the failure deposit over a total distance of 5 km, we identified at least 5 discrete failure events and evidence of lateral variation in the age of the failures, younging to the west. The slope failure deposits therefore represent the lateral migration of intermittent submarine slope failures. The initial slope failure was triggered by earthquake-induced liquefaction at about 2 Ma, and subsequently failures propagated northwards perpendicular to the ancient trench axis. The geological evidence for the systematic lateral migration of intermittent submarine slope failures accords with the migration style identified by physical models of failure propagation.

11: Indian Ocean and Asian Pacific / 47

Seismic Characteristics and Distribution of Large Scale Mass Transport Deposits in the Qiongdongnan Basin, South China Sea

Author: Dr. WANG, dawei [1]

Co-Authors: WU, Shiguo [2]; LÜ, Fuliang [3]; SPENCE, George [4]

[1] *institute of oceanology, chinese academy of science*

[2] *Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China*

[3] *PetroChina Hangzhou Institute of Geology, China National Petroleum Corporation, Hangzhou, China*

[4] *School of Earth and Ocean Sciences, University of Victoria,Canada*

Corresponding Author: wangdawei@qdio.ac.cn

Large-scale mass-transport deposits (MTDs), here called the Huaguang MTDs, occur in the South China Sea region within the Qiongdongnan Basin, north of Guangle Uplift and west of Xisha Uplift. As a large-scale buried MTD system, the Guaguang MTDs cover an area of more than 18,000 km2 and can be divided into four distinct sub-MTDs. Sediment sources for MTD1, MTD2 and MTD3 are from southern Guangle Uplift and eastern Xisha Uplift, and their transport directions are generally from south to north. However, the flow direction for MTD4, located in the northwest portion of the study area, is from west to east with a source in the Yinggehai Basin region. MTD1 and MTD4 merge to form two connected depocenters. Along their length, the MTDs are seen as continuous packages that extend to the northwest, with a maximum distance of ~180 km from Guangle Uplift. The maximum thickness of the deposits reaches ~950 ms two-way travel time. The Huaguang MTDs show prominent features characteristic of large landslides. The overall seismic facies includes highly disrupted reflectors, truncated reflectors, and steep side walls. The lateral margins are easily recognized on seismic profiles perpendicular to the flow direction as abrupt boundaries between the inner highly chaotic or weakly reflective seismic facies and the outer continuous undisturbed facies. The MTDs are widely distributed in the Late Miocene upper Huangliu Formation (8.3-5.5 Ma). The analysis of the Huaguang MTDs provides constraints for Late Miocene tectonic activity on the passive continental margin of the South China Sea.

11: Indian Ocean and Asian Pacific / 40

Modeling of potential landslide tsunami hazards off western Thailand (Andaman Sea)

Author: Mrs. SCHWAB, Julia [1]

Co-Authors: Prof. KRASTEL, Sebastian [2]; Dr. HEIDARZADEH, Mohammad [3]; BRUNE, Sascha [4]

[1] *GEOMAR*

[2] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

[3] *Kiel University*

[4] *GFZ German Research Centre for Geosciences, Potsdam, Germany*

Corresponding Author: jschwab@geomar.de

We model several scenarios of potential submarine landslide tsunamis in the Andaman Sea off the Thai west coast. Our results suggest that landslides may be capable of producing significant tsunamis. Two categories of submarine landslide scenarios were evaluated. Geometry parameters of the first category are taken from identified mass transport deposits (MTDs); the second category considers a potentially unstable block identified in seismic data. Our preliminary modeling approach shows that run-up values may reach significant tsunami heights for some scenarios. We point out that our results have to be regarded as only preliminary due to several limitations in our modeling approach. Our results, however, show the need for more sophisticated modeling of landslide tsunamis, especially regarding the failure process and inundation on dry land

Poster session / 0

Local Tsunamis and Submarine Landslides in Selected Pacific Island Nations

Author: Dr. POHLER, Susanne [1]

Co-Author: Mr. KRUGER, Jens [2]

[1] *University of the South Pacific*

[2] *SPC*

Corresponding Author: pohler_s@usp.ac.fj

In the 1990s several modest earthquakes generated surprisingly large tsunamis without any significant transoceanic tsunami. A number of studies investigated these local tsunami events and concluded that submarine landslides were to blame. It seems timely that Pacific Island Nations investigate the nature and location of submarine landslides and unstable slopes. The Pacific Island Countries (PICs) which constitute the USP region are of four principal types: (1) Islands located over active subduction zones (Solomon Islands, Tonga and Vanuatu); (2) High volcanic Islands which formed over thermal plumes (Cook Islands, Western Samoa); (3) Atolls which formed over long extinct and subsided seamounts (Kiribati, Marshall Islands, Nauru, Niue, Tokelau, Tuvalu); (4) Islands located over an extinct subduction zone (Fiji). Each one of these settings is prone to different types of slope instability but all have in common that submarine landslides are frequent and often predictably occurring at certain sites e.g., fault zones, river mouths, gas hydrate fields. Submarine landslides are often retrogressive hence identifying their location is important.
For the purpose of this paper the location of submarine landslides will be compiled from available bathymetric data and published reports. Known landslide generated tsunamis in the PICs of the USP region will be reviewed and a compilation of various causes and triggering mechanisms deemed responsible for slope instability and failure in the four different island settings will be evaluated.

Poster session / 4

Quaternary mass-transport deposits on the north-eastern Alboran seamounts (SW Mediterranean Sea)

Author: Prof. ALONSO, Belen [1]

Co-Authors: ERCILLA, G. [2]; GARCIA, M. [3]; VÁZQUEZ, J. T. [4]; JUAN, C. [2]; CASAS, D. [5]; ESTRADA, F. [2]; D´ACREMONT, E. [6]; GORINI, Ch. [6]; EL MOUMNI, B. [7]; FARRAN, M. [2]

[1] *ICM-CSIC, Barcelona Spain*

[2] *Instituto de Ciencias del Mar, CSIC, Barcelona, Spain*

[3] *CSIC-Universidad de Granada, Granada, Spain*

[4] *Instituto Espanol de Oceanografía, Centro de Málaga, Spain*

[5] *Instituto Geol´ogico Minero de Espa˜na, Madrid, Spain*

[6] *UPMC Univ. Paris 06, ISTEP, Paris, France*

[7] *Université Abdelmalek ESSAADI, Tangier, Morocco*

Corresponding Author: belen@icm.csic.es

The Quaternary stratigraphic architecture of seamounts and surrounding deposits in the eastern Alboran Sea reveals at least 53 stacked MTDs in the Pollux Bank, Sabinar Bank (Sabinar Platform and Western Sabinar), Maimonides Ridge, and Adra Ridge. These MTDs are grouped into two types based on their size: small-scale MTDs (length < 5 km and thickness < 18 ms) and large-scale MTDs (length > 5 km and thickness > 18 ms). The study of these deposits has allowed us to define a close relationship between size (thickness-length) and source area gradients. The frequency of MTD events has varied between 40 kyr and 373 kyr throughout the Quaternary (1.8 Ma to present). Correlation between individual MTDs is difficult but could be done for at least one local MTD event between Sabinar Platform and Western Sabinar (Sabinar Bank); in addition, one regional MTD event has been recognized around all of the studied seamounts. These failure events could have been triggered by tectonically controlled seismicity at both regional and local scale.

Poster session / 58

Potential for tsunami generation along the western Great Bahama Bank by submarine slope failures

Author: SCHNYDER, Jara S. D. [1]

Co-Authors: KIRBY, James T. [2]; SHI, Fengyan [2]; TEHRANIRAD, Babak [2]; EBERLI, Gregor P. [1]; MULDER, Thierry [3]; DUCASSOU, Emanuelle [3]; PRINCIPAUD, Mélanie [3]

[1] *Comparative Sedimentology Laboratory, Miami*

[2] *Center for Applied Coastal Research*

[3] *UMR 5805 EPOC*

Corresponding Author: jschnyder@rsmas.miami.edu

Multibeam and seismic data reveal repeated slope failures at various scales along the western slope of Great Bahama Bank. In addition, creeping and incipient slump scars indicate slope instabilities that will lead to large-scale slope failures in the near future. To assess the potential of tsunami generation by these mass movements several tsunami scenarios have been constructed and simulated numerically for the Straits of Florida. They are based on the estimated volume and nature of a potential landslide, and failure scenarios of the known scars and mass transport complexes (MTC).

During the 2010 Carambar cruise four connected scars with widths of 2.0, 2.2, 3.7 and 1.6 km and lengths of 3.0, 1.4, 3.2 and 3.0 km, respectively, were identified. Three tsunami scenarios have been chosen and simulated for the Straits of Florida. The first scenario, Single Slope Failure (SSF), assumes a failure mass volume of 1.18 km3, which corresponds to the largest of the three failure scars. For the second setup, Combined Slope Failure (CSF), we add the extent of the failure scars together (9 km) and assume that the landslides were sliding in a single event. The failure volume was estimated to be 3.42 km3. For the third Major Slope Failure scenario (MSF), a scar length of 80 km, observed south of the MTC, and failure volume of 24 km3 is used. The numerical model is based on the non-hydrostatic wave model NHWAVE developed at the Center for Applied Coastal Research at the University of Delaware.

Results show that for the first Scenario within one minute after the failure event a wave height up to 1 m is generated. For the second Scenario initial wave heights up to 2 m can be expected. A catastrophic release, such as the third Scenario assumes, would generate an initial tsunami wave height of 2.5 m, with a possible major impact on both sides of the Straits. The waves propagate across the Straits of Florida, impacting on the coastline only 15 min after their initial release. Three different terminal velocities for the failure masses were used for the simulations; i.e. 20 m/s, 50 m/s and 100 m/s. Initial wave heights strongly depend on terminal velocity and duration of the landslide. A massive slope failure, such as MSF, with a terminal velocity of 50 m/s and a duration of 2 min could release a wave up to 5.5 m height.

The modeling demonstrates that the generation of tsunamis by slope failure in a tectonically inactive area can cause a potential hazard in the densely populated urban areas of south Florida and the Keys.

Poster session / 55

Characteristics and mechanisms of the submarine landslides off SW Taiwan

Author: Prof. HSU, Shu-Kun [1]

Co-Authors: Mrs. LIN, Shiao-Shan [1]; Dr. YEH, Yi-Ching [2]; Dr. TSAI, Ching-Hui [1]; Dr. CHEN, Song-Chuen [3]

[1] *Department of Earth Sciences, National Central University, Taiwan*

[2] *Taiwan Ocean Research Institute, Taiwan*

[3] *Central Geological Survey, Ministry of Economic Affairs, Taiwan*

Corresponding Author: hsu@ncu.edu.tw

The area off SW Taiwan is situated in an active convergent margin where the Eurasian Plate subducts eastwards beneath the Philippine Sea Plate. Because of the collision of the Luzon Arc (situated on the Philippine Sea Plate) against the Eurasian Plate margin, the area off SW Taiwan is also in an initial stage of orogeny. On the other hand, the area off SW Taiwan has a wide distribution of BSR (Bottom Simulating Reflector) indicating a high potential area of gas hydrate reservoir. Because of above two factors, submarine mud volcanoes, mud diapirs, pockamrks and gas seepages are widely distributed off SW Taiwan. As shown by the gas plumes (or gas "flares") from 38 kHz echo sounder above some mud volcanoes, the gas emissions in the area off SW Taiwan are quite active. In consequence, several submarine landslides can be triggered. To understand the characteristics and mechanisms of the submarine landslides, we have compiled the distributions of the mud diapirs, mud volcanoes, gas seep sites and gas plumes locations. We have also conducted several multi-channel seismic reflection profilers across the continental margins. We also use multi-beam bathymetric data.

We find that the submarine landslides generally occur along two main traces. The first trace is near continental break. The scales of those submarine landslides are general small. The submarine landslides are due to gravity instability near the continental break. Thus, the mass slumping is observed. Marked by the distribution of gas seeps, the second trace is near the bathymetric contour of 500 m. This water depth is close to the possible gas hydrate dissociation depth (pressure). A distinctive seafloor subsidence or faulting is present along this trace. This trace can be further separate into western and eastern portions. In the western portion, the mud volcanoes and gas plumes are not so active. Thus, clear failure surface in the seabed and displaced masses can be clearly observed. In contrast, in the eastern portion, the submarine mud volcanoes and gas plumes are very active. The gas supply from the free gas could be sufficiently. Clear failure surfaces can be observed only in the deeper part. However, the mass transport deposit (MTD) can be found at the feet of the active mud volcanoes. In our study area, the development of the submarine canyons is related to the occurrence of the mud diapirs. The channels of the submarine canyons have cut the continental slopes and also provide the lateral boundaries of the submarine landslides.

Poster session / 54

Morphostratigraphy of nearshore shallow-water submarine mass-movements in the Charlevoix area, Middle St. Lawrence Estuary (Eastern Canada)

Author: JOYAL, Gabriel [1]

Co-Authors: Prof. LAJEUNESSE, Patrick [1]; Prof. LOCAT, Jacques [2]; TURMEL, Dominique [2]

[1] *Laval University and Centre for Northern Studies (CEN)*

[2] *Laval University*

Corresponding Author: gabriel.joyal.1@ulaval.ca

In the past few years, a number of terrestrial and submarine surveys undertaken along the north shore of the St. Lawrence Estuary (eastern Canada) have led to a better understanding of underwater mass movements failure mechanisms, their terrestrial extent, their probability of occurrence and their chronology (e.g., Cauchon-Voyer et al., 2008, 2011, Locat et al., 2012). Here we present a compilation of multibeam and seismic data collected during cruises on board R/V Coriolis II in 2011 and R/V Louis-Edmond-Hamelin in 2012 in the Charlevoix region (Middle St. Lawrence Estuary) in order to describe the geomorphology and extent of nearshore submarine mass movements. These results are of great significance in this region because of transport infrastructures and communities built in the coastal zone (Locat et al., 2012). The mapped sectors, Cap-au-Corbeau and St-Irénée, are located in Charlevoix-Kamouraska seismic zone (CKSZ), the most active seismic zone in eastern Canada (Lamontagne, 1987). This region is also locally covered with a thick Quaternary sedimentary sequence (Praeg et al., 1992) that can potentially fail during important seismic events.

Here, we present results from a swath bathymetry survey using a multibeam echosounder (Reson Seabat 8101, 250 kHz) and an interferometric bathymetric sonar (GeoAcoustic GeoSwath, 250kHz) as well as results from a seismic survey using sparkers (Applied Acoustics Squid 2000; Locat et al., 2011). These data allow the mapping of the surface morphology and internal structures of a shallow water (<70 m water depth) landslide complex (Joyal and Lajeunesse, 2013; Turmel and Locat, 2013).

The Cap-au-Corbeau sector consists of three coalescent mass wasting systems that cover an area of <1 km2 and has a 1 km long crown, with a maximal offshore extent of <750 m. Translated block up to 240 000 m3 induced compression ridges in the outer part of the landslides. Above the easternmost headwall scarp (<1-8 m WD), we mapped a 180-m wide and 80-m long oval-shaped bathymetric depression that could be representative of an active landslide. This depression is up to 6 m deep and is located at less than 80 m from the coastline. Terrestrial field observations have shown evidences soil lowering in the sedimentary units located directly onshore the bathymetric depression.

In the St-Irénée sector, four distinct mass movement lobes ranging from 0.8 km2 to 5.2 km2 were identified. The surface and subsurface morphology of these landslides indicate that the westernmost lobes were formed by retrogressive landslides and the easternmost lobes were formed by translated outrunner blocks that have spread downslope along a 300 to 500 m path on a well-defined and almost horizontal basal shear surface. The translated block also produced in this sector a thick pressure ridges zone characterized by fold and thrust. The distance between the headwall scar and the coastline varies between 80 and 460 m. In this sector we did not identified evidence for interactions between terrestrial and submarine sections of mass movements since the coastline is essentially rocky.

These results demonstrate that, in the Cap-au-Corbeau sector, the upper depression could be a second phase of mass movement that occurred in a larger and older mass movement complex or an evidence for recent landslide activity. In the St-Irénée sector, larger submarine mass movement lobes are either 1) located near the coastline, but in area of rocky coastal environment, or 2) located relatively far enough offshore to reduce potential hazards onshore. Nevertheless, as we know that the farthest headwall scars are located near the sedimentary coastline, constant monitoring and surveying need to be undertaken in order to detect eventual signs of retrogression.

The identification of potential links between the onshore and offshore part of a landslide is of great

importance in hazards management for coastal transportation facilities. Subsidence in the nearshore zone might be a key in understanding the post-failure behavior of landslides in this type of environment. Future work is needed to assess the internal morphology of the shallowest part of the landslide using high resolution seismic data. These data are the key to interpreting the processes that drive coastal lowering in this sector and could allow deciphering whether the formation of the nearshore bathymetric depression is due to sediment settlement, rotational slumping or landslide retrogression.

Finally, we consider that better integrated knowledge from terrestrial and submarine morphology is needed in this specific research field to precisely assess natural hazards associated to the onshore extent of submarine mass movements. Combined LiDAR and multibeam bathymetry mounted on a very shallow water (<1 m) research vessel would provide valuable data for identifying areas of either slow or rapid coastal lowering and sediment transport dynamics along the coast.

References cited

Cauchon-Voyer, G., Locat, J., St-Onge, G., 2008. Late-Quaternary morpho-sedimentology and submarine mass movements of the Betsiamites area, Lower St. Lawrence Estuary, Quebec, Canada. Marine Geology 251, 233–252.

Cauchon-Voyer, G., Locat, J., Leroueil, S., St-Onge, G., Demers, D., 2011. Large-scale subaerial and submarine Holocene and recent mass movements in the Betsiamites area, Quebec, Canada. Engineering Geology 121, 28–45.

Joyal, G., Lajeunesse, P. 2013. Projet Charlevoix : Glissements côtiers sous-marins de Charlevoix ouest : Cap-au-Corbeau, St-Joseph-de-la-Rive et St-Irénée, Rapport LERN-Charlevoix-13-01, 26 p.

Lamontagne, M., 1987. Seismic activity and structural features in the Charlevoix region, Quebec. Canadian Journal of Earth Sciences 24, 2118–2129.

Locat, J., Terhzaz, L., Turmel, D., Lajeunesse, P., Mucci, A., Pelletier, É., St-Onge, G. 2011. Rapport de mission COR1103 – Fjord du Saguenay et estuaire du Saint-Laurent, May 24th to June 2nd 2011.

Locat, J., Turmel, D., Noël, F., Amiguet, C., Lajeunesse, P., St-Onge, G., Terhzaz, L., 2012. Exploring the contrasting signatures of submarine landslides along the North Channel of the St. Lawrence Middle Estuary (Charlevoix), Québec, Canada. In Eberhardt et al. (eds.) Landslides and Engineered Slopes : Protecting Society through Improved Understanding, Taylor & Francis Group, London, 1077–1083.

Praeg, D., D'Anglejan, B., Syvitski, J.P.M., 1992. Seismostratigraphy of the Middle St. Lawrence Esturary: A Late Quaternary Glacial Marine to Estuarine Depositional/Erosional Record. Géographie physique et Quaternaire 46, 133–150.

Turmel, D., Locat, J., 2013, Projet Charlevoix : Rapport sur les données de sismique marine, Rapport LERN-Charlevoix-13-02, 28p.

Poster session / 57

On the origin of submarine mass movements on the continental slope offshore Lofoten, northern Norway - a multi-disciplinary approach

Authors: Mrs. BAETEN, Nicole Jeanne [1]; Dr. LABERG, Jan Sverre [1]

Co-Authors: FORWICK, Matthias [1]; VORREN, Tore O. [1]; VANNESTE, Maarten [2]; FORSBERG, Carl Fredrik [2]; KVALSTAD, Tore J. [2]; HAFLIDASON, Haflidi [3]

[1] *Department of Geology, University of Tromsø, Norway*

[2] *NGI, Norway*

[3] *University of Bergen, Norway*

Corresponding Author: nicolebaeten@gmail.com

Different styles of smaller-scale mass movements characterise the continental slope offshore Lofoten, northern Norway. We use a multi-disciplinary approach to evaluate their origin as well as the present-day stability of the area, by combining morphological, sedimentological, geotechnical and geophysical data, complemented with slope stability modelling. The mass movements occur in water depths between 1100 and 2500 m and have volumes of 0.06-8.7 cubic kilometers. The instabilities are interpreted as translational slides involving spreading and multi-phase retrogression and have glide planes between 12.5-130 mbsf. Data from a sediment core shows that the shallowest style of mass movement (12.5 mbsf) was initiated within contouritic sediments characterized by high sensitivities and water contents. These sediments overlie a plumite interval characterized by dilative behaviour with pore pressure decrease with increasing shear strain and high undrained shear strength. The interface between these units acted as the basal glide plane, with deformation of the overlying sediments during slab spreading. Numerical modelling shows that the present-day continental slope is essentially stable, and allows reconstruction of the instability process initiated by an external trigger. The mass movement are probably triggered by undercutting and removal of support at the foot of the slope due to larger-scale mass movements that have occurred immediately south of the study area, including the Trænadjupet or Nyk Slides.

Poster session / 56

Mass-transported deposit deduced from the benthic foraminifera stratigraphy at Site U1413: IODP Exp. 344 (CRISP2), Costa Rica subduction margin

Author: Ms. UCHIMURA, Hitomi [1]

Co-Authors: Prof. HASEGAWA, Shiro [2]; Dr. YAMAMOTO, Yuzuru [3]

[1] *Student*

[2] *Kumamoto University*

[3] *IFREE, JAMSTEC*

Corresponding Author: h.uchimura.foram@gmail.com

IODP Exp.344 (Costa Rica Seismogenesis Project: CRISP 2) is designed to understand the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones and drilled five sites off the western coast of Costa Rica around the southern end of the Middle America Trench, where the oceanic Cocos Plate is subsiding beneath the Carrbbean Plate.
Main objective of this study in the Site U1413 is to understand the tectonic-induced submergence/ uplifting history or paleoslope instabilities in the upper slope area. Benthic foraminifera (BF) are a useful tool to estimate the past bottom-ocean environment. Based on benthic foraminiferal biostratigraphy of U1413, we have recognized the following four biozones for the sequence of past 2 million years and identified plausible slump mass came from the shallower-water environment:

Zone I: Hole C, Cores 42R-18R
- Characterized by dominant Uvigerina peregrina and Gyloidina altiformis, which are accompanied by Nonion sp. A (Group A)

Zone II: Hole C, Cores 14R-2R, Hole A, Core 25X-18X
- Dominated by Epistominella smithi, and accompanied by Chilostomella oolina (Group B)

ZoneⅢ: Hole A, Cores 17H-11H
- Characterized by Brizalina spp. (Group C)

Zone Ⅳ: Hole A, Core10H-1H
- Characterized by Angulogerina angulosa, Cassidulina tumida, and Uvigerina excellence (Group D)

The BF divided into Group A (Zone I) is distributed on the lower continental slope in the modern equatorial Pacific. (Smith, 1963, 1964). Group B in Zone II is reported mainly from the lower to middle slope environment of the Pacific. Group C in Zone Ⅲ is estimated to be distributed in the upper slope. Group D in Zone Ⅳ lives in the upper to middle slope as well as the drill site.
On the other hand, some shelf species such as Brizalina bicostata, Cibicorbis inflatus and Uvigerina incilis (Group E) occur throughout the sequence of the hole. Those species are, however, considered to be reworked specimens from shallower environment, because they co-occurred with deeper water species as Groups A to D, and because a similar occurrence has been reported in the Peru-Chile Trench area by Ingle and Kolpack (1980).
In Zone III, another species group composed of Brizalina spp., (Group C), which is distributed mainly in the upper slope areas in the modern oceans. Because Group C is not accompanied by Group D or other deeper-water species, the interval of Cores 17H-11H in Hole A apparently correspond to the upper continental slope, at least shallower than the depth of Group D. Also, the tests of Brizalina spp. are well-preserved in contrast to the co-occurred Group E. These results imply that Zone III is allocated Mass transported sediments, like a slump. This interpretation has been also supported by geochemical and logging data. The slump mass has been inferred at the interval between 45-150 mbsf based on the irregular profiles for organic matters and a fold structure plausibly formed by slumping. The slump mass might reflects the active subsidence due to tectonic erosion or passage of subducting seamount at the plate interface.

Smith, P., 1963, Geological survey professional paper, 429-A
Smith, P., 1964, Geological survey professional paper, 429-B
Ingle and Kolpack, 1980, micropaleontology, vol. 26, no.2, pp. 113-150, pls. 1-9
Expedition 344 Scientists, 2013. Costa Rica Seismogenesis Project, Program A Stage 2 (CRISP-A2): sampling and quantifying lithologic inputs and fluid inputs and outputs of the seismogenic zone. IODP Prel. Rept., 344. doi:10.2204/iodp.pr.344.2013

Poster session / 53

Submarine landslides on the Crary Trough Mouth Fan, Antarctica.

Author: Ms. GALES, Jenny [1]

Co-Authors: Dr. LEAT, Phil [2]; Dr. LARTER, Rob [2]; Dr. HILLENBRAND, Claus-Dieter [2]; Dr. KUHN, Gerhard [3]; Prof. JOKAT, Wilfried [3]; Mr. LONG, David [1]

[1] *British Geological Survey*

[2] *British Antarctic Survey*

[3] *Alfred Wegener Institute*

Corresponding Author: jgales@bgs.ac.uk

New multibeam bathymetric data from the southeastern Weddell Sea reveal three large-scale submarine slides on the upper slope of the Crary Fan, a trough mouth fan offshore from the glacially carved Filchner Trough. All slides head at the shelf edge (~500 m water depth), with the largest slide measuring 20 km wide and with an incision depth of 60 m. Multibeam and seismic data show elongate slide blocks on the seafloor surface of the mid-slope. The lack of a discernible sedimentary cover suggests that they were generated after the Last Glacial Maximum (LGM). This is unusual because post-LGM submarine slides are very rare on the Antarctic continental margin, and to our knowledge, no other Late Quaternary slides have been documented on an Antarctic trough mouth fan. This contrasts many other previously glaciated high-latitude continental margins, where submarine landslides are common. The large-scale differences in landslide occurrence between the Crary Fan and other Antarctic margins suggest a significant variation in slope and sedimentary processes, environmental characteristics and/or glacial dynamics between these regions. We speculate that weaker, unconsolidated sedimentary layers within the subsurface are important for slide initiation here.

Poster session / 52

Characteristics and distribution of submarine canyon-related landslides in Shenhu area, northern South China Sea margin

Author: Mr. KUANG, Zenggui [1]

Co-Authors: Prof. WANG, Liaoliang [1]; Prof. GUO, Yiqun [1]

[1] *Guangzhou marine geological survey, China*

Corresponding Author: kzg21001@163.com

High-resolution 2-D multichannel seismic data, combined with high-precision multibeam bathymetric relief map, were utilized to investigate the characteristics and distribution of submarine landslides in Shenhu area in the upper slope of northern South China Sea (SCS) margin. In the region, a set of submarine canyons are developed. The canyons are 2-4 km apart, and are separated by sedimentary ridges. Water depth ranges from 400 to 1500 m. Regional slope is about 2 degree in average.

Numerous submarine landslides are developed. On seismic profiles, the landslides are easily differentiated from the normal sedimentary layers by their deformed and/or chaotic reflections. They are bounded by head scars and basal gliding planes. Within the landslides, faults and folds are common. Totally 75 landslides were defined, including 56 slumps and 19 two- or multi-stage landslide complexes. The geomorphological parameters of the submarine landslides, including their area, volume, runout distance, headscarp height, headscarp gradient and landslide slope gradient were measured. Statistics suggested that the slandlides are generally 5-40 km2 in area, and runout distance of the landslides is usually less than 5-6 km. Most landslides are developed on slopes of 4 to 8 degrees in gradient. The landslides are majorly distributed in the head regions or on the walls of the canyons.

It is obviously that the generation of the submarine landslides is related with the canyons. It is suggested that increase of local slope gradient resulting from the headward erosion and/or downward incision of the canyons is responsible for the development of the submarine landslides.

Poster session / 114

New Imaging Of Submarine Landslides From The 1964 Earthquake Near Whittier, Alaska, And A Comparison To Failures In Other Alaskan Fjords

Author: Dr. HAEUSSLER, Peter [1]

Co-Authors: PARSONS, Tom; FINLAYSON, David P. [1]; HART, Pat [1]; Dr. CHAYTOR, Jason [1]; RYAN, Holly [1]; LEE, Homa [1]; LABAY, Keith [1]; PETERSON, Andrew [1]; LIBERTY, Lee [1]

[1] *USGS*

Corresponding Author: pheuslr@usgs.gov

The 1964 Alaska Mw9.2 earthquake triggered numerous submarine slope failures in fjords of southern Alaska. These failures generated local tsunamis, such as at Whittier, where they inundated the town within 4 minutes of the beginning of shaking. Run-up was up to 32 m, with 13 casualties. We collected new multibeam bathymetry and high-resolution sparker seismic data in Passage Canal, and we examined bathymetry changes before and after the earthquake. The data reveal the debris flow deposit from the 1964 landslides, which covers the western 5 km of the fjord bottom. Individual blocks in the flow are up to 145-m wide and 25-m tall. Bathymetry changes show the mass transfer deposits originated from the fjord head and Whittier Creek deltas and had a volume of about 42 million m3. The 1964 deposit has an average thickness of ~5.4 m. Beyond the debris flow, the failures likely deposited a ~4.6-m thick megaturbidite in a distal basin. We have studied the 1964 submarine landslides in three fjords. All involved failure of the fjord-head delta. All failures eroded basin-floor sediments and incorporated them as they travelled. All the failures deposited blocks, but their size and travel distances varied greatly. We find a correlation between maximum block size and maximum tsunami run-up regardless of the volume of the slides. Lastly, the fjord's margins were influenced by increased supply of glacial sediments during the little ice age, which along with a long interseismic interval (~900 yrs) may have caused the 1964 earthquake to produce particularly numerous and large submarine landslides.

Poster session / 88

Earthquake-triggered onshore mass movements cause widespread deformation of basin-plain sediments and multidirectional, stacked turbidites and debrites (Aysén fjord, Chilean Patagonia)

Author: Dr. VAN DAELE, Maarten [1]

Co-Authors: Prof. CNUDDE, Veerle [2]; Prof. DUYCK, Philippe [3]; Prof. PINO, Mario [4]; Prof. URRUTIA, Roberto [5]; Prof. DE BATIST, Marc [6]

[1] *Renard Centre of Marine Geology, Ghent University*

[2] *Department of Geology and Soil Science, Ghent University*

[3] *Department of Radiology and Medical Imaging, Ghent University Hospital*

[4] *Instituto de Geociencias, Universidad Austral de Chile (Valdivia)*

[5] *Centro EULA, Universidad de Concepción*

[6] *Renard Centre of Marine Geology (RCMG), Department of Geology and Soil Science, Ghent University*

Corresponding Author: maarten.vandaele@ugent.be

The 2007 Mw 6.2 earthquake in Aysén fjord caused not only onshore mass movements, but also widespread basin-plain deformation and density-flows. Deformed basin-plain deposits are mapped using multibeam bathymetry and seismic-reflection (sparker) profiling. To better understand the facies successions in, and the intercalation of, the (distal) density-flow deposits, we also studied the 2007 deposits in 22 short sediment cores by combining grain-size analysis with X-ray computed tomography (CT) scanning. Deformed basin-plain deposits can be divided in frontally emergent and confined deposits, with both a deep and shallow basal shear surface. All deformed basin-plain deposits with a deep basal shear surface are induced by the weight and impact of a slope-adjacent mass-flow wedge. The frontally emergent –most mobile– basin-plain deformation is triggered by mass flows originating from onshore mass movements (i.e. debris flows, rock slides and avalanches) propagating into the fjord. The encountered facies in the sediment cores correspond to classical divisions of debrites and turbidites. The deposits consist of a succession of several sub-deposits deposited under different flow directions and can be interpreted as stacked turbidites. We used orientations of i) folds, ii) imbricated mud clasts, iii) back- and foresets of climbing ripples and iv) asymmetric convolute lamination, to determine relative flow directions at the location of the cores. By assigning the basal flow of the stacked debrites and turbidites to the closest principal mass-flow, the absolute flow directions of the sub-deposits were determined, which, in combination with multibeam basin-floor morphology, allowed reconstruction of the 2007 density-flow successions in Aysén fjord. We conclude that X-ray CT scans provide crucial information for reconstructing paleoflows and can be a useful tool in marine and lacustrine sedimentology and paleoseismology. The multidirectionality of sub-deposits in turbidites is, next to differences in mineralogy, a new criterion to identify stacked turbidites. These multidirectional, stacked turbidites are an indication of simultaneous triggering of density flows and can therefore in most cases be attributed to earthquakes, ruling out other triggers, such as floods, storms or other sediment failures. Similar event deposits (with both basin-plain deformation and distal turbidites) are encountered in the sedimentary infill of the fjord. We hypothesize that during the Holocene three to four similar events have struck Aysén fjord.

Poster session / 89

Dynamics of Submarine Landslides in an Active Margin from Analysis of Particle Size, 3D Seismic, and Logs: IODP Expedition 338, Nankai Trough, offshore Japan

Author: Mr. MOORE, Zachary [1]

Co-Author: Prof. SAWYER, Derek [2]

[1] *University of Kentucky Earth and Environmental Sciences*

[2] *University of Kentucky*

Corresponding Author: zac1525@gmail.com

The deposits of two submarine landslides were cored at Site C0021B in the Nankai Trough during Integrated Ocean Drilling Program (IODP) Expedition 338. Mass transport deposits (MTDs) are identified at 94-117 meters below seafloor (mbsf) and 133-176 mbsf by decreased porosity, tilted bedding, and semi-transparent seismic facies. Grain size analyses documented that sediment samples from 0-194 mbsf consist of two distinct lithologies: sediments from 0 - 155 mbsf are composed of approximately > 75% silt-sized, 15% clay-sized, and 5% sand-sized particles. Sediments between 155 - 194 mbsf have increased sand content (approximately 65% silt-sized, 15% clay-sized, and 20% sand-sized particles). The shallow MTD is composed of silt, while the deeper MTD is comprised of two zones: (1) silt from 133 - 155 mbsf and (2) sandy-silt from 155 – 176 mbsf. We are conducting a detailed 3D seismic and core-log correlation of MTDs to characterize slope geometry and deposit morphology of the failures. We use slope geometry, runout distance, and deposit morphology to address whether the slope failure was a relatively rapid-moving, low-viscosity failure or relatively slow-moving, high-viscosity failure. Preliminary results from seismic data indicate that MTDs are thick, blocky, and relatively viscous flows. However, given the high silt and sand content especially with high seismicity in the region, we would assume a landslide would have a high velocity, low viscosity behavior. One potential mechanism to explain this observation is seismic strengthening in which repeated shaking from non-failure earthquakes progressively dewater and thus strengthen the sediment and increase slope stability. Understanding the dynamics of failures is integral in evaluating slide-induced tsunami amplitude and landslide effects on subsea infrastructures

Poster session / 110

Preliminary investigations of rheological properties of Busan clays and possible implications for debris flow modelling

JEONG, SuengWon [1]

[1] *Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea*

Corresponding Author: swjeong@kigam.re.kr

To investigate the post-failure dynamics of subaerial and subaqueous landslides in various environments, we need a detailed analysis of the geotechnical and rheological behaviour of fine-grained sediments. For fine-grained sediments found in the subaerial and subaqueous environments, rheological research should be conducted as a prelude to understanding flow behaviour and hazard assessment. In this paper, the rheological characteristics of Busan clays from the Nakdong deltaic plain are examined in a shear rate-controlled system. A comparison is made between the Busan clays and low-activity clays in terms of rheometer geometry. Flow curves obtained from the controlled shear rate and the shear stress mode are examined. The viscosity and yield stresses obtained from different geometries, which may produce wall-slip among cylinder, ball-measuring and vane-measuring systems, are highlighted. Based on the relationship between the liquidity index and rheological values (viscosity and yield stress), flow motions are compared. Results show that the differences in mobility are significant when assuming that the flowing materials behave as a Bingham fluid. The runout distance is controlled by the yield stress of fine-grained sediments. Differences in yield stress may be caused by wall roughness and the distance between the ball (vane) and the wall in the rheometer. Under the same geomorphological conditions, the runout distance calculated from vane-measuring systems is much lower than that from ball-measuring and cylinderic systems. These difficulties must be minimized to predict debris flow mobility and to correctly perform hazard risk assessment.

Poster session / 113

How Stable Is the Nice Slope? – An Analysis Based on Strength and Cohesion from Ring Shear Experiments

Author: STEGMANN, Sylvia [1]

Co-Author: KOPF, Achim [1]

[1] *MARUM – Center for Marine Environmental Sciences, Marine Geotechnics, University of Bremen, Germany*

Corresponding Author: akopf@uni-bremen.de

The upper shelf of the landslide-prone Ligurian Margin (Western Mediterranean Sea) off Nice well-known for the 1979 Airport Landslide is a natural laboratory to study preconditioning factors and trigger mechanisms for submarine landslides. For this study low-stress ring shear experiments have been carried out on a variety of sediments from >50 gravity cores to characterise the velocity-dependent frictional behaviour. Mean values of the peak coefficient of friction vary from 0.46 for clay-dominated samples (53 % clay, 46 % silt, 1 %) sand up to 0.76 for coarse-grained sediments (26 % clay, 57 % silt, 17 % sand). The majority of the sediments tested show velocity strengthening regardless of the grain size distribution. For clayey sediments the peak and residual cohesive strength increases with increasing normal stress, with values from 1.3 to 10.6 kPa and up to 25 % of all strength supported by cohesive forces in the shallowmost samples. A pseudo-static slope stability analysis reveals that the different lithologies (even clay-rich material with clay content≥50 %) tested are stable up to slope angles <26° under quasi-drained conditions.

Poster session / 82

Geo-Hazard Types along the Deep Section of the Submarine Pipeline Route in the Liwan 3-1 Gas Field

Author: Dr. LIU, Lejun [1]

Co-Authors: Mr. LI, Jiagang [2]; Dr. LI, Xishuang [1]; Dr. SU, Tianyun [1]; Ms. XU, Xiaoqing [1]; Ms. GAO, Shan [1]

[1] *The First Institute of Oceanography, SOA*

[2] *Research Center of China National Offshore Oil Corporation*

Corresponding Author: liulj@fio.org.cn

Based on the data from the multi-beam bathymetric survey, the sub-bottom profiling and the high-resolution multi-channel seismic exploration carried out in the Liwan 3-1 Gas Field, the first deep-water gas field in China, the geo-hazard types that have been identified along the deep section of the submarine pipeline route in the area studied include submarine canyons, seafloor landslides and collapses, paleo-coral reefs, seafloor sand waves and mega-ripples, shallow faults, submarine scarps, bluff and abrupt slope, debris flow deposits and turbidity current deposits. Of them, the seafloor landslides and collapses are well developed on the upper continental slope and the wall of submarine canyons, and the paleo-coral reefs, the submarine canyons, and the seafloor landslides and collapses are the potential geological risk factors for the layout and safe operation of the submarine pipeline.

Poster session / 83

Catalogue of mass movement deposits in Lake Geneva during the last ~ 4000 years

Author: KREMER, Katrina [1]

Co-Author: Dr. GIRARDCLOS, Stéphanie [2]

[1] *Earth and Environmental Sciences, University of Geneva*

[2] *Earth and Environmental sciences, University of Geneva*

Corresponding Author: katrina.kremer@unige.ch

Similarly to steep oceanic continental margins, lake slopes can collapse, producing large sublacustrine landslides and tsunamis. Lake sediments are excellent natural archives of such mass movements and their studies allow the reconstruction of these events on historic and prehistoric timescales.
In Lake Geneva (central basin, called 'Grand-lac'), more than 100 km of high-resolution seismic reflection profiles reveal the ~ 30 upper meters of late Holocene sedimentation history divided into two sequences: (a) The upper 5 m thick sequence, characterized by parallel, continuous and high-amplitude reflections intercalated with transparent horizons, is interpreted as hemipelagic sediments interbedded with turbiditic deposits due to floods, forming the 'background' lake sediments. (b) The lower 25 m thick sequence consists of large mass movement units characterized by lense-shaped, transparent to chaotic seismic facies with irregular lower boundaries. These chaotic seismic units alternate with decimeter-scale intervals of "background" seismic facies identified in the upper sequence.
14C dating of one distal 12-m-long sediment core reveals that the mass movements deposited between 3690 and 1342 cal BP.
The Grand-Lac mass movement's catalogue reveals units/deposits with varied size, distribution and facies which lead to different interpretations of deposition and trigger processes. Among them, two outstanding and contrasted deposits point to different causes:
- The largest event deposit in this sequence is a 6 m-thick bed, with thinning upwards granulometry and an erosive base that covers the entire deep basin with a minimum volume of 0.25 km3. This layer can be associated with the Tauredunum rockfall event of 563 AD (1342 cal BP; Kremer et al., 2012). This historical event is known because of large human and material loss in the Rhone valley and in the old city of Geneva due to a tsunami.
- The oldest mass movement imaged in our seismic sequence, is situated on the same horizon than (at least) one large mass movement offshore Thonon and is dated at 3690 cal BP. Its scar lies at >100 m water depth and thus was probably caused by an earthquake. Numeric modeling indicates that this mass movement was likely tsunamigenic and may be linked to an occupation gap of pile dwellers living on the lake's shores (Kremer et al., in review).
Overall, this catalogue shows that mass movement events occurred at least 6 times over ~ 2400 years and that at least two of them were large enough to induce high tsunami waves over the lake.

This project is funded by the Swiss National Fund nr. 200021-121666

References

Kremer K., Simpson G., Girardclos S. (2012), Giant Lake Geneva tsunami in AD 563, Nature Geoscience 5, 756-757.

Kremer K., Marillier F., Hilbe M., Simpson G., Dupuy D., Yrro B., Rachoud-Schneider A.-M., Corboud P., Bellwald B., Wildi W., Girardclos S., Pile dwellers occupation gap in Lake Geneva (France-Switzerland) possibly explained by an earthquake – slide – tsunami event during Early Bronze Age, in review at EPSL.

Poster session / 80

Submarine Mass Movements in the Law of the Sea

Author: Dr. MOSHER, David [1]

Co-Authors: Dr. LABERG, Jan Sverre [2]; Dr. MURPHY, Alain [3]

[1] *Natural Resources Canada*

[2] *University of Tromso*

[3] *GeoLimits Consulting, 41 Condor Rd., Bedford, Nova Scotia, Canada*

Corresponding Author: dmosher@nrcan.gc.ca

Article 76 of the United Nations Convention on the Law of the Sea delineates a number of approaches that a nation may employ to determine its' outer jurisdictional limits beyond 200 nautical miles. In these scenarios, the "foot of the continental slope" is a critical metric. Article 76 defines the "foot of the continental slope" rather vaguely: "In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient at its base". Geomorphologic complexity or low gradients (<1°) of continental slopes rarely permits a ready determination of the maximum change in gradient; particularly at a position that a geologist might qualitatively recognize as the base-of-slope zone. Recognizing that submarine mass movement is a slope process that also influences the shape of the continental margin, several nations have successfully argued that the downslope termination of MTD's assist in distinguishing the continental slope from the rise and abyssal plain. Over segments of their margins, countries such as Ireland, Norway, New Zealand, French Guyana and Canada identified the extent of surficial MTD's to help delineate the base of slope zone within which the foot of the continental slope is chosen. From the foot of the continental slope, a country may measure 60 nautical miles outboard to determine its' outer jurisdictional limit, or it may measure outboard to a point where sediment thickness is 1% of the distance from the foot-of-slope; whichever is greater. The outer limit cannot exceed 350 nautical miles from the baseline (its legally defined coast) or 100 nautical miles from the 2500 m isobath.

Poster session / 87

Detection of seismic anisotropy using ocean bottom seismometers: a case study from the accretionary prism off southwest Taiwan

Author: Prof. CHENG, Win Bin [1]

Co-Authors: Prof. HSU, Shu-Kun Hsu [2]; Prof. DONG, Jia-Jyun [3]; Dr. LIN, Jing-Yi [4]

[1] *Jinwen University of Science and Technology*

[2] *Department of Earth Sciences, National Central University, Taiwan*

[3] *National Central University, Graduate Institute of Applied Geology*

[4] *National Central University*

Corresponding Author: wbin@just.edu.tw

A multicomponent ocean-bottom seismometer data set was collected by National Central University, Taiwan in the accreationary prism off southwestern Taiwan in April 2013. The OBS contains four component receivers, including a three component 4.5 Hz geophone unit containing three orthogonal components and a hydrophone. GI-gun shots located at 1 mile radius from the OBS, with spacing approximately 40 m along the sail line. The OBS recorded data at a sampling rate of 250 Hz and from a shot pattern that gave good azimuthal coverage around the OBS. Based on P and P-S converted waves recorded between the direct and multiple arrivals, this experiment targeted the top few hundred meters of sediment in the study area. Synthetic seismograms were calculated from a model representative of the sediment sequence at this site indicating that converted amplitudes are dominated by P to S mode-converted waves generated on reflection. After preliminary processing, including a static correction, the data were optimally rotated to radial (R) and transverse (T) components. The principal technique used to detect the anisotropy was azimuthal stacking of the radial and transverse horizontal geophone components. The R component shows azimuthal variation of traveltime indicating variation of velocity with azimuth; the corresponding T component shows azimuthal variation of amplitude and phase. From the radial component azimuthal gather and mode-converted wave amplitude variation for the first few layers and determined corresponding anisotropy parameter and Vp/Vs values. We attribute the observed azimuthal anisotropy to the presence of microcracks and grain boundary orientation due to stress since fracture at this depth is not likely to occur.

Poster session / 84

Study of Gas Hydrate Stability

Mr. SUNJAY, SUNJAY [1]

[1] *GEOPHYSICS ,BHU,VARANASI 221005 ,INDIA*

Corresponding Author: sunjay.sunjay@gmail.com

Methane hydrate (white gold) is a crystal fuel which releases 164 unit volume of methane gas from one unit volume of gashydrate.Hydrate dissociation could be critical in inciting slope failures for low permeability sediments in shallower water depths. Since gas hydrates are located on the continental slope and – if present in sufficient amounts – may increase sediment strength, their dissociation possibly influences slope stability. The boundary of the gas hydrate stability zone (GHSZ) can be affected by hydrostatic pore pressure changes due to a sea-level decrease, tectonic uplift, rapid sedimentation or erosion, or changes in sea bottom temperatures. Gas hydrates are linked to large submarine slides, in part because hydrate dissociation results in loss of solid material, production of free gas, and increased fluid pressures; all which have the effect of reducing sediment strength. Gas hydrates and submarine slope stability, exploring the role of gas hydrates in triggering and/or propagating submarine mass movements is pertinent task before geoscientist . Biochemical study reveals the impact on the stability, structure, and gas composition of the gas hydrate .In fact, methanogenesis is indirectly involved in the formation of a highly abundant form of gas hydrates on earth-biogenic methane hydrate. Biochemical reaction and diffusion in seafloor gas hydrate capillaries affects gas hydrate stability. Biochemical reactions occurring within gas hydrate accumulations provide a driving force for diffusion of organic and inorganic components into and out of gas hydrate interior. Study of GHSZ show transport phenomenon can affect gas hydrate stability in multiple ways, depending on the biochemical reactions occurring. Seismic imaging by wavelet transform provides precise causes of slope stability. Gas Authority of India Limited research & development projects on "Slope instability due to gas hydrate dissociation in continental margins of India". The Methane Hydrate monitoring station consists of three types of observing systems: Geochemical, Microbial And Seismo-Acoustic. CeNSE :Central Nervous System for the Earth can be used for our purpose.

Poster session / 85

Blocky Mass Transport Deposit, Argentina

Author: Mr. SOBIESIAK, Matheus Silveira [1]

Co-Authors: Prof. KNELLER, Benjamin [1]; Prof. ALSOP, Ian [1]

[1] *University of Aberdeen*

Corresponding Author: sobiesiak.ms@abdn.ac.uk

Downslope mass movement involves changes in material properties and rheology induced by compactional dewatering and shear strains. The structures and kinematics indicative of these strains are very complex; they have been described in seismic data (e.g. Bull et al., 2009), but equivalent structures may be very difficult to identify in outcrop studies, largely due to the large scale difference.

The study area is the Cerro Bola Anticline, which exposes part of a Carboniferous pericratonic basin located in the western part of Argentina, that was filled with glacially-derived sediment during and immediately after the mid to late Carboniferous glaciations of Gondwana. The mass transport deposit consist of a re-sedimented subaqueous rain-out till. It ranges in thickness between 100-140m and displays considerable variation in texture and structures; it can be subdivided into 3 main zones (lower, middle and upper) (Dykstra et al., 2011; Milana et al., 2010; Fairweather & Kneller, in prep.). The lower zone is characterized by sandstone blocks, interpreted as being derived from the underlying fluvio-deltaic sandstone. The middle zone comprises structureless greenish coloured siltstone with glacial dropstones inherited from the protolith, and rafts of relatively undeformed parent material. The upper zone consists of folded and sheared siltstone. The presence of blocks of the underlying unit within the lower zone of the MTD bears witness to the degree of coupling between the mass flow and the substrate, with deformation extending many metres into the autochthonous material below the obvious lithological contact. Drag across this interface resulted in blocks being plucked from the substrate and incorporated into the mass flow.

Observations were made in the lower zone of MTD where deformation zones around sandstone blocks are visible as sheared sand streaks, folds and faults, which act as strain markers. We compare these deformation zones to quadrant structure that develops around rigid objects in mylonites zones (e.g. Fossen, H. 2010; Hanmer & Passchier 1991). Since the allochthonous sand blocks are more rigid than the main MTD matrix, deformation zones tend to develop all around the blocks, due the differences in rheology, and to the resulting distribution of shear strain around the blocks; an asymmetric distribution of structures is expected over the four quadrants around the blocks. Deformation zones are complex and vary from block to block, depending on their orientation, degree of translation and/or stratigraphic level.

Poster session / 102

Large Diameter Piston Coring for Geotechnical and Geohazard Applications

Authors: MAGAGNOLI, Massimo [1]; ZANOLI, Omar [2]

Co-Author: RAVASCHIO, Paolo [2]

[1] *Carmacoring s.r.l.*

[2] *D'Appolonia S.p.A.*

Corresponding Author: omar.zanoli@dappolonia.it

Carmacoring and D'Appolonia provide an innovative large diameter piston coring system for use in offshore geotechnical and geophysical surveys. The main advantages of the system are 1) easy installation and deployment from a wide range of vessels, 2) excellent recovery of high quality samples using an active piston, 3) variable barrel length (3 to 30 m) 4) no water depth limitations and 5) cores can be used for both geotechnical and geohazard assessment. The system can be deployed to collect long piston cores during conventional geophysical surveys, allowing considerable schedule savings for offshore projects.

This poster discussed the main attributes of the system: characteristics of the Carma Piston Corer system, the track record of the tool in terms of sample recovery and water depths, Angel Descent deployment for reduced disturbance, geotechnical sample quality, and examples of application to both geotechnical and geohazard projects.

Poster session / 103

Timing and implications of mass-wasting processes in the history of Martinique volcanoes: First insights from expedition IODP 340

Author: Ms. BRUNET, Morgane [1]

Co-Authors: Ms. LE FRIANT, Anne [1]; Mr. BOUDON, Georges [1]; EXPEDITION IODP 340 SCIENTISTS, IODP [1]

[1] *Institut de Physique du Globe de Paris*

Corresponding Author: mbrunet@ipgp.fr

Volcanic flank-collapses usually produce voluminous debris avalanches, potentially destructive on land and tsunamigenic as well when they enter the sea. The expedition IODP 340 from 3rd March to 17th April 2012, offshore the Lesser Antilles arc volcanoes, yielded a unique record of the eruptive activity of the most active complexes over the last million years. The first observations of drilled cores revealed that large deposits offshore Martinique previously interpreted as debris avalanche deposits were largely composed of deformed sediments. We are trying to get a complete eruptive history of the northern part of Martinique volcanoes and to better constrain slide processes in time, so that we could highlight the importance of construction versus destruction processes in the volcano evolution. Analyses of deformation structures within drilled cores, re-interpretation of bathymetric and seismic reflexion data and tephrochronologic studies allow to better constrain ages of deposits and replace them into the long-term history of the volcano.

Poster session / 100

Why every dimension matters: Interpretation of volcanic landslide deposits from 3D seismic and time-lapse bathymetric data from offshore Montserrat

Author: Mr. KARSTENS, Jens [1]

Co-Authors: Prof. BERNDT, Christian [2]; Dr. CRUTCHLEY, Gareth J. [3]; Dr. TALLING, Peter J. [4]

[1] *Geomar*

[2] *GEOMAR*

[3] *GNS Science*

[4] *National Oceanography Centre, Southampton*

Corresponding Author: jkarstens@geomar.de

The Soufrière Hills volcano on Montserrat has become one of the closest monitored island arc volcanoes since the onset of the ongoing (1995 - present) eruptive phase, which is characterized by the growth and collapse of andesite lava domes resulting in voluminous pyroclastic flows. In 2010 we acquired the first three-dimensional (3D) seismic dataset covering the submarine deposits of these recent pyroclastic flows, which overlie the remnants of much larger debris avalanches. The 3D seismic data allow a detailed reconstruction of changes in emplacement direction and the concurrent trigger of secondary failure of large amounts of seafloor sediment during the emplacement of a debris avalanche. We show how 3D seismic attributes add important information regarding the internal structure of landslide deposits and the tectonic framework. In combination with repeated bathymetric surveys covering the island's shelf during the progressing emplacement of submarine pyroclastic flows, we are able to show that the pyroclastic deposits from distinct volcanic events are still well preserved and there is no significant basal erosion during the emplacement of submarine pyroclastic deposits on volcanic substrate. The cumulative deposition of pyroclastic deposits accounts for a significant part of the volcanic edifice.

Poster session / 101

Geomorphological and statistical characterization of submarine volcanic centers of Pantelleria Volcano (Italy)

Author: Dr. CALARCO, Marilena [1]

Co-Authors: DI CATERINO, Sara [1]; Prof. CHIOCCI, Francesco Latino [2]

[1] *D'Appolonia S.p.A.*

[2] *Sapienza, University of Rome*

Corresponding Author: marilena.calarco@dappolonia.it

Pantelleria Volcano is well known for its subaerial activity and as the type locality for pantellerite rocks. However, the last eruption (1891) was submarine occurring 5 km W-NW of Pantelleria harbor. Recent high-resolution mapping offshore Pantelleria volcano has revealed a complex seafloor morphology characterized by volcanic features mostly represented by lava flows, volcanic outcrop remnants and several volcanic centers. These centers, located both on the insular shelf and along the flanks (down to 850 m bsl), are mainly concentrated NW of the island.

A geo-morphological analysis of Pantelleria submarine cones was performed. The cones along the flanks were found to range in height up to about 360 m, have basal widths of 0.2-2.3 km, slopes from 21° to 42°, and an average aspect ratio of 0.15. Their volumes vary from 7x10-4 to 0.37 km3. The volcanic centers exhibit a well-preserved morphology and were classified as pointed, elongated, or composite. They are mainly characterized by a single or multi-peak profile rather than displaying craters or flat-topped summits.

It is worth to note that some cones show small-scale summit collapses with a newly reconstructed dome within the scar. Pre-collapse morphologies of these cones were reconstructed and dimensions and volumes were estimated to better understand their growth and failures. The statistical analysis showed a good correlation between cone diameter and height suggesting that the cones evolved self-similarly, in response of analogous constructional and erosional processes. Slope stability was also evaluated and indicated that the cones affected by sector collapses would have been stable in static conditions. It should be noted that the cones affected by collapses result to have had the peak at shallower depths. Therefore, a relationship between summit depth, volcanic activity, and collapse was inferred.

Overall, this study provides for the first time key information on the nature of Pantelleria submarine cones, which represent a significant contribution to the growth of the volcano, and gives new insights to better understand associated instability phenomena.

Poster session / 104

Subaquatic landslides and fluid expulsion features within the sedimentary archive of Lake Neuchâtel, Switzerland

Author: REUSCH, Anna [1]

Co-Authors: Dr. MOERNAUT, Jasper [2]; HILBE, M. [3]; MOSAR, J. [4]; MEINECKE, G. [5]; ANSELMETTI, F. S. [6]; Prof. STRASSER, Michael [7]

[1] *ETH Zürich*

[2] *ETH Zürich, Geological Institute (Sediment Dynamics)*

[3] *Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department of Surface Waters, CH-8600 Dübendorf*

[4] *University of Fribourg, Department of Geosciences, CH-1700 Fribourg*

[5] *Marum, Center for Marine Environmental Sciences, D-28359 Bremen*

[6] *University of Bern, Institute of Geological Sciences and Oeschger Centre for Climate Change Research, CH-3012 Bern*

[7] *ETH Zurich*

Corresponding Author: anna.reusch@erdw.ethz.ch

Subaquatic landslide deposits are important components of the sedimentary infill of lakes. Lakes offer the unique possibility to study subaqueous mass-wasting phenomena, similar to the processes in marine environments, under more accessible and spatially confined conditions. Lake sediments are highly sensitive archives of environmental changes and geological events, such as earthquakes. Previous studies linked subaquatic landslide deposits to historic earthquakes, in the marine, as well as in the lacustrine realm. Synchroneity of multiple mass-transport deposits at different locations within a basin is the main criterion to postulate seismic triggering. Additionally, subaquatic landslide events are often accompanied by fluid expulsion features. In this study, we investigate the sedimentary archive of sublacustrine mass-transport deposits in Lake Neuchâtel, Western Switzerland. We show that sublacustrine slopes failed several times since Late Glacial times and that these multiple landslide events were accompanied by expulsion phases of large-scale pockmarks on the lake floor. Eventually, this project aims to investigate the potential link between sediment remobilization, fluid flow and neotectonic activity.

We present results from an extensive high-resolution reflection seismic and swath bathymetry survey, as well as newly acquired and published sediment-core data. Swath-bathymetry data (Kongsberg EM 2040 multibeam) provide precise high-resolution lake floor morphological data. Dense grids of high-resolution reflection seismic data (3.5 kHz pinger source) are used to image the sedimentary infill of the Lake Neuchâtel basin with decimeter-scale vertical resolution. Additionally, selected morphological features were investigated using ultra-high-resolution lake-floor surface and subsurface imaging tools (sub-bottom profiler [0.6 – 15 kHz Chirp System] and side scan sonar) mounted on an autonomous underwater vehicle (AUV “MARUM SEAL”). This allows for systematic mapping of mass-movement deposits, landslide scars and fluid-seepage structures.

Results of the sediment cores, integrated with seismic data, indicate sequences of interbedded lacustrine background sediment and thin turbiditic deposits, which are intercalated with mass-transport units. Seismic-stratigraphic correlation is used to determine the chronostratigraphic relations between the mass-transport units assigned to seismic-stratigraphic event horizons.

Our data reveal strong evidence for at least two distinct seismic-stratigraphic horizons with multiple, basin-wide subaquatic landslides in the sedimentary record of Lake Neuchâtel. These multiple landslide event horizons are interpreted as the fingerprint of past earthquakes. Furthermore, seismic reflection and swath-bathymetry data image large pockmarks of up to 160 m in diameter and 30 m depth. Geochemical and hydrological analyses on the pockmarks are ongoing, and further analysis will reveal whether these features indicate active fluid seepage structures, possibly related to karst features (e.g. sublacustrine karst springs) and/or migration pathways along possibly active fault zones. The edges of these pockmarks are characterized by several distinct overflow deposits, clearly showing multiple phases of outflow events at discrete periods in the past. Seismic-stratigraphic correlation reveals that two of the multiple landslide horizons correlate with pockmark overflow-events, suggesting that landslide and overflow deposits were emplaced simultaneously or within a very short time period.

A causal link between multiple landsliding and fluid-expulsion activity, likely triggered by past earthquakes, is hypothesized. Future investigations, which include dating of the event horizons for correlation with independent paleoseismological archives, will reveal whether the observed event horizons relate to past seismic activity.

Poster session / 105

Pore pressure rebound and long-term instability in retrogressive submarine landslides

Author: Prof. SAWYER, Derek [1]

Co-Author: FLEMINGS, Peter [2]

[1] *University of Kentucky*

[2] *The University of Texas*

Corresponding Author: derek.sawyer@uky.edu

Many large submarine landslide complexes on passive margins are retrogressive in which the head scarp back-steps over time. What controls the timescale of retrogression and are present-day slide complexes along the world's continental margins stable or progressively weakening? Retrogressive failure is a coupled process. When an initial slope failure occurs, sediments behind the headwall experience short-term strengthening because unloading decreases the lateral stress and the pore pressure. However, over time, fluid flows toward the unloaded scarp resulting in a progressive increase in pore pressure (decrease in effective stress) and weakening of the slope. Specifically, once an initial scarp forms, the lateral stress is reduced in sediments near the scarp face. The reduction in lateral stress increases shear stress. However, since fluids in headwall sediments are also no longer laterally confined, fluid pressures are also reduced. At this point, the in situ shear stress is less than the failure strength and the system is stable. However, over time, lateral flow occurs toward the scarp and pore-pressure begins to rise back towards its original values. On a p-q (mean stress-shear stress) plot, the stress path moves horizontally. As it does, sediments near the headwall further weaken until failure again occurs. This long-term pore pressure rebound may play a key role in driving cyclic, time-dependent retrogression in submarine landslide complexes. If the undrained unloading does not weaken the sediment below the gravitational driving stress, the subsequent pore pressure rise could progressively weaken the slope sediments until it does.

Poster session / 38

Post-failure processes on the continental slope of the Central Nile Deep-Sea Fan: interactions between fluid seepage, sediment deformation and sediment-wave construction

Prof. MIGEON, Sébastien [1]

[1] *Géoazur*

Corresponding Author: migeon@geoazur.unice.fr

Voluminous mass-transport deposits (MTD) have been identified on seismic profiles across the central Nile Deep-Sea Fan (NDSF). The youngest MTDs are buried under 30-100 m of well-stratified slope deposits that, in water depths of 1800-2600 m, are characterized by undulating reflectors correlated with slope-parallel seabed ridges and troughs. Seabed imagery shows that, in the western part of the central NDSF, short, arcuate undulations are associated with fluid venting (carbonate pavements, gas flares), while to the east, long, linear undulations have erosional furrows on their downslope flanks and fluid seeps are less common. Sub-bottom profiles suggest that the western undulations correspond to rotated fault-blocks above the buried MTDs, while those in the east are sediment waves generated by gravity flows. We suggest that fluids coming from dewatering of MTDs and/or from deeper layers generate overpressures along the boundary between MTDs and overlying fine-grained sediment, resulting in a slow downslope movement of the sediment cover and formation of tilted blocks separated by faults. Fluids can migrate to the seafloor, leading to the construction of carbonate pavements. Where the sediment cover stabilizes, sediment deposition by gravity flows may continue building sediment waves. These results suggest that complex processes may follow the emplacement of large MTDs, significantly impacting continental-slope evolution.

Poster session / 60

Landslides and mega-thrust earthquakes at convergent margins - trigger-bang, or trigger-trigger-trigger ... bang? The case of the Maule earthquake, Chile

Author: Dr. VÖLKER, David [1]

Co-Authors: Prof. BEHRMANN, Jan [2]; Dr. HARDERS, Rieka [3]; GEERSEN, Jacob [4]; WEINREBE, Wilhelm [2]

[1] *GEOMAR*

[2] *GEOMAR Helmholtz Center for Ocean Research*

[3] *University of Barcelona*

[4] *University of Southampton*

Corresponding Author: dvoelker@geomar.de

Earthquakes trigger landslides, if there are accumulations of instable slope sediments and the slope is sufficiently steep. It is a simple as that. Is it? Obviously it is not....
On 27 February 2010, the Central Chilean Maule Region was ruptured by a megathrust earthquake of magnitude (Mw) 8.8. This 6th largest ever instrumentally recorded earthquake occurred after a phase of relative seismic quiescence since 1835. The hypocenter of the main shock was located ~10 km offshore. Close to the epicenter, the earthquake produced horizontal ground acceleration of up to 6ms–2 and maximum slip was between 10 and 20 m. In spite of a multitude of morphological features of past mass movement events the youngest of which are some ky old, no new slides of a size > ~ 4 km2 were detected as a consequence of the earthquake. On the other hand, a recent microslide was reported and dated to some months after the main shock. We hypothesize that frequent shaking of the active continental margin with megathrust earthquake recurrence of 100-200 years rather shifts the size spectrum of mass wasting events towards smaller events.
We also established a rough size-frequency relation for mass wasting events which holds for Central Chile and Central America. This relation allows to make reasonable assumptions on the temporal frequency of events of different size scale. A major result is that it should take a time span that exceeds the seismic cycle by far to create a landslide voluminous enough to be considered tsunamogenic.

Poster session / 61

Mass movement prediction of submarine landslide in the South China Sea Liwan 3-1 gas field

Author: Dr. XIU, zongxiang [1]

Co-Authors: Dr. LIU, lejun [1]; Dr. LI, xishuang [1]; Dr. SU, tianyun [1]; WANG, Dong [2]; Ms. XU, xiaoqing [1]

[1] *The First Institute of Oceanography, State Oceanic Administration,P.R.China*

[2] *The first institute of Oceanography, State Oceanic Administration, P. R. China*

Corresponding Author: xiuzongxiang@163.com

A submarine slope at the head part of the submarine valley in the South China Sea Liwan 3-1 gas field is taken as an example for the mass movement prediction of submarine landslide in this area. Firstly, the FEM strength reduction method is used for submarine slope stability analysis, and then the height and length of the potential submarine landslide can be obtained. The travel distance of the moved mass is predicted with Computational Fluid Dynamics method, in which the dynamic interaction between moved soil and sea water is simulated by the Eulerian-Eulerian two-phase model. Considering that the soil strength may be gradually decreasing during the movement, we develop an equivalent parameters method to simulate mass movement. The Herschel - Bulkley rheological model is chosen to simulate the soil, and the rheological parameters are obtained by a series of submarine landslide back-calculations. The submarine landslides which have been chosen for back-calculations are identified in the adjacent area based on the multibeam data and seismic cross-section, and they have similar size and soil properties with the potential ones. Finally, the stability safety factor of the target slope and the corresponding travel distance of moved mass are obtained.

Poster session / 62

Structural characteristics of large-scale submarine landslide on a very gentle continental slope off Shimokita Peninsula, Northeast Japan.

Author: Mr. NAKAMURA, Yuki [1]

Co-Authors: Dr. MORITA, Sumito [2]; Dr. ASHI, Juichiro [1]

[1] *The University of Tokyo*

[2] *Geological Survey of Japan, AIST*

Corresponding Author: yukinaka@aori.u-tokyo.ac.jp

Submarine landslides have been observed even on very low-angle slope well below the angle of response, and are often greater in size and in migration distance than landslides on land. A number of large-scale submarine landslide (slump) deposits were identified in Pliocene and upper formations by analyzing METI's 3D seismic data "Sanrikuoki 3D" obtained off Shimokita Peninsula (Morita et al., 2011). The slump deposits generally indicate layer-parallel slip on a very gentle and flat continental slope, and often exhibits imbrication structure formed by repeated thrusting of slide sedimentary sheets and related dewatering structure which occurs in the slip planes and cuts the imbrication vertically. Our research aims to understand modes of submarine landslide occurrence that form in such low-angle continental slope.

We have investigated detailed distribution and geometry of the slump deposits, using several seismic data in the survey area, determining a criteria of slip plane, seabed before sliding, top of slump deposit, and slip direction. Slip plane corresponds to the bottom of slid layer. Seabed before sliding is identified as a horizon overlaid by slump deposits at the distal portion of the slumping. The domain between the layer corresponding to slip plane and the seabed before sliding is original thickness of slid sedimentary bed. Top of slump deposits is recognized at a boundary covered by normal layers. Slip direction is determined by imbrication and related parallel dike structure which are both basically perpendicular to the slip direction.

Being based on the criteria, we identified slump-dominant horizons and structural characteristics of each slump deposits. The slump deposits are interbedded among normal formation in the Pliocene and Quaternary formations, where each slump deposit is basically composed of the above-mentioned imbrication of thrust sheets and chaotic cover sequence, however, the coherent portion of the imbricated thrust sheets are typically dominant in volume rather than the chaotic portion, avoiding fatal collapse of original sedimentary structure. This may be likely a characteristic feature of slump deposits in such very gentle continental slope.

Keywords
submarine landslides, slump, low-angle continental slope, Shimokita Peninsula, 3D seismic data

Poster session / 63

Submarine landslides along the eastern Mediterranean Israeli continental slope

Author: Dr. KATZ, Oded [1]

Co-Authors: REUVEN, Einav [1]; Prof. AHARONOV, Einat [2]

[1] *Geological Survey of Israel*

[2] *The Hebrew University of Jerusalem, Israel*

Corresponding Author: odedk@gsi.gov.il

Numerous shallow submarine slope failures (scars and deposits) are observed in recent high resolution bathymetric grids of the continental slope off the Israeli eastern Mediterranean coast. The nature of these slope failures is currently not comprehensively understood as well as the question of whether the eastern Mediterranean continental slope is continuously or episodically unstable.

We report here first steps towards understanding the present state of this submarine landslide system, which include mapping and analyzing the geology of the landslides and the hosting slopes. The continental slope extends from water depths of about 150 to more than 1000 meters with a slope of less than 5° in general. Bathymetric grids with pixel resolution of 15 m till water depth of 700 m and 50 m till water depth of 1700 m were used.

Analyzing the bathymetry revealed three main submarine surface features on the continental slope: (a) numerous shallow landslides, within the upper sequence of the post-Messenian sediments. Landslide widths range between hundreds to thousand of meters at the scar, with scar heights up to hundred meters. The toes of the landslides are not always mapable and lay up to a few kilometers down slope from the scar. Slope angles within the scars are 5° to more than 15°. In general landslides size decreases from south to north where their head scar depth turns to be shallower northwards. At least two types of landslides were detected: presumably young slides with sharp scars and presumably old slides with secondary slides and secondary drainage systems developed within the scar area; (b) a few kilometers long, north striking step-like lineaments. Step heights are up to 100 meters and the slopes are up to 20°. The offset between parallel steps is less than a kilometer to a few kilometers. Analyzing seismic lines, the steps are interpreted as surface expressions of growth faults rooted at the Messinian evaporates up to 1.5 kilometers below surface; (c) a few north striking channels were also detected with steep walls of more than 15°, up to two kilometers width and a few kilometers length. The nature of these channels is not clear yet although apparently they are also a surface expressions of the growth faults rooted at the Messinian evaporates.

Field relations show that the landslides, both young and old, either emerge from the over-steepened steps, or are displaced by them, and hence submarine landslides and steps are apparently contemporaneous. In addition this suggests that salt dynamics at depth is a main drive for at least some of these shallow slides. The above preliminary results testify to the complicated and highly dynamic nature of the studied continental slope, yet to be revealed.

Poster session / 68

Modification of the Shape of Pacific Islands by Submarine Landslides: Banaba, Nauru, and Niue

Author: Mr. KRUGER, Jens [1]

Co-Author: Dr. POHLER, Susanne [2]

[1] *SPC*

[2] *University of the South Pacific*

Corresponding Author: jensk@spc.int

The three uplifted atoll islands Banaba, Nauru and Niue are shaped by submarine mass wasting. For each island, the most distinct submarine landslide is described using multibeam bathymetry. All three islands are fractured through tectonic uplift. Subaerial exposure caused further structural weakness through karstification and dolomitisation, which increased porosity and permeability of the limestone cap. Initial fractures became enlarged into chasms, caves and caverns which ultimately resulted in flank failure. The ages of these submarine landslides are poorly constrained, but were probably youngest for Home Bay, Banaba, (>10,000 BP); between 1.6 Ma and 10,000 BP for Anabar Bay, Nauru; and 700,000 BP or less for Tepa Point, Niue.

Poster session / 69

Fram Slide off Svalbard: A new type of glacial continental margin slope failure

Author: JUDITH, Elger [1]

Co-Authors: Prof. BERNDT, Christian [2]; Prof. KRASTEL, Sebastian [3]; Dr. PIPER, David [4]

[1] *CAU / GEOMAR*

[2] *GEOMAR*

[3] *Institute of Geosciences, Christian-Albrechts-Universität zu Kiel*

[4] *Dalhousie University, Halifax, Canada*

Corresponding Author: jelger@geomar.de

Submarine slop failures are a wide spread phenomena and a huge geo hazard. They reshape margin landscapes and can destroy seafloor installations or even coastal infrastructure by generating tsunamis. The mechanisms that create submarine landslides at continental margins are believed to be related to rapidly deposited glacigenic material generating overpressure in previously deposited hemi-pelagic sediments. However, knowledge about the main reasons for the destabilization of slopes is still partial since these results are mainly related to the studies of the Storegga Slide and might not be representable. Here we show a newly discovered landslide off Svalbard called Fram Slide. We discuss which destabilizing factors may contributed there to submarine slope instability while we show that there is no indication for rapid glacigenic debris deposition. We use bathymetric, 2D high resolution seismic and Parasound data to study the shape and the structure of the slide area. Apart from tectonic movement and over-steepening of the slope we consider overpressure due to the cementation by gas hydrates to play a major role because there is evidence for faults, free gas beneath gas hydrates and upwards migrating fluids and gas. Our results demonstrate that there are other major processes that determine the genesis of slop failures which has to be studied more detailed and that the Fram Slide is an excellent example to document their relevance.

Poster session / 6

Recurrent superficial sediment failure and deep gravitational deformation in a Pleistocene slope marine succession: the Poseidonia Slide (Salerno Bay, Tyrrhenian Sea)

Author: Ms. BUDILLON, Francesca [1]

Co-Authors: CESARANO, Massimo [2]; CONFORTI, Alessandro [1]; PAPPONE, Gerardo [3]; DI MARTINO, Gabriella [1]; PELOSI, Nicola [1]

[1] *IAMC-CNR, Italy*

[2] *DiBT, Universita degli Studi del Molise, Pesche, Italy*

[3] *DiSAm, Universita Parthenope, Napoli, Italy*

Corresponding Author: francesca.budillon@cnr.it

A large number of exposed scars, originated by multievent sediment failures, have been identified on the southern flank of a deep submarine valley in Salerno Bay (Southern Tyrrhenian Sea), between depths of 300 m and 700 m. A 200 km2 complex slide lies across a 17 km-long SW-NE trending anticline, which is exposed 40 m above the seafloor of the continental slope and folds a Pleistocene marine successions. The exposed anticline, as well as others which are more subdued, have been formed by gravity-driven deformation of a deep and unconsolidated slope succession. The deep deformation seems to be coeval with recent stages of regional tectonic activity, given that a regional unconformity related to MIS 6 lowstand seals both the deep slide features and the fault planes. A combined dataset of 2D high resolution seismics, swath-bathymetric digital elevation model of the seafloor and a gravity core was used to establish a possible relation between recurrent sediment failures at the seabed and the stack of positive reliefs in the compressional toe region of the buried slide system and to learn more on the timing of the deformation phases.

Poster session / 99

Records of Mass Movement Events and Their Potential Triggers in the Active Fangliao Fault Zone Offshore Southwestern Taiwan

Author: Dr. HSU, Ho-Han [1]

Co-Authors: Prof. LIU, Char-Shine [1]; Prof. DEFFONTAINES, Benoît [2]; Prof. SU, Chih-Chieh [1]; Mr. HSIA, Pei-Cheng [1]

[1] *Institute of Oceanography, National Taiwan University, Taipei, Taiwan*

[2] *Laboratoire de Géomatériaux et Géologie de l'Ingénieur, 5 Boulevard Descartes, Université de Marne-la-Vallée, F-77454 Marne-la Vallée Cedex 2, France*

Corresponding Author: yun986@ms24.hinet.net

In the past few years, large earthquakes and torrential rains triggered several large scale mass movement events offshore Southwestern Taiwan. They induced severe submarine hazards and caused series of submarine cable breakages. In this study, we use high-resolution bathymetry, chirp sonar, and seismic profile data together with core samples to investigate possible factors which may increase the vulnerability of generating submarine mass movements in the Fangliao Fault Zone offshore Southwestern Taiwan. Our study indicates that these mass movement events are not only related to earthquakes and floods, but that the geological and hydrological settings also play important roles in generating them. High-resolution bathymetric data and seismic reflection profiles show that the Fangliao and Hongtsai submarine canyons have different structural and sedimentary implications. The Fangliao Canyon is guided by a mud diapiric ridge which might be developed along a major north-south trending strike-slip fault zone in the incipient arc-continent collision system. This left-lateral strike-slip fault could have caused a major submarine landslide on the western side of the asymmetric Hengchun anticline, and shaped the Hongtsai canyon which flows into the Fangliao Canyon. The active tectonic environment and opposite vertical displacement rates in the west (subsidence) and east (uplift) sides of the Hengchun Fault make the study area highly vulnerable to large scale submarine mass movements. Chirp sonar profiles, in conjunction with core sample analyses are used to identify the sources, transport and deposition of the turbidites (or hyperpycnite), and to reconstruct the history of earthquake and flood events in the study area. They present mass movement deposits not only distributed in the offshore Southwestern Taiwan area, but parts of them could be transported to deep sea through submarine canyon systems in the form of turbidity currents. We reconstruct the possiable interactions between neotectonics and submarine canyon paleodrainages, and suggest that the geometries of the Fangliao and Hongtsai submarine canyons were affected by the activation of this Hongtsai submarine landslide. The tectonic setting and local structures include the active left lateral strike-slip fault, earthquakes, floods and submarine liquefaction structures are proposed to be the main factors which cause large scale submarine mass movement events offshore Southwestern Taiwan.

Poster session / 91

Submarine landslides on the Hovgaard Ridge, central Fram Strait – preliminary results

FORWICK, Matthias [1]; Dr. LABERG, Jan Sverre [1]; HUSUM, Katrine [1]

[1] *Department of Geology, University of Tromsø, Norway*

Corresponding Author: matthias.forwick@uit.no

The Hovgaard Ridge is located in the central Fram Strait between Greenland and Svalbard, approx. 80 km southwest of the Molloy Fracture Zone that separates the Molloy and Knipovich spreading ridges. It is approx. 110 km long, rises up to ~1800 m above the surrounding sea floor, and has a triangular shape narrowing from ~20 km in the SE to <4 km in the NW. The dip of its southern slope is ~10-40° and the gradients of the western and eastern slopes decrease gradually from up to 30° in the south to <15° in the north. The ridge top is an up to 10 km wide, northward-narrowing, "convex plateau" with a gradient typically below 5°.

The bathymetry of the western and eastern slopes provides multiple evidence of sediment failure and downslope sediment transport. This includes channels incising the southern and central parts of the western slope. Here, the largest channels are approx. 130 m deep, up to 1.5 km wide and maximum 8 km long. They originate in areas of increasing in slope angle at the margins of the plateau, below 1300 m water depth. The northern parts of the western and eastern slopes contain multiple slide scars with up to ~20 m high headwalls. Single scars are up to 5 km wide, and the lateral extent of merged multiple scars is up to 12 km. The absence of internal escarpments on the western slope is interpreted to be due to failures limited to one stratigraphic level. However, a staircase-like morphology on the eastern slope suggests slope failures affecting multiple stratigraphic levels. The relatively high width-to-depth ratio of these scars is assumed to indicate failures of sediment slabs. Up to 130 m deep and 3 km wide slide scars with rough internal morphology occur in the central parts of the eastern slope. The width of the slide scars is either constant or it narrows towards the foot of the slope. The irregular internal morphology suggests that the slides affected multiple stratigraphic levels, and/or that evacuation of failed sediments from the slide scars was incomplete.

The following processes may have led to sediment failure and channel formation on the Hovgaard Ridge:

1) The scars on the northern part of the western slope, as well as along the entire eastern slope are assumed to be the result of failure of weak layers triggered by seismicity related to seafloor-spreading along the nearby Molloy and Knipovich Ridges and/or tectonic adjustments along the Molloy Fracture Zone. The failures probably developed retrogressively due to initial sediment removal from the steepest parts close to the foot of the ridge leading to undercutting and removal of support.

2) Channel formation on the southern and central parts of the western slope may have resulted from a) cascading water masses of the Return Atlantic Current (RAC) crossing the Hovgaard Ridge in south-westerly direction, and/or b) sediment-gravity flows originating from failure at the slope break due to deposition of sediments winnowed from the plateau by the RAC.

Poster session / 90

Stability and failure mechanism for landslides at the Upper Continental Slope off Vesterålen, Norway

Author: Dr. L'HEUREUX, Jean-Sebastien [1]

Co-Authors: Dr. VANNESTE, Maarten [2]; Dr. RISE, Leif [3]; Dr. BRENDRYEN, Jo [4]; Dr. LONGVA, Oddvar [3]; Dr. FORSBERG, Carl F. [2]; Dr. KVALSTAD, Tore J. [2]; Prof. HAFLIDASON, Haflidi [4]

[1] *Norwegian Geotechnical Institute (NGI)*

[2] *NGI*

[3] *NGU*

[4] *UiB*

Corresponding Author: jsl@ngi.no

Several relatively small and spatially-isolated landslides with low mobility characterise the geomorphology of the upper continental slope off the Vesterålen islands. Here, we present results from a multidisciplinary study that integrates swath bathymetry data, high-resolution seismic reflection profiles and a multitude of geological and geotechnical laboratory tests from a 12 m long piston core in order to investigate the origin and hazard potential of these shallow landslides. Four of the landslides have their upper headwall around the 500 m isobath, whereas the main escarpments of another four landslides lie around 700 to 800 m. The slip planes of the translational landslides lie within laminated glacial marine clays, overlying a well-defined seismic horizon. These clays have a higher plasticity and water content compared to the surrounding soils (sandy clays), and they exhibit a modest strain-softening behaviour in triaxial tests. The interdisciplinary data set is used as input to various numerical analyses in order to assess the failure and triggering mechanisms for these landslides, as well as their hazard potential. Stability analyses, dynamic analyses and post-earthquake pore pressure dissipation modelling suggest that the margin is essentially stable and that it would require a large magnitude earthquake to trigger landslides. The resulting deformation and excess pore pressure generation occur primarily within the top 10 m of the soil, and they become more pronounced towards the surface. The simulations depend strongly on the input parameters, which are determined from a limited number of samples, geotechnical tests and geophysical data. Therefore, the results must be seen as preliminary. Additional sediment cores and in situ geotechnical tests data are planned to gain further insights into the variety of slope processes in this pristine region of the Norwegian margin.

Poster session / 93

Shaking Engadine: Prehistoric insights into Lake Silvaplana, SE Switzerland

Author: BELLWALD, Benjamin [1]

Co-Authors: ANSELMETTI, Flavio [2]; GILLI, Adrian [3]

[1] *University of Bergen*

[2] *Institute of Geological Sciences and Oeschger Centre for Climate Change Research, University of Bern, Switzerland*

[3] *Geological Institute, ETH Zürich, Switzerland*

Corresponding Author: benjamin.bellwald@gmail.com

Lakes in perialpine realms, commonly, comprise high-resolution sedimentary archives, which record climatic, environmental, tectonic and anthropogenic changes and events. In this study, we focus on Lake Silvaplana, using 3.5 kHz single-channel pinger profiles and a 10.5 m long sediment core, in order to improve our knowledge on tectonic and sedimentologic processes and their interactions. Lake Silvaplana is located at 1791 m.a.s.l., it has a surface area of 2.7 km2 (width×length ~1×2 km), a maximum water depth of 78 m, and it is surrounded by up to 4049 m high mountains. Lake Silvaplana is, furthermore, influenced by a prominent fault system, the Engadine Line, along which prehistoric and historic earthquakes have occurred.

Generally, the seismic profiles used in this study show a good penetration (up to 90 m below the subsurface) and the acoustic basement (bedrock or moraines) could be identified throughout the lake. The sediment core was taken from the deepest part of the lake using an Uwitec percussion piston-coring system covering the last ~3000 years. The core was analyzed for density, magnetic susceptibility, grain-size, as well as lithology and allowed a precise core-to-seismic correlation. A core chronostratigraphy was established using a combination of 14C AMS dating, gammaspectroscopic measurements of 210Pb and 137Cs radionuclides and inferred sedimentation rates.

The seismic data show that the sediment archive above the acoustic basement compromises three different seismic facies: acoustically stratified (Seismic Facies 1, SF1), transparent (SF2) and chaotic (SF3). Laminated draping background deposits (ρ: 1.4-1.5 g/cm3, clay-silt; SF1) are found all over the lake. They are interrupted by mass movement deposits, which were separated into two facies: i) Chaotic wedging bodies (ρ: 1.4-1.5 g/cm3, clay-silt; mass flow, SF3), showing deformed and erosive character, are deposited at the toe of the slopes and ii) transparent onlapping masses, characterized by normal grading (ρ: 1.4-1.8 g/cm3, clay-sand; megaturbidite, SF2), having the deepest part of the lake as sedimentary environment, overlying SF3. All these sediments are filling the lake basin defined by the acoustic basement (SF4).

In total ten horizons with synchronously initiated mass-movement deposits have been recognized in Lake Silvaplana. Four of these subaquatic mass movements were also recorded in the core and dated to 1800, 1720, 820 and 600 AD. The ages of the other six events were estimated, using a constant sedimentation rate, to 1200, 1400, 2900, 4800, 7400, 8000 BC. The inferred ages of the mass failures have been compared with the existing historic and prehistoric earthquake catalogues from the region showing that seismic shaking is the most likely triggering mechanism for the latest four events. The most prominent multiple-slide horizon, dated to an age of 600 ± 50 yr AD, was correlated with lacustrine mass movement deposits of other paleoseismic archives (Lake Como and Lake Sils). The strong regional correlation of this event is a further criterion for seismically-induced slope failure. Eventually, this study allows expanding the earthquake catalogue of the Eastern Swiss Alps and the neighboring northern Italian area, providing novel insights for the regional seismic hazard assessment.

Poster session / 92

Geomorphology of a mass failure zone and their implication on the submarine slope stability in the northwestern part of the East Sea (Japan Sea), Korea

Author: Dr. KIM, Seong-Pil [1]

Co-Authors: Dr. G.S., Kong [1]; Mr. Y.-H., Yoon [2]; Mr. B.Y., Koo [3]; Dr. J.J., Bahk [1]; Dr. S.-W., Jeong [4]; Dr. G.Y., Kim [1]; Dr. H.C., Han [5]; Dr. S.H., Lee [1]; Prof. S.-S., Park [6]

[1] *Principal Researcher*

[2] *Researcher*

[3] *Research Student*

[4] *Senior Researcher*

[5] *principal researcher*

[6] *Associate Professor*

Corresponding Author: spkim@kigam.re.kr

Topographic and geologic features of a mass failure zone were investigated in the mid-eastern continental margin of the Korean peninsula. The surveyed area resides on a gentle (less than 2 degree) continental slope running down to a submarine plateau in the northwestern part of the Ulleung Basin. The Ulleung Basin is a back-arc basin which was opened during the Tertiary Period behind the Japanese islands. High-resolution echo-sounders, a 3.5-kHz acoustic profiler and a meter-scale sediment corer were used for onboard data acquisition, which was followed by laboratory data processing and sediment analyses. Based on the study results a well-preserved slope failure scar could be delineated and examined in detail. The overall shape of the slope scar is tongue-like and comprised of at least two superimposed scars. Each of the scars runs more than ten kilometers downward toward the top of the Kangwon Plateau (the eastern part of the Korea Plateau) covering more than 20 km2 of aerial extent. In the along-scar sections the headwalls could clearly be defined with abrupt depth changes and shallow subsurface acoustic reflectors. The internal surfaces of the scars are generally flat and show similar slope angle down to about 1,000-m depth contour. Further below the 1,000-m contour the surfaces change their shapes into hummocky mounds with deformed and irregular acoustic reflectors implying the existence of mass-transported sediment deposit. In the cross-scar sections stepped seafloor could clearly be noticed, which indicates the overall shape of the scar zone is a cumulative result of recursive failure events. According to the textural and geotechnical properties of the cored samples the sediments in the failure zone are clay-rich, highly plastic and shear-resistant, which is not in favor of mass wasting. Considering the earthquake records around the Korean peninsula the mass failures in the study area imply the tectonic condition.

Poster session / 95

Shimokita-oki submarine landslides and feasibility studies for future scientific drilling

Author: Dr. MORITA, Sumito [1]

Co-Authors: Dr. GOTO, Shusaku [2]; Prof. MIYATA, Yuichiro [3]; Mr. NAKAMURA, Yuki [4]; Mr. KITAHARA, Yu [5]; Dr. YAMADA, Yasuhiro [6]

[1] *Geological Survey of Japan, AIST*

[2] *GREEN, Geological Survey of Japan, AIST*

[3] *Yamaguchi University*

[4] *The University of Tokyo*

[5] *Kochi University*

[6] *Kyoto University*

Corresponding Author: morita-s@aist.go.jp

By a high-resolution 3D seismic data analysis, a great number of buried submarine landslide deposits were identified off Shimokita Peninsula, NE Japan. The submarine landslide deposits are interpreted as slump deposits interbedded in the Pliocene and Quaternary formations in northern Sanrikuoki Basin. Some of the slump deposits are over size of the survey area and are likely more than 30 km in both length and width. The structure tells that the slumping is almost all layer-parallel slip on a very gentle continental slope, where sedimentary formations are very flat and parallel to the present seafloor of less than 1 degree in gradient. So, the slump deposits have avoided fatal collapse. They basically indicate block-supported structure containing regularly imbricated thrust sheets of slid ancient surface layers with little matrix of chaotic cover. Dewatering structure strongly dependent on the imbrication forms parallel dikes occurring from the base of the slid layers, i.e. from slip plane. The layers corresponding to the slip plane are easy to trace due to a typical reflection of low-amplitude having some thickness. In 2011, Integrated Ocean Drilling Program (IODP) raised submarine landslide as one of science targets on the new science plan for the next 10 years from 2013. So, we recognize that the large slump deposits off Shimokita Peninsula are appropriate target to determine submarine landslide mechanism because of the simple layer-parallel slip, ensuing regular re-depositional structure and the traceable slip planes. For that reason, we started various research activities to examine feasibility of future scientific drilling. Further detailed structural analysis is in progress using 2D and 3D seismic data to extract candidate site for scientific drilling. Since the area is known as high flux of temperature-sensitive methane, we performed detailed heat flow measurements, deploying a long-term bottom water temperature monitoring system for precise correction of heat flow values. Vitrinite reflectance analysis and Rock-Eval pyrolysis were carried out using sediment samples recovered by IODP Expedition 337, which is conducted just in a part of the study area in summer, 2012. Results of the analyses will be available to determine maturity of organic materials and to model thermal history in the basin. In September, 2012, we held a field excursion in Nichinan Group in Kyushu, Japan to observe typical geologic structures related to slumping and dewatering. The slumping and dewatering in the outcrops are also considered to have occurred in such low-angle slope where flute cast remarkably develops. The field excursion was a good opportunity to share general ideas about the slump deposits off Shimokita Peninsula among the science community. The seismic analysis, the vitrinite reflectance analysis, the Rock-Eval pyrolysis, and the field excursion and science meeting in Miyazaki were supported by the foundation of “Feasibility studies for future IODP scientific drillings” by JAMSTEC CDEX in 2012-2013. A part of organic materials analyses are supported by the CDEX’s fund for IODP post-expedition researches. The detailed heat flow analysis was funded by 2012 GREEN Grant, AIST. This study uses the 3D seismic data from the METI seismic survey “Sanrikuoki 3D” in 2008.

Poster session / 94

Timing of submarine canyon incision on the east Australian continental margin

Author: Ms. YU, Phyllis [1]

Co-Authors: Dr. CHAPRONIERE, George [2]; Dr. HUBBLE, Thomas [3]; Prof. AIREY, David [1]; Ms. CLARKE, Samantha [3]; Dr. BOYD, Ron [2]; Prof. KEENE, John [1]; Prof. EXON, Neville [4]; Prof. GARDNER, James [5]

[1] *University of Sydney*

[2] *University of Newcastle*

[3] *University of Sidney*

[4] *Australian National University*

[5] *University of New Hampshire,*

Corresponding Author: phyllis.yu@sydney.edu.au

Sediment composition and biostratigraphic age data are reported for nine dredge samples collected from submarine scarps located on the middle continental slope portion of the eastern Australian continental margin. These data are used to confirm the depositional origins of these materials and constrain the timing of the onset of submarine erosion and canyon incision.

Sediments dredged from canyon walls and landslide scarps in this region are primarily comprised of calcareous sandy-silts, and present terrestrial plant macrofossils in addition to marine microfossils. Biostratigraphic dating of foraminifera indicates the sediments were deposited between Early Oligocene and Late Pliocene, with the majority of samples of Middle to Late Miocene age.

These ages have a number of implications for the geological history of the margin, most importantly, enabling a likely maximum age to be determined for the onset of pronounced canyon incision into the margin. The geological events that formed slump scars and canyon incision cannot be older than the sediments in which these features are presented; it is therefore inferred that the eastern Australian margin underwent a change in character from a dominantly stable depositional system in which sediments gradually accumulated on the slope, to a less stable erosional system characterised by canyon incision and frequent submarine landsliding at some time after the Middle Miocene.

Poster session / 97

Repeated large-scale slope failures associated with a rapidly prograding shelf margin from the Plio-Pleistocene of the Deepwater Taranaki Basin, New Zealand

Author: Dr. BULL, Suzanne [1]

Co-Author: ARNOT, Malcolm [2]

[1] *GNS Science*

[2] *GNS Science, 1 Fairway Drive, Avalon, Lower Hutt 5011*

Corresponding Author: s.bull@gns.cri.nz

A series of large-scale, stacked and locally amalgamated mass transport complexes (MTC's) have been identified using 2D seismic reflection lines in the deepwater area of the Taranaki Basin, offshore Western New Zealand.

The MTC's represent a significant proportion (c. 40 %) of the Plio-Pleistocene succession and cover a combined area in the excess of 40,000 km2, with individual examples showing run out distances of over 200 km and thicknesses of approx. 300 m. In a stratigraphic context, the MTC's form a series of stacked bodies, some interbedded with undisrupted background sedimentation, while others directly overlie one another, and in some examples, merge laterally to form amalgamated complexes.

Key kinematic information is derived from the identification of primary constraining features such as headwall scarps and lateral margins, indicating a gross general transport direction to the north-west. In addition, a range of internal features and deformational fabrics including basal shear surface ramps and flats, slide blocks and imbricate thrusts are imaged.

Slope failure is believed to be linked to rapid northward progradation of the shelf margin from Late Miocene to recent times, during which over 2km of sediment was deposited as outward building stacked clinoforms. The rapid development of clinoforms has had a significant impact on the thermal regime of the basin, which is currently New Zealand's only hydrocarbon producing region.

Correlation with two exploration wells suggests that some failed sediments predominantly comprise unconsolidated mud rich facies, while seismic reflection lines indicate that headwall scarps developed along the bounding surfaces of progradational foresets,and that slope instability may have been triggered by over-steepening of sediments.

This work aims to evaluate the impact of the repeated large scale slope failure on the petroleum system of the deepwater Taranaki Basin, which is receiving increased interest as a site of potential future exploration.

Poster session / 96

Investigation into the relationship between large submarine landslides and regional sea level

Author: Ms. PALM, Franziska Anna [1]

Co-Authors: Ms. URLAUB, Morelia [2]; VARDY, Mark E. [3]

[1] *University of Southampton- National Oceanography Centre*

[2] *GEOMAR Helmholtz Centre for Ocean Research*

[3] *Ocean and Earth Science, National Oceanography Centre Southampton University of Southampton Waterfront Campus, Southampton, UK*

Corresponding Author: franziska@palmlife.de

Large landslides (>1 km3) are a globally observed sediment facies- found on active and passive open continental slopes as well as at both high and low latitudes. They represent a significant geohazard due to their potential to create devastating tsunamis and destroy seabed infrastructures. A number of hypotheses for the causes of these landslides have been brought forward, which may be divided into climate-dependent and climate-independent controlling factors. A comparison of landslide timing and frequency with past sea level trends as a proxy for climate change may thus allow distinguishing between these causes. A relationship between landslide frequency and global sea level was not identified by recent studies. However, not all regions where landslides are observed correspond to the mean global sea level trend and local sea level fluctuations may differ significantly from the global trend. The aim of this study is to identify a possible connection between large submarine landslides and regional/local sea level. Sixty-eight landslides and ~1600 sea level reconstruction points from thirteen regions in which large landslides have occurred were collated from previously published data. An objective reliability index was used to evaluate the quality of the combined landslide timing and sea level data, taking into account the uncertainties involved with both the landslide age estimation and sea level reconstruction. Fifty-one landslides occurred in regions in which sea level data followed the global sea level trend while, eight occurred in regions in which sea level data did not follow the global sea level trend. Nine landslides had to be rejected due to a lack in local sea level data. We did not identified periods of considerable increased landslide frequency, which might indicate that triggers are climate-independent.

Poster session / 11

Slope failures and timing of turbidity flows north of Puerto Rico

Prof. CHAYTOR, Jason [1]

[1] *U.S. Geological Survey*

Corresponding Author: jchaytor@usgs.gov

The submerged carbonate platform north of Puerto Rico terminates in a high (3000-4000 m) and in places steep (> 45o) slope characterized by numerous landslide scarps including two 30-50 km-wide amphitheater-shaped features. The origin of the steep platform edge and the amphitheaters has been attributed to: 1) catastrophic failure, or 2) localized failures and progressive erosion. Determining which of the two mechanisms has shaped the platform edge is critically important in understanding landslide-generated tsunami hazards in the region. Multibeam bathymetry, seismic reflection profiles, and a suite sediment cores from the Puerto Rico Trench and the slope between the trench and the platform edge were used to test these two hypotheses. Deposits within trench axis and at the base of the slope are predominantly composed of sandy carbonate turbidites and pelagic sediment with inter-fingering of chaotic debris units. Regionally-correlated turbidites within the upper 10 m of the trench sediments were dated between ~25 and 22 kyrs and ~18 to 19 kyrs for the penultimate and most recent events, respectively. Deposits on the slope are laterally discontinuous and vary from thin layers of fragmented carbonate platform material to thick pelagic layers. Large debris blocks or lobes are absent within the near-surface deposits at the trench axis and the base of slope basins. Progressive small-scale scalloping and self-erosion of the carbonate platform and underlying stratigraphy appears to be the most likely mechanism for recent development of the amphitheaters. These smaller scale failures may lead to the generation of tsunamis with local, rather than regional, impact.

Poster session / 19

Searching for the record of historical earthquakes, floods and anthropogenic activities in the Var Sedimentary Ridge (NW Mediterranean)

Author: Ms. HASSOUN, Virginie [1]

Co-Authors: MARTÍN,, J. [2]; Prof. MIGEON, Sébastien [3]; LARROQUE, C. [4]; Dr. CATTANEO, Antonio [5]; ERIKSSON, M. [6]; SANCHEZ-CABEZA, J.A. [7]; MERCIER DE LEPINAY, B. [4]; KWONG, Liong Wee [6]; LEVY, I. [6]; HEIMBÜRGER, L.-E. [8]; MIQUEL, J.-C. [6]

[1] *Géoazur, Université de Nice Sophia-Antipolis, CNRS, Observatoire de la Côte d'Azur*

[2] *ICM-CSIC, 08003 Barcelona, Spain*

[3] *Géoazur*

[4] *Géoazur, UNS-UPMC-CNRS-OCA, Valbonne, France*

[5] *IFREMER*

[6] *IAEA-EL, Monaco*

[7] *Institut de Cíencia i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Spain*

[8] *GET-OMP, Toulouse, France*

Corresponding Author: hassoun@geoazur.unice.fr

Submarine landslides on continental slopes are triggered by diverse mechanisms such as sea-level variations, climate-driven sediment supply fluctuations, slope steepening related to long term tectonics, earthquakes and human activities. In the present work, we try to discriminate the origin of major gravity events recorded in three sediment cores collected on the Var Sedimentary Ridge (NW Mediterranean) by means of X-ray imaging, grain-size distributions and 210Pb-based chronologies supported by 137Cs and AMS 14C dating. An alternation of hemipelagic mud and sandy turbidite layers is apparent in all cores. In two of them, the topmost turbidite can be correlated to the well-known 1979 Nice-Airport landslide. A sub-surficial sandy layer is identified in all three cores with an approximate age of 120 years, suggesting for the first time a relationship with the largest earthquake in the region (1887; Mw = 6.9). Below the depth of that major event, sand beds are tentatively related to older local earthquakes and centennial floods.

Poster session / 1

Mapping the South Queensland margin: collapses, depressions and general instability

Author: Dr. VÖLKER, David [1]

Co-Authors: Dr. HUBBLE, Thomas [2]; Ms. CLARKE, Samantha [2]; Dr. WEBSTER, Jody [3]; Dr. PUGA-BERNABEU, Angel [4]

[1] *GEOMAR*

[2] *University of Sidney*

[3] *University of Sydney*

[4] *Universidad de Granada, España*

Corresponding Author: dvoelker@geomar.de

Continental margins characterized by low seismic activity and low sedimentation rate like the continental slopes offshore East Australia are often not considered as being subject to significant submarine landsliding and related tsunami hazard. Recent observations of the R/V Southern Surveyor expeditions however call for a re-evaluation of the stability of the continental slopes off East Australia as they documented ubiquitous landslides. Gravity core samples from slide planes of three upper slope slides presented almost historical ages of 15,000 and 20,000 years whereas sedimentary geotechnical testing and numerical slope stability estimations resulted in the puzzling conclusion that these submarine slopes should be stable against sliding The need to better unserstand the mechanisms of these landlsides was the rationale to man a third expedition on the R/V Southern Surveyor in Jan. 2013, the first results of which are presented here.

Poster session / 77

The influence of excess pore pressure, fluid flow and depositional patterns on subaquatic slope instability: a detailed case study of Lake Villarrica (South-Central Chile)

Author: Dr. MOERNAUT, Jasper [1]

Co-Authors: Mr. WIEMER, Gauvain [2]; Prof. STRASSER, Michael [3]; Ms. REUSCH, Anna [4]; Ms. STARK, Nina [5]; Mr. KEMPF, Philipp [6]; Mr. DE BATIST, Marc [6]; Dr. PINO, Mario [7]; Dr. URRUTIA, Roberto [8]; Mr. LADRÓN DE GUEVARA, Bruno [9]; Prof. KOPF, Achim [2]

[1] *Geological Institute, ETH Zürich, Switzerland*

[2] *MARUM, Centre for Marine Environmental Sciences, Bremen, Germany*

[3] *Geological Institute, ETH Zürich ,Switzerland,*

[4] *Geological Institute, ETH Zürich, Switzerland,*

[5] *Department of Civil and Environmental Engineering, Virginia Tech, Blacksburg, USA*

[6] *Renard Centre of Marine Geology, Ghent University, Belgium*

[7] *Instituto de Geociencias, Universidad Austral de Chile, Chile*

[8] *Centro EULA, Universidad de Concepción, Chile,*

[9] *BENTOS, Santiago, Chile*

Corresponding Author: jasper.moernaut@erdw.ethz.ch

One of the key challenges in submarine landslide research is to understand and quantify the role of different preconditioning factors that affect subaquatic slope stability. Excess pore pressure in a sedimentary sequence reduces effective stress and lowers the factor of safety. In-situ measurements and observations of fluid escape features at the sea floor commonly provide evidence for such overpressure. However, a detailed study of the spatial relationship of fluid flow indicators and landslides, and the origin and timing of the fluid flow is often lacking.

In the present study, we characterize a failed and remnant sublacustrine slope in a seismically-active region, based on high-resolution seismic profiling, side-scan sonar, multibeam bathymetry and geotechnical lab tests on piston cores. Moreover, free-fall CPTU measurements allow characterizing the in-situ shear strength and ambient pore pressure state of the sedimentary column.

Composite pockmarks (up to 80 m wide), acoustic turbidity and wipe-outs spatially correlate with the headwall scarp of several large subaquatic landslides. This suggests that focused fluid escape locally influenced the stability of the sedimentary column. Where no fluid escape features were found, the headwall scarp developed above a distinct downward-steepening slope break. The occurrence of isolated pockmarks which do not relate to slide scars implies that fluid escape is not triggered by sudden unloading due to slope failure, but is a persistent phenomenon. The location of the pockmarks is strongly controlled by morphological highs in the buried glacial landscape. Thick sequences of older lake sediments and glacial till may provide the source and pathway for excess fluids, respectively. Fluid flow from these sequences can also be interpreted from in-situ dissipation tests showing increasing values of excess pore pressures with stratigraphic position (i.e. largest values in lowermost stratigraphic units), but no correlation with overburden.

The basal shear surface of the slope failures developed on top of a prominent sitly-sand tephra layer and retrogressive failure took place in a unit of quick clay. Quick clay development in fresh water is rare and we speculate that persistent upwards fluid flow maintained high pore pressures in the clay unit. This prevented normal consolidation, and retained the flocculated framework of the rapidly-deposited fine-grained proglacial sediments.

This study confirms that pore fluid pressure and focused fluid escape can be major preconditioning factors for subaquatic slope failure in formerly glaciated areas. Moreover it reveals that the relative position of the headscarp may be determined by these factors. However, more research is needed to unravel the respective role of excess pore water pressure and free gas in the pore spaces on effective stress conditions.

Poster session / 76

The evolution of small canyons influenced by landslides: a case in LW area, north of the South China Sea

Author: Dr. LI, Xishuang [1]

Co-Authors: Dr. LIU, Lejun [1]; Dr. SU, Tianyun [1]; Dr. XIU, Zongxiang [1]; Ms. XU, Xiaoqing [1]; Ms. GAO, Shan [1]

[1] *The First Institute of Oceanography, SOA*

Corresponding Author: lxs@fio.org.cn

Dozens of small canyons arrange closely in the modern shelf break in LW area, north of South China Sea (SCS). These canyons have been formed and eroded since the middle Miocene. The significant terrain feature of these canyons are asymmetry cross-sections in which eastern flanks are steeper than the west. Multibeam bathymetry data and sub-bottom profiles revealed large quantities of small recent landslides in the canyon walls. Some larger landslides in the canyon head region were identified with multi-channel seismic data. The trigger mechanism of landslides in LW area is gravitational overloading, slope angle and properties of soil. Sliding direction of these landslides is perpendicular, parallel or oblique to the canyon axis. This indicates a complex process of mass transportation. We propose that the canyon was mainly excavated by turbidite current in the low sea level stage when the coast line advanced to the ocean and sediments supply in the upper slope was high. However, the canyon was mainly filled with mass sediments transported by landslides in the high sea level stage when the coast lines advanced to the land and sediments supplied to the upper slope reduced sharply.

Poster session / 75

Geohazard from submarine landslides in the Mediterranean Sea: a basin approach

Author: Dr. URGELES, Roger [1]

Co-Author: Dr. CAMERLENGHI, Angelo [2]

[1] *Institute of Marine Sciences (CSIC)*

[2] *OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy*

Corresponding Author: urgeles@icm.csic.es

Submarine landslides are ubiquitous along Mediterranean continental margins. With the aim to understand mass wasting processes and related hazard at the scale of a large marine basin encompassing multiple geological settings, we have compiled data on their geometry, age, and trigger mechanism with a geographic information system. The distribution of submarine landslides in the Mediterranean reveals that major deltaic wedges have a higher density of large submarine landslides, while tectonically active margins are characterized by relatively small failures. In all areas landslide size distributions display power-law scaling for landslides > 1 km3. We find consistent differences on the exponent of the power-law (θ) depending on the tectonic setting. Available age information suggests that failures exceeding 1000 km3 are infrequent and may recur every ~40 kyr. Smaller failures that can still cause significant damage might be relatively frequent (failures > 1 km3 may recur every 40 years). The database highlights that our knowledge of submarine landslide activity with time is limited to a few tens of thousands of years. Available data suggest that submarine landslides may preferentially occur during lowstand periods, but no firm conclusion can be made on this respect, as only 70 landslides (out of 696 in the database) have relatively accurate age determinations. The temporal pattern and changes in frequency magnitude distribution suggest that sedimentation patterns and pore pressure development have had a major role in triggering slope failures and control the sediment flux from mass-wasting to the deep basin.

Poster session / 74

Submarine landslide at Kick 'em Jenny volcano: analysis of an extreme scenario and its hazards

Author: Dr. DONDIN, Frederic [1]

Co-Authors: Dr. DORVILLE, Jean-François [2]; Dr. ROBERTSON, Richard E. A. [1]

[1] *Seismic Research Centre, The University of the West Indies, St Augustine, Trinidad Tobago*

[2] *Physics Department, Faculty of Sciences and Technology, The University of the West Indies, Mona, Jamaica*

Corresponding Author: fredericdondin@gmail.com

In the Lesser Antilles Volcanic Arc numerous sector collapse events
have been identifi ed in the last 30 years. So far 53 submarine deposits associated with sector collapse episodes have been identified off of the southern part of Montserrat and in the deep Grenada basin in the southern part of the arc. In both areas volumes of several tens of km3 have been identi ed. Some of these events were large enough to erode the submarine part of the island where they occurred e.g., Dominica, Martinique, St. Lucia or some previous submarine deposits (e.g., off of Montserrat south eastern coast).

Kick 'em Jenny (KeJ) is the only submarine active volcano of the
Lesser Antilles Arc. KeJ underwent 12 eruptions between 1939 and
2001 which makes it one of the most active volcanoes of the arc in the 20th century. KeJ is a strato-volcano located ca. 8 km north of Grenada on the steep (slope ca. 22°) eastern fl ank of the Grenada Basin. It culminates at −185 m u.s.l and the deepest sector within the vent is at ca. −264 m u.s.l. (Lindsay et al., 2005). According to Dondin et al.[2012] KeJ displays 3 episodes of sector collapses during its eruptive history recognized by 3 distinct generations of deposits off of its horseshoe-shaped structure. They showed that one of the deposit is ca. 4.4 km3 and has a runout of 14 km. Based on numerical simulations they also showed that the landslide behaved like a slump as it traveled as a stiff cohesive flow affected by minimal granular disaggregation and slumping on a non-lubricated surface. Dondin [2010] previously revealed that such an event was capable of generating a regional tsunami with the closest islands being the most vulnerable.

In this study we investigate the case of an extreme potential sub-
marine landslide scenario that would involve the NW-SE sector of the
current edi fice of KeJ (Vcollapse ~ 4.6 × 107 m3), and the tsunamigenic potential of such a landslide and its hazards for the surrounding islands. A numerical simulation of landslide propagation along an incline model is performed, retrieved from a preliminary slope stability analysis performed as a final step of a relative slope stability analysis after the Borselli et al. [2011] method. The landslide numerical simulation and tsunami source were performed using the validated bi-fluid version of VolcFlow (Kelfoun et al. [2010]), a code based on depth-integrated mass and momentum equations with a shallow water approximation for the mass- flow and the sea surface. The tsunami propagation is performed using FUNWAVE TVD (Shi et al. [2012]), a validated code based on the resolution of the Boussinesq equations on a 30 seconds resolution bathymetry (GEBCO 08).

References:

Borselli, L., Capra, L. Sarocchi, D., De la Cruz-Reyna, S. (2011). Flank collapse scenarios at Volcán de Colima, Mexico: A relative instability analysis. Journal of Volcanology and Geothermal Research, 2008:51-65.

Dondin, F. (2010). Simulations numériques et impact tsunamogène d'une détabilisation de flanc au volcan sous-marin Kick 'em Jenny, Petites Antilles. PhD thesis, Université des Antilles et de la Guyane, pp. 1-256.

Dondin, F., Lebrun, J.-F., Kelfoun, K., Fournier, N., and Randriana-
solo, A. (2012). Sector collapse at Kick 'em Jenny submarine volcano
(Lesser Antilles) Numerical simulation and mass fl ow behaviour im-
plications. Bulletin of Volcanology, 74:595607.

GEBCO C.E.,(2003). General Bathymetric Chart of the Ocean. British
Oceanographic Data Center.

Kelfoun, K., Giachetti, T. and Labazuy, P. (2010). Landslide-generated tsunamis at Réunion island. Journal of Geophysical Research, vol. 115, F04012, doi:10.1029/2009JF001381.

Lindsay, J., Shepherd, J. B. and Wilson, D. (2005). Volcanic and scienti fic activity at Kick 'em Jenny submarine

volcano 2001-2002: Implications for volcanic hazard in the southern Grenadines, Lesser Antilles. Natural Hazards, 34:1-24.
Shi, F., Kirby, J. T., Harris, J. C., Geiman, J. D., and Grilli, S. T.(2012). A high-order adaptive time-stepping TVD solver for Boussi-
nesq modeling of breaking waves and coastal inundation, Ocean Mod-
elling, 43–44, 36–51, doi:10.1016/j.ocemod.2011.12.004.

Poster session / 73

RECENT MORPHOLOGICAL CHANGES INDUCED BY SUBMARINE LANDSLIDES ON THE NICE CONTINENTAL SLOPE

Author: Ms. KELNER, Maelle [1]

Co-Authors: Dr. MIGEON, Sébastien [1]; Dr. TRIC, Emmanuel [1]; Dr. COURBOULEX, Francoise [1]; Mr. DANO, Alexandre [1]; Dr. LEBOURG, Thomas [1]; Dr. TABOADA, Alfredo [2]

[1] *Geoazur*

[2] *Geosciences Montpellier*

Corresponding Author: kelner@geoazur.unice.fr

Time series bathymetric data acquired between 1991 and 2011 have been used to evaluate the recent morphological evolution of Nice upper continental slope (SE France, Ligurian Sea).This area is affected by a large number of submarine landslides. Frequency, size and impact of small size failure are not well-known and difficult to detect using classical tools.However it lead to regressive motion of continental slope, to the deposition of high-frequency turbidites in the basins and could generate local tsunami. Cartographic analysis was made to identify individual scarps, slope variations and shelfbreak location. Then DEM comparisons were performed for each time interval, using ArcGIS “Raster calculator”.
It provided the specific background to locate and to quantify morphological changes over the last 20yrs at shallow water depths (0-200m).Shelfbreak migrations toward the coastline up to 60m following retrogressive scarp and chute incision is visible over time periods of 7-8 years where the continental shelf is >170m large. Sediment remobilizations on the upper slope are fast and significant; failure scars with volumes > 25000 m3 can appear, or scars with volumes ~150 000 m3 can disappear of the seafloor in less than 8 years. Between 1991 and 2011, alternation between periods of low morphological changes and periods of active failure events with significant volumes is clearly found.
Erosion volumes can be multiplied by 10 during periods of enhanced landslide activity (1999-2006). The triggering processes are still questioned for this landslide activity variation.
On the basis of local seismic data, hydrogeological analysis and chirp sismic cross sections, we try to define mechanisms on a few years period.All these observations and quantifications reveal that failure processes can be quite active and significant over very short periods of time (<7years). This whole study is a next step in term of current stability evaluation of the Nice submarine slope.

Poster session / 71

Characterization of submarine landslide complexes offshore Costa Rica: An evolutionary model related to seamount subduction

Author: Dr. HARDERS, Rieka [1]

Co-Authors: Dr. RANERO, Cesar [2]; Dr. WEINREBE, Wilhelm [3]

[1] *University of Barcelona*

[2] *Barcelona Center for Subsurface Imaging (Barcelona-CSI), ICM, ICREA at CSIC*

[3] *GEOMAR Helmholtz Center for Ocean Research Kiel*

Corresponding Author: rharders@ub.edu

Offshore Costa Rica large seamounts under-thrust the continental convergent margin causing slides of complex morphology. The large dimension of the structures has attracted previous investigations and their basic characteristics are known. However, no detailed mapping of their complex morphology has been reported. Here we present a detailed mapping of the failure-related structures and deposits. We use deep-towed sidescan sonar data, aided by multibeam bathymetry to analyze their geometry, geomorphologic character, backscatter intensity, and spatial distribution. Those observations are used to analyze the relationship between landslide characteristics and abundance, to the changes in the style of deformation caused by the subduction of seamounts to progressively greater depth under the margin.

Poster session / 79

Influence of MTD-related relief on the stratigraphic architecture of subsequent gravity-flow and current-controlled deposits

Author: Dr. MOSCARDELLI, Lorena [1]

Co-Authors: Dr. JACKSON, Christopher A. -L [2]; Dr. WOOD, Lesli [3]; Dr. HODGSON, David M. [4]; Dr. DYKSTRA, Mason [1]

[1] *RDI Statoil Austin*

[2] *Imperial College, London*

[3] *Bureau of Economic Geology*

[4] *University of Leeds*

Corresponding Author: lorena.moscardelli@gmail.com

Significant seabed relief can develop along the upper surface of mass transport deposits (MTDs). However, the style of accommodation associated with MTD-related seabed relief and the way in which it influences the evolution and distribution of subsequent gravity-driven (e.g. turbidites) and current-controlled (e.g. contourites) deposits is relatively unknown and scarcely documented. This work seeks to address the fundamental questions associated with the influence that MTDs have on slope morphology, accommodation and depositional patterns in overlying units. Seismic reflection data from the Gulf of Mexico (Lobster area) and offshore Brazil (Santos Basin) are used to illustrate how complex MTD surface topography varies in deep-water environments. The Gulf of Mexico (GoM) data showcases a detached-MTD that locally developed on the flank of a salt body; a series of rotational slides were generated within this MTD and multiple, low-relief depocentres originated on its upper surface. Younger strata onlap the top surface clearly indicating that the underlying MTD formed significant seabed relief that influenced subsequent depositional patterns. In contrast, the Santos Basin seismic data showcases a regionally-developed attached-MTD that contains kilometer scale megablocks that have been transported from the slope onto the distal basinfloor. These megablocks generated seabed relief that modified the average gradient of the MTD upper surface, thus generating additional accommodation and constraining the location of localized depocenters. The relationships illustrated by these subsurface examples are also observed in outcrops in the Paganzo Basin (northwest Argentina), Ablation Point Formation (Antarctica) and Sierra Contreras (Chile), as well as in the subsurface of the UK North Sea using core correlations. It is clear that MTD-related seabed relief can control accommodation development in deep-water settings, and our work is part of an ongoing attempt to better document this influence and integrate data from the subsurface and outcrops. This study is relevant for oil and gas exploration activities because it can help us improve our capacity to predict areas where reservoir prone intervals (e.g. turbidites) can preferentially accumulate in deep-water settings.

Poster session / 78

Back Analysis of the Strength Parameters of the Offshore Sediment from an Earthquake-triggered Submarine Landslide

Author: Prof. HSU, Huai-Houh [1]

Co-Authors: Prof. DONG, Jia-Jyun [2]; Mr. YANG, Che-Ming [2]; Prof. HSU, Shu-Kun [3]

[1] *Department of Civil Engineering, Chienkuo Technology University*

[2] *Graduate Institute of Applied Geology, National Central University*

[3] *Department of Earth Sciences, National Central University, Taiwan*

Corresponding Author: geolab.hsu@msa.hinet.net

The strength parameters of marine sediments play an important role in the assessment of seabed slope stability. Laboratory and in situ tests are usually utilized to determine the sediment strength for engineering purposes. However, for marine sediments in water depth over hundreds of meters, it becomes difficult to carry out in situ tests and obtain undisturbed sediment samples for laboratory tests. Back analysis of the failed slope is then usually adopted to obtain the representative shear strength of the sliding surface. Occurred in the offshore of SW Taiwan on 26 December 2006 with a magnitude of 7.0, the Pingtung earthquake had triggered numbers of submarine landslides (Hsu et al., 2008). This event provides an excellent opportunity to incorporate the back analysis approach to evaluate the representative in situ strength. In this study, two chirp sonar images of the seabed near the SW Xiaoliuqiu before (OR1-809, 29 Step. 2006) and after (OR1-820B, 8 Jan. 2008) the Pingtung earthquake are adopted to identify the location of sliding surface. It is indicated that the studied landslide resulted in a circular sliding surface. The dimensions of the landslide body are 330m in length and a maximum thickness of 30m. Utilizing the widely used software for slope stability (SLIDE 5.0; limit equilibrium method), the strength parameters under the critical condition (i.e. safety factor = 1) can be back calculated. The input parameters included unit weight (ϒ=17 kN/m3, the sediments sampled near the landslide site) and seismic coefficient for pseudo-static analysis (kh=0.067, and kv=0.033) related to the Pingtung earthquake (Central Weather Bureau, Rec. No. 95107). The results indicate that the friction angle (ϕ) of the sliding surface is 14◦with a cohesion (c) of 6 kPa. According to the infinite slope stability theory, the landslide with a thickness of 30m yields an undrain shear strength (Cu) of 37kPa under the critical condition. These evaluated strength parameters are close to the results obtained from the triaxial tests.
Key words: submarine landslide, sediment strength, back analysis, Pingtung earthquake, SW Taiwan.