The sedimentary record of tsunami and storms 2

16:45 - 18:30 Monday, 29th July, 2019
Liffey Hall 1 (Level 1)
Track Coastal and Marine Processes

Posters will be on display on Monday 29th July in Liffey Hall A and B and the abstracts are available to download in the poster session for Monday.

Chairperson: Vanessa Heyvaert

16:45 - 17:00

O-3162 Metagenomics of tsunami deposits using eDNA: First results from the Shetland Islands, U.K.

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Abstract

With the development of high-throughput sequencing technologies in the recent years, there has been a growing number of projects using environmental DNA (eDNA) technologies in environmental, ecological and conservation research and broad areas of Quaternary science.

We will present the first results of the “GEN-EX - Metagenomics of Extreme Wave Events” pioneer project, which is developing high-throughput, metagenomic sequencing techniques to identify foraminifera assemblages (key bioindicators in tsunami and storm deposits), and to unravel their cryptic diversities in onshore extreme wave deposits from their DNA remains.

The project has sampled tsunami deposits from coastal peat sections at three sites on the Shetland Islands, UK (Dury Voe, Garth Loch and Maggie Kettle's Loch), dated to approximately 1.5, 5.5 and 8 ka BP, respectively. By applying classical micropalaeontological techniques, no foraminiferal tests have been found in any of the tsunami deposits analysed to date, whilst inter- to subtidal offshore source deposits show moderate to high foraminiferal concentrations, indicating likely post-depositional dissolution of foraminifera in the onshore tsunami deposits, i.e. a massive loss of information.

The first DNA results are very promising. In the laboratory using stringent precautions to avoid extraneous contamination, foraminiferal DNA has been successfully extracted from palaeo- and modern sediments and also from individual foraminifera. After extensive Polymerase Chain Reaction (PCR) optimisation, amplification of the D1– D2 region of the Large ribosomal Subunit (LSU; 18S) ribosomal DNA from modern individuals has been successfully achieved.

Currently foraminifera are an underrepresented taxonomic group in genetic databases such as GENBANK and BOLD. Thus, Sanger DNA sequencing is in progress to allow us to construct a reference database. For the first time, sequences available to deposit in this database are presented, including our methodology protocols for DNA sample treatment and for the development of custom nuclear DNA primers, which are specific to the target taxonomic group.

All molecular analyses have been complimented by an integrative and comparative approach utilising geoscientific techniques such as micropalaeontological analysis (foraminifera), grain-size distribution, CT scanning, multi-sensor core logging and geochemical analyses.

17:00 - 17:15

O-3163 Characterization of coastal sediments in Zamboanga del Sur, Philippines in relation to offshore tsunamigenic earthquakes

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Abstract

The 1976 Mw 8.1 Moro Gulf earthquake, which occurred on the shallow portion of the subducting slab along the Cotabato Trench in northern Celebes Sea, produced a tsunami with reported tsunami wave heights of up to 9 m. Among the worst-hit areas in southern Philippines include the province of Zamboanga del Sur where the height of tsunami waves reached up to 5 m. This unprecedented event resulted to thousands of casualties and millions worth of damage in the coastal communities bordering Moro Gulf. In order to gain insight on the potential of Cotabato Trench to generate large magnitude tsunamigenic earthquakes, our study conducted sediment sampling in the coastal areas of Pagadian City and Tukuran, Zamboanga del Sur to find potential geologic evidence of past tsunami events. Test pits, auger, and the handy geoslicer were used to observe the subsurface stratigraphy of coastal plains and mangrove swamps up to 1.5 m deep. The sedimentary structures observed in the stratigraphy, i.e. parallel laminations, heavy mineral laminations, and erosive base overlain by coarser sediments, are similar to the descriptions of tsunami deposits in Asia, such as the 2011 Tohoku and 2004 Indian Ocean tsunamis. The sediments collected from the subsurface were also compared to nearshore, fluvial, and terrestrial samples to further understand the sedimentary environment. Satellite imageries from Landsat were also used to interpret if the changes in sediment sizes are influenced by anthropogenic activities. The sediment samples vary in sizes from mud to very coarse sand. The composition is generally detrital grains such as mica, quartz, diorite, andesite, pumice, and other volcanic and pyroclastic rock fragments. While additional analyses are needed to confirm if the sedimentary characteristics are related to a tsunami event, this study is the first to report the characteristics of coastal sediments in northern Celebes Sea, particularly in the Moro Gulf region.

17:15 - 17:30

O-3164 Storm-wave movement of megagravel, and formation of imbricated boulder ridges: evidence from Froude-scaled wave-tank experiments

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Abstract

Coastal boulder deposits (CBD) are supratidal clastic deposits that include isolated boulders, small clusters, and extensive ridge systems built of stacked, imbricated clasts. Individual boulders can weigh many 10s to 100s of tonnes. They are emplaced by waves along steep rocky coasts. Some are on cliffs as high as 50m above high water, and others are found at the back of shallowly dipping coastal ramps, up to 250 m inland of the tide line. They occur worldwide, but some of the best examples occur on the west coast of Ireland. An outstanding question about these deposits is whether storm waves can produce the structured and imbricated boulder ridges that are characteristic of CBD, or whether they are the signatures of tsunami.

We carried out Froude-scaled 1:100 wave tank experiments, using a JONSWAP spectrum to simulate realistic storm conditions, with Hs ranging from 10-14 m (scaled equivalent). Model boulders (441-1075t scaled equivalent) were situated on a cliff-top platform (10 m a.s.l. scaled equivalent), and we examined both the movement of individual blocks and the formation of boulder clusters and ridges on the platform. We ran multiple tests, varying boulder size and configuration. Wave gauges at several locations in the tank recorded water surface elevation, and video footage captured wave parameters and wave-boulder interactions that are difficult to measure at full scale.

Overtopping waves did not disperse cliff-top boulders, but tended to deposit them in clumps and ridges, with imbrication and geometry matching coastal boulder deposits, indicating that storm waves can and do form imbricated boulder ridges. The majority of boulder displacements were caused by a small subset of the incident waves, the key to boulder transport being development of a high velocity bore. The largest waves are not necessarily the most effective: instead, wave-front steepness just before cliff impact seems to control the strength of post-collapse cross-platform flow. Waves that approached the cliff unbroken, had a front slope angle in the range 15°-25°, and were taller than the cliff, generated the most powerful bores. These waves moved very large boulders with masses in excess of those predicted by existing hydrodynamic equations.

17:30 - 17:45

O-3165 Pluri-decadal to annual storm-induced geomorphic processes on the Valahnúkur coastal boulder ridge, SW Iceland

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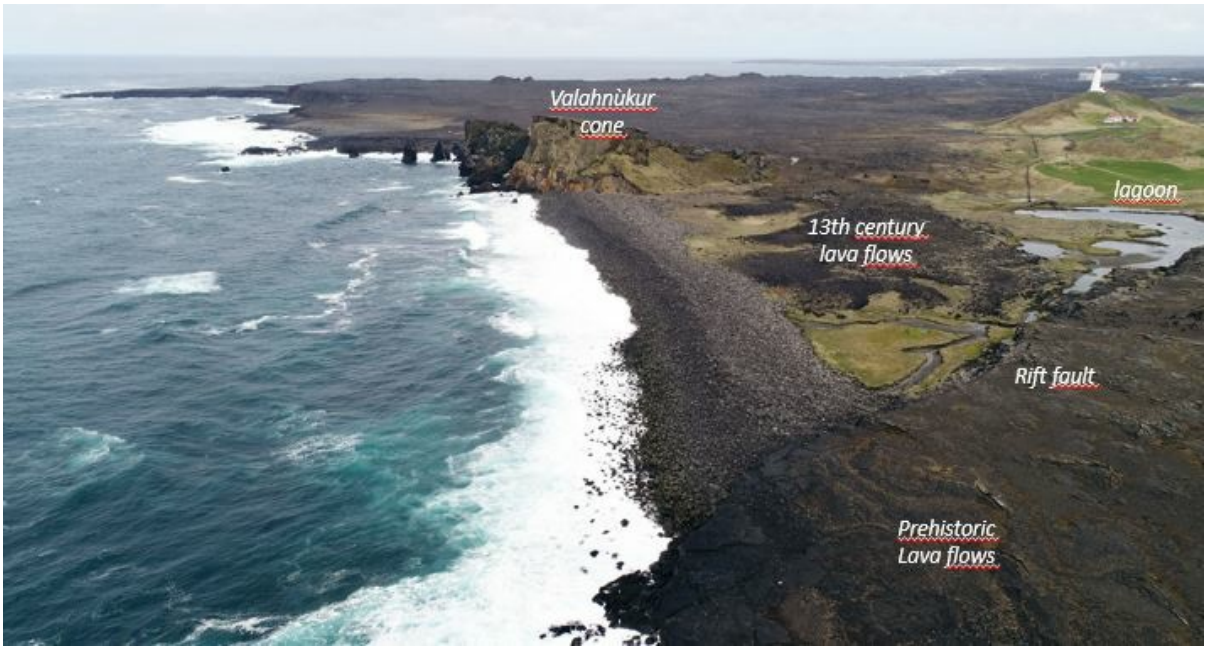
Abstract

While recent studies highlighted the great mobility of boulder beaches related to the impact of storm waves, numerous researches are still needed to better understand the morphodynamic of coastal boulder accumulations and to better interpret fossil boulders deposits. This paper provides original data about storm-induced geomorphic processes and their impact on the Valahnúkur boulder ridge (figure 1). The study site is located west of the Reykjanes Peninsula, in the south-west of Iceland.

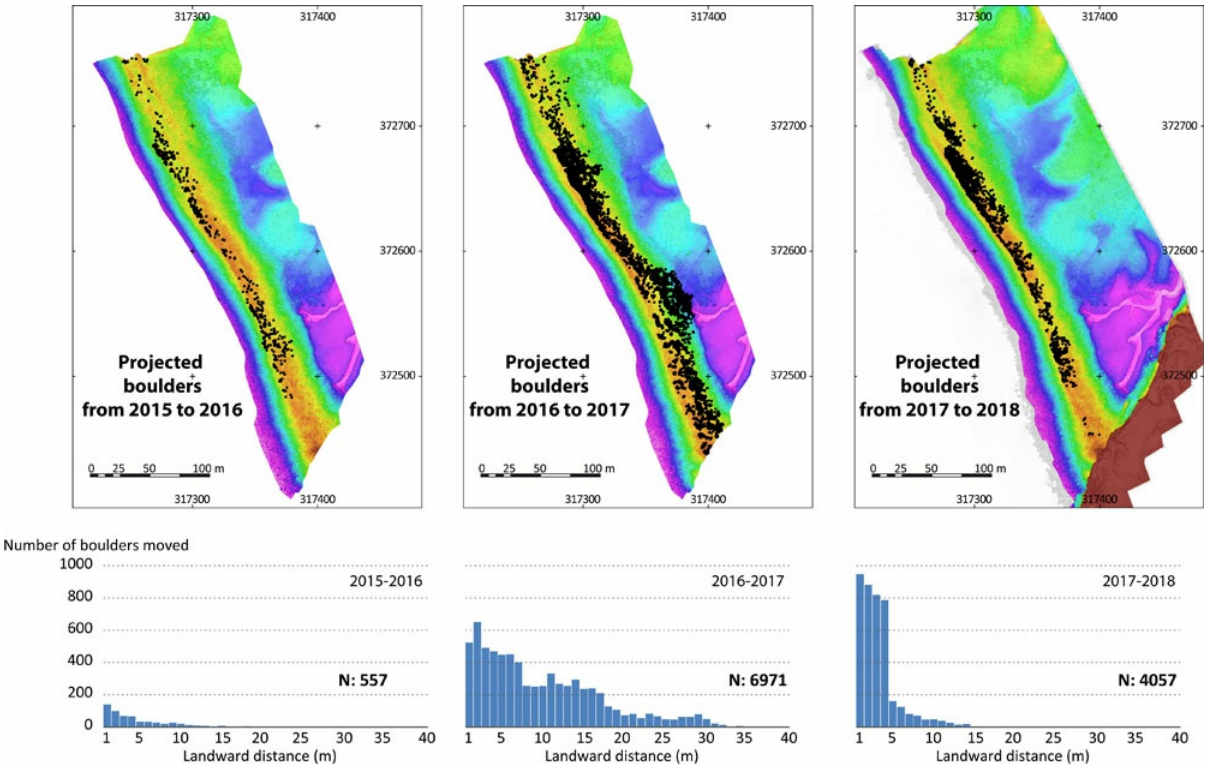


Firstly, the historical evolution of the boulder ridge was reconstructed from a set of aerial photographs between 1978 and 2010. Photographs were geometrically corrected and georeferenced according to the standard procedure to quantified the shoreline changes. Secondly, four kite and drone surveys were realized yearly between May 2015 and May 2018. The Digital Elevation Models (DEMs) produced using Structure-from-Motion photogrammetry were compared to deduce the morphological changes. Four orthophotographs were analyzed to quantified the movement of boulders. Hydrodynamic conditions were reconstructed using wave buoy and tide gauge measurements. Storminess was first assessed using a POT method. The extreme morphogenetic events were recognized using the 98th percentile of the significant wave height. The storm duration was estimated using the 75th percentile to define the start-time and the end-time of storm events. Wave runup were calibrated from the analysis of a wave/swash motion data set acquired by video monitoring.

The historical analysis of shoreline change shows a significant landward retreat of the ridge during the last 40 years. The Highest rates of retreat are recorded in the northern part of the barrier where a large washover fan was formed during the 1990s and reactivated in the 2000s. This suggests a set of overwash events and the episodic flooding of the boulder ridge, probably during major storm events. The southern part of the barrier also shows high migration rates suggesting sediment transfers from the beachface to the back-barrier.

The annual topo-morphological survey indicates various morphological responses according to the frequency and magnitude of winter storm events. From May 2015 to May 2016, the swash processes were dominant. The mobility of boulders was moderate (N=557) and restricted to the beachface (figure 2). These changes were attributed to fair weather conditions during the winter. The period from May 2016 to May 2017 was dominated by overwash processes. The results highlighted a crest reworking and a landward projection of high number of boulders (N= 6971) due to several intense winter storm events associated with high water levels. From May 2017 to May 2018, the morphodynamic regime was dominated by overtopping processes. Despite the large

number of boulders moved (N=4057), the sediment transfer was limited to the crest line. These changes can be attributed to three storm events associated to moderate water levels.



17:45 - 18:00

O-3166 Modern and historical tropical cyclone and tsunami deposits at the coast of Myanmar

Dominik Brill[1], Katharina Seeger[1], Felix Reize[1], Kay Thwe Hlaing[2], Martin Seeliger[3], Anna Pint[1], Kyaw Kyaw[4], Frauke Kraas[1], Helmut Brückner[1]
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Abstract

Myanmar's coast is prone to flooding by both tropical cyclones (TCs) and tsunamis from multiple sources. However, although TCs (e.g. TC Mala 2006 and TC Nargis 2008) and tsunamis (2004 Indian Ocean Tsunami) repeatedly caused flooding during the last decades, the temporal restriction of existing records limits the robustness of regional long-term frequency-magnitude information. While there is only a single historical tsunami in AD 1762, associated with a major rupture of the Rakhine segment and with inconclusive information with regard to its impact at the coast, that provides data beyond the instrumental record, sediments of past flooding events might allow the extend it to much longer time periods.

So far, very limited research on coastal flooding deposits has been conducted in Myanmar. This study presents results of a field survey along Myanmar's western (Rakhine) and eastern (Thanintharyi) coast. To provide a local reference for the sediment characteristics and preservation potential of TC and tsunami sediments, onshore deposits of 2006 TC Mala and 2008 TC Nargis were documented. Both events formed sand sheets with landward extents of up to ~100 m or washover fans in back-barrier areas. Significant flooding by the 2004 tsunami was only reported at the eastern coast, where it is reflected by a thin sand sheet identified in a paddy field. However, at most sites the flooding deposits display a very poor preservation potential. After only a few years most evidence is already overprinted by soil formation that probably obliterates all differences to sandy subsoils within decades.

Only where sand sheets extend into swales or back-barrier depressions characterized by the deposition of terrestrial fine sediments during the rainy season, preservation may potentially allow for detection after longer time periods. In the swales of a beach-ridge plain at the west coast, distinct marine sand layers predating the TCs and tsunami in the early 2000s were identified. A combination of luminescence, radiocarbon and ^{137}Cs dating points to 1982 TC Gwa and an unrecorded TC in the 1950s as the most likely candidates. Comparison with the complete historical TC record indicates that the archive is only sensitive to TCs of category 4 (or higher) with landfall directly in or a few tens of kilometers north of the study area. While the presented TC records are restricted to the last 100 years, luminescence ages of the beach-ridges indicate that the swales landward of the one investigated in this study might provide TC information for at least the past 700 years.

18:00 - 18:15

O-3167 Sedimentary and erosional features caused by hurricane Irma

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Abstract

The 2017 Atlantic Hurricane Season drew renewed attention to the need for storm risk assessment as it was the costliest season on record. Irma was the strongest recorded hurricane to form in the Atlantic Ocean and reached the northwestern Caribbean Islands as a category 5 hurricane on Sept 5th 2017.

A post-hurricane survey was conducted on Anegada (British Virgin Islands). The project takes advantage of pre-event field data collected on Anegada in earlier years that allows for a detailed comparison of pre- and post-Irma data. Irma passed ca. 35 km south of Anegada. Maximum wind speed on Anegada was ~256 km/h, related maximum offshore wave heights were ~17 m. Irma had a surprisingly weak storm surge of <3 m as indicated by wrack lines and overwash deposits. The small surge may be explained by the fact that Irma's eyewall passed south of the island and winds were mainly shore parallel. Thus, even though a category 5 hurricane, very close to the island, Irma does not represent the worst-case scenario for a storm on Anegada.

Substantial coastal erosion occurred on Anegada's north shore. A steep erosional scarp of about 1 to 1.5 m height and a retreat of the coastline by several meters were documented. While erosion dominates the northwest and central north shore, depositional evidence is present along the northeastern and southern shore. Thick faintly laminated sand sheets that cover beach sand have a max. thickness of ca. 35 cm. Deposits are massive and well-sorted carbonate sands. Small washover lobes that contain shell hash have sediment thicknesses of 5 cm. The deposits contains *Homotrema rubra*, a red foraminifer that bleaches predictably following detachment from the reef. The relatively high concentration of vibrantly colored *Homotrema* suggests that the majority of sediment was freshly sourced from the fringing reef. Furthermore, a pre-existing coast-parallel coral rubble ridge was entirely reworked. Cobbles and boulders were moved several meters in landward direction. Few cobbles were washed into the sea, moved shore parallel towards the west and transported back onto the coastal platform.

The depositional and erosional evidence of Irma differ significantly from features left by historical tsunami that breached the coastal dunes and transported sand and large living corals several hundreds of meters on land. The deposits of the 1755 Lisbon tsunami revealed key differences in their sediment provenance as they contain reef crest foraminiferal assemblages with a contribution of offshore planktics, whereas the Irma deposits are characterized by reef flat to reef crest assemblages.

18:15 - 18:30

O-3168 3500-year western Pacific storm record warns of additional storm activity in a warming warm pool

Yuanfu Yue[1], Kefu Yu[1], Shichen Tao[2], Huiling Zhang[3], Guohui Liu[2], Ning Wang [1], Wei Jiang[1], Tianlai Fan[1], Wuhui Lin[1], Yinghui Wang[1]

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Abstract

Frequent storm surges often cause catastrophic impacts on human lives and the global economy; however, these phenomena are not well understood. In this study, a regional storm reconstruction is performed based on a grain-size analysis and stratigraphic modelling of the accelerator mass spectrometry radiocarbon dates of benthic foraminifera from two neighbouring lagoon cores from Lingyang Reef in the Xisha Islands located in the northern South China Sea of the western Pacific. The dating results from the lagoon cores reveal a ~3500-year depositional history. Three different depositional units are recognized based on a time series of distinct grain-size variations that correspond to the following three stages of storm activity: intense and frequent storms from ~3500 to 3100 cal yr BP and ~1800 cal yr BP to present and weak and infrequent storms from ~3100 to 1800 cal yr BP. A high sedimentation rate is observed from ~2800 to 2600 cal yr BP in both cores, and it was likely caused by a slump deposit associated with a tsunami event. In addition, grain-size variability may be associated with changes over time caused by the synchronous Asian monsoon and may also be correlated with climate records retrieved from the ice cores from Greenland; thus, this variability could indicate pervasive global climatic teleconnections. The overall temporal patterns of the isolated coral branches and shells from the sediment sequences are well correlated with the high sea surface temperatures in the western tropical Pacific. We suggest that increasing sea surface temperatures in the future may lead to more intense storm activity in the western Pacific warm pool as the planet warms.