



United Nations
Educational, Scientific and
Cultural Organization

Organisation
des Nations Unies
pour l'éducation,
la science et la culture

Organización
de las Naciones Unidas
para la Educación,
la Ciencia y la Cultura

Организация
Объединенных Наций по
вопросам образования,
науки и культуры

منظمة الأمم المتحدة
للتربية والعلم والثقافة

联合国教育、
科学及文化组织



UNIVERSITY OF MALTA
L-Università ta' Malta



Reducing Earthquake Losses in the Extended Mediterranean Region

Final Report

UNESCO-RELEMR XXXII International Workshop

13 – 16 February 2012

University of Malta
Sliema - Malta



United Nations
Educational, Scientific and
Cultural Organization

Organisation
des Nations Unies
pour l'éducation,
la science et la culture

Organización
de las Naciones Unidas
para la Educación,
la Ciencia y la Cultura

Организация
Объединенных Наций по
вопросам образования,
науки и культуры

منظمة الأمم المتحدة
للتربية والعلم والثقافة

联合国教育、
科学及文化组织



UNIVERSITY OF MALTA
L-Università ta' Malta

Reducing Earthquake Losses in the Extended Mediterranean Region

FINAL REPORT

UNESCO-RELEMR XXXII International Workshop

13 – 16 February 2012

University of Malta
Sliema - Malta

United Nations Educational, Scientific and Cultural Organization – UNESCO
U.S. Geological Survey – USGS
University of Malta

Editorial coordinators: Frederick Simon
Pauline Galea
Jair Torres

Cover photo credit: Jair Torres

For further information, please contact:

Unit for Natural Disasters
Natural Sciences Sector
UNESCO
1, rue Miollis
75732 Paris cedex 15 France
Phone: + 33-1-45 68 41 20
Fax: + 33-1-45 68 58 21
E-mail: b.rouhban@unesco.org

The authors are responsible for the choice and presentation of facts contained in this publication and for the opinions expressed therein, which are not necessarily those of UNESCO and do not commit the Organization. The designations employed and the presentation of the material throughout this publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Foreword

In many countries of the Mediterranean Basin, disasters caused by natural and environmental hazards continue to exact a heavy toll in terms of the loss of human lives and the destruction of economic and social infrastructure. With population growth in the coastal areas of countries concerned, expanding public and private infrastructure, and continuing trends towards urbanization and industrialization, the risks from great disasters are expected to increase over the coming years and decades.

Among the numerous natural disasters that the countries of the Mediterranean have experienced, earthquakes have historically had great impacts. It is necessary to mobilize scientific knowledge and technological know-how to assess earthquake hazards in the Extended Mediterranean Region (EMR) and to strengthen disaster mitigation measures. To this end, regional collaboration needs to be encouraged. Since 1993, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United States Geological Survey (USGS) have been cooperating with EMR scientific and engineering organizations under the programme: Reduction of Earthquake Losses in the Extended (formerly Eastern) Mediterranean Region (RELEMR). The programme benefits from the collaboration of the International Seismological Centre (ISC) and other entities. The purpose of the Programme is to provide a platform for examining regional approaches to improve seismic data and earthquake risk mitigation. A number of collaborative activities have taken place under this initiative. These activities have included more than thirty workshops that have been held since the start of the programme in 1993. Participants from countries in the region extending from Northern Africa to the Middle East were invited to attend.

A workshop was convened in Sliema, Republic of Malta, 13 – 16 February 2012. The present report provides an overview of the outcome of this workshop. This workshop and its follow-up should be seen in the context of the implementation by the countries concerned of the Hyogo Framework for Action 2005-2015, which was adopted at the World Conference on Disaster Reduction held in Kobe, Japan, in January 2005 and convened within the United Nations International Strategy for Disaster Reduction.

UNESCO thanks the USGS and the University of Malta for their cooperation in the implementation of the workshop and for the production of this report. The commitment and hospitality of the University of Malta have made the meeting a successful event. UNESCO wishes to express its gratitude to all those who have contributed to the success of the workshop. UNESCO is especially grateful to Dr. Pauline Galea and Dr. Sebastiano D'Amico for their careful attention before, throughout, and after the workshop.

The content of this report does not necessarily reflect the views of UNESCO.

March 2012



Badaoui Rouhban
Director, Unit for Natural Disasters
Natural Sciences Sector,
UNESCO, Paris

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

Sliema, Republic of Malta
13 – 16 February 2012

Executive Summary

In recent years, there were several major, damaging earthquakes in the extended Mediterranean region (EMR). In the interest of reducing earthquake risk in the EMR, UNESCO, the USGS, and the University of Malta convened a workshop in Sliema, Republic of Malta, 13 – 16 February 2012, on *Seismicity and Earthquake Engineering in the Extended Mediterranean Region*. Participants from Northern Africa to the far Middle East were invited to attend. Sixty (60) participants from the following UNESCO Member States attended the Malta 2012 workshop: Algeria, Cyprus, Egypt, France, Iraq, Israel, Italy, Jordan, Lebanon, Libya, Malta, Morocco, Oman, Palestine, Saudi Arabia, Spain, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, and the United States. This report provides an overview of the outcome of this workshop.

The workshop was opened by Dr. Pauline Galea (University of Malta), Dr. Michael Foose (USGS), Dr. Badaoui Rouhban (UNESCO), Dr. Charles V. Sammut (Dean, Faculty of Science, University of Malta), and the Hon. Dr. Ray Bondin (Ambassador Permanent Delegate of Malta to UNESCO).

The first keynote address was presented by Professor Ruben Borg from the Department of Civil and Structural Engineering, Faculty for the Built Environment, University of Malta: *Seismic Damage Assessment of Structures: Case Study of the Abruzzo 2009 Earthquake*. The second keynote address was presented by Professor Pauline Galea from the Physics Department, University of Malta: *The Maltese Islands - Tectonic Environment, Seismicity and Hazard*.

Three Special Sessions were held during the Malta 2012 RELEMR Workshop: *Paleoseismicity in the Extended Mediterranean Region*, *Site Effects*, and *Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects*.

In addition to the two keynote addresses, 34 papers were presented on topics including, but not limited to: Structural and non-structural damage and assessments, ambient noise assessments, tsunami vulnerability, national seismic networks, estimation of earthquake risk parameters, recent seismicity in the RELEMR region, seismic hazard and risk assessment and mitigation, site effects, paleoseismology and archeoseismology, seismic risk awareness, induced seismicity, post-earthquake evaluation of structural damage, seismic site response and zonation.

An open discussion on the objectives of RELEMR was co-chaired by Mike Foose (USGS) and Badaoui Rouhban (UNESCO). The discussion focused on two aspects: (1) the definition of short and longer term objectives and (2) the way to develop synergies with on-going initiatives at European and global levels. There was a consensus among the participants that recognized that RELEMR is a unique and very valuable initiative. Rémy Bossu (EMSC) presented a number of projects and initiatives that raised a large interest among the participants. Real time waveform exchange was rapidly identified as an objective of interest for a number of partners. A second objective to be refined at a later stage could

be the production of an educational map in Arabic. The next RELEMR meeting will include a 1-2 day workshop on real time waveform exchange organized in collaboration with EMSC and ORFEUS and coordinated with the development of the tsunami warning systems in the Mediterranean region.

The field trip was planned to observe the geology and neotectonics of the south coast of Malta and to visit two of the most beautiful Neolithic temples on the islands. It also included a visit to one of the oldest cities in Malta – Vittoriosa – lying on one side of the Grand Harbour, opposite Valletta. Because of inclement weather, many geologic stops could not be visited.

Introduction

The Mediterranean region, because of its geological structure, seismicity, active tectonics, topography and climate, has been frequently subjected to natural disasters resulting in great losses of life and property. Field studies and investigations of disasters indicate that large areas of the land surface, population, infrastructure, and industry of the region have been subjected to earthquakes in the past or will be subjected to earthquakes in the future.

In the Eastern Mediterranean Region, these earthquakes are associated with the northward movement of the Arabian plate. The 1,000-km long western boundary of the Arabian plate is a complex plate boundary, extending from zones of sea-floor spreading in the Red Sea to zones of plate convergence in Turkey, and lies along the line of the Gulf of Aqaba, the Dead Sea rift, the Bekaa Valley and the Ghab depression. The sense of motion along the Dead Sea transform fault system is left lateral, with the eastern side moving northward relative to the western side. Total displacement is estimated at about 107 km since Oligocene time, with an annual rate of about 0.5 cm. over the last 7 to 10 million years.

On 22 November 1995, an M_w 7.2 earthquake occurred in the central Gulf of Aqaba region causing damage in nearby communities in Jordan, Egypt, Israel, and Saudi Arabia and was felt for more than 700 km. An aftershock sequence lasted for more than one year with numerous shocks exceeding M_s 5.0. The size of the main shock and some of the aftershocks demonstrates the threat that earthquakes pose to the EMR. These events occurred during RELEMR's (Reduction of Earthquake Losses in the Eastern Mediterranean Region) second Joint Seismic Observing Period (JSOP-II) and therefore we had the ability to accurately locate the earthquake sequence by integrating data from all the national networks in the region. This permitted greatly improved accuracy in epicenter and magnitude determinations. In October 1997, a workshop was hosted by the Cyprus Geological Survey Department to locate the main shock and approximately ten aftershocks.

In the western Mediterranean region, which includes portions of Greece, Italy, Portugal, Spain and northern Africa, seismicity is widely distributed and there are many earthquake hazards. Modern interpretations of this seismicity suggest the existence of seven micro-plates, with seismic activity concentrated at the micro-plate boundaries, which coincide with the Alps, Apennines, and Hellenic arc. Among the most notable recent (1996) seismic events was the M 6.8 earthquake in the historic city of Assisi in the Italian Apennines which destroyed numerous cultural artifacts, including important frescoes.

In 2003, the Extended Mediterranean Region (EMR) experienced devastating earthquakes in Boumerdes, Algeria, and Bam, Iran. Both countries experienced extensive economic losses in addition to the loss of lives and injuries.

Since 1993, the USGS and UNESCO have been cooperating with Eastern Mediterranean Region earth science organizations under the RELEMR program. Countries from the Western Mediterranean Region have participated since 1995. The International Seismological Centre (ISC), the European-Mediterranean Seismological Center (EMSC), Lawrence Livermore National Laboratory (LLNL) and Observatories and Research Facilities of European Seismology (ORFEUS) have also cooperated in the program.

The Malta – 2012 Workshop

Background

In recent years, there were several major, damaging earthquakes in the extended Mediterranean region (EMR). In the interest of reducing earthquake risk in the EMR, UNESCO, the USGS, and University of Malta convened a workshop in Sliema, Republic of Malta, 13 – 16 February 2012. Participants from organizations in countries extending from Morocco in the west to Iran in the east were invited to attend. The list of participants is given in Annex A.

This workshop continued efforts addressed in similar RELEMR workshops in Amman, Jordan, 4-7 May 1998; in Istanbul, Turkey, 14-17 October 1998, 29 May – 2 June 2000 and 25-27 October 2000, Nicosia, Cyprus, 3-7 May 1999 and 10-13 September 2003; Kumburgaz, Turkey, 29 May – 2 June 2000; Santa Susanna, Spain, 20-25 May 2001; Larnaca, Cyprus, 19 – 22 March 2002; Antakya, Turkey, 11 – 14 December 2002; Nicosia, Cyprus, 2003; Aqaba, Jordan, 18 – 28 January 2004; Ankara, Turkey, 26 – 29 January 2005; Valletta, Malta, 24 – 27 April 2006; Barcelona, Spain, 19 – 21 December 2006; Madrid, Spain, 26 – 29 November 2007, Istanbul, Turkey, 27 – 29 May 2008, Lisbon, Portugal, 26 – 29 October 2009, Ankara, Turkey, 21 – 24 June 2010, and Nicosia, Cyprus, 28 February – 3 March 2011.

The goals of RELEMR workshops are to foster data exchange among countries in the region, to conduct joint activities and experiments that would improve the quality of seismic data, to improve hazard and loss assessments in the Mediterranean region, to improve the dissemination of earthquake engineering data, and ultimately to improve the seismic provisions of building codes in the region. In Amman, working groups were formed on 1) seismic calibration and 2) the development of a RELEMR seismic hazard map. The 1998 workshop in Istanbul was organized along these themes. The Cyprus-1999 workshop added sessions on the role of auxiliary station operators and their responsibilities and the interaction with their earthquake-reporting activities. The first Istanbul-2000 workshop was dedicated to seismic calibration using the Dead Sea explosions and selected natural events while the second Istanbul-2000 workshop was dedicated to large earthquakes in the region. The Spain 2001 workshop focused on Earthquake Hazard Assessment Practice and Velocity Models and Reference Events in the Mediterranean Region and this workshop focused on seismicity and hazard assessment in the Mediterranean region. The Lisbon 2009 and Ankara 2010 had sessions on the use and modification of the HAZUS software package developed by the U.S. Federal Emergency Management Agency. The Cyprus-2011 workshop had special sessions on the *RELEMR data exchange website*, *Tsunamis in the Mediterranean Sea and the Persian Gulf*, *CTBTO supporting activities in RELEMR*, and the *Earthquake Model of the Middle East Region*. The Malta-2012 workshop had special

sessions on *Paleoseismicity in the Extended Mediterranean Region, Site Effects, Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects*, and open discussion on programs for future RELEMR meetings and school safety. The program for this workshop is presented in Annex B.

Sixty (60) participants from the following UNESCO Member States attended the Malta 2012 workshop: Algeria, Cyprus, Egypt, France, Iraq, Israel, Italy, Jordan, Lebanon, Libya, Malta, Morocco, Oman, Palestine, Saudi Arabia, Spain, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, and the United States. This report provides an overview of the outcome of this workshop.

Workshop Proceedings

In earlier workshop reports, detailed notes on the presentations were included. In this workshop, abstracts of the papers are given in Annex C and all of the papers were presented using PowerPoint™ and are included on the DVD that accompanies this report. Therefore, as in all reports since 1999, no detailed notes of contributed presentations are included in this report. Notes of presentations in the Special Sessions (mainly taken from the Abstracts) are summarized below.

Opening Remarks

In the Opening Session, welcoming remarks were made by:

- Dr. Pauline Galea, University of Malta
- Dr. Michael Foose, USGS
- Dr. Badaoui Rouhban, UNESCO
- Prof. Charles V. Sammut, Dean, Faculty of Science, University of Malta
- Hon. Dr. Ray Bondin, Ambassador Permanent Delegate of Malta to UNESCO

Presentations

Keynote addresses

The first keynote address was presented by Professor Ruben Borg from the Department of Civil and Structural Engineering, Faculty for the Built Environment, University of Malta: *Seismic Damage Assessment of Structures: Case Study of the Abruzzo 2009 Earthquake*.

The Abruzzo earthquake hit the city of L'Aquila and its surroundings on the 6th April 2009. A magnitude $M_w=6.3$ ($M_s=6.3$, $M_L=6.2$, INGV) normal faulting earthquake struck the Abruzzo Region located in the central part of Italy, with an epicentre of shallow focal depth (9.5 km) very close to L'Aquila, a city of about 73,000 inhabitants. This main event was the strongest of a sequence which had started a few months earlier, releasing 23 earthquakes (including major aftershocks) of $M_w>4$ between March 30 and April 23, 2009.

The earthquake struck during the night, when most people were sleeping. A wide area was affected by the seismic event including the historic center of L'Aquila, the suburbs and 90 nearby villages. The death toll was dreadfully high with 305 people killed, approximately 1500 were injured, more than 24,000 people were left homeless, and 70,000-80,000

residents were temporarily evacuated in the first months after the disaster. Many of cultural sites in the region were badly damaged or destroyed, including Romanesque churches, historic buildings, and other monuments dating from the Middle Ages to the Renaissance and Baroque periods.

The second keynote address was presented by Professor Pauline Galea from the Physics Department, University of Malta: *The Maltese Islands - Tectonic Environment, Seismicity and Hazard*.

The Maltese islands lie in the Sicily Channel, on a shallow submarine platform that extends northwards to southeast Sicily. Geologically, the islands are very similar to the Ragusa platform in the SE corner of Sicily. The Malta-Ragusa plateau is bounded to the east by the spectacular and seismically active Sicily-Malta escarpment that drops down steeply to the Ionian basin and to the north by the Hyblean mountain range. To the south and west, the Sicily Channel plateau is interrupted by a series of tectonic features – most prominently the three grabens of the Sicily Channel Rift Zone, trending NW – SE and active since the Late Miocene, inter-related by a number of transform lineaments.

The tectonics of the Sicily Channel, and in particular, the dynamics that control the extension of the grabens, are still under discussion. They are necessarily related to major tectonic readjustments that have taken place, and are still occurring, in the Central Mediterranean region – the northwesterly rotation of the African plate relative to Europe, the retreat and slowing down of subduction at the Calabrian arc, the north-easterly directed subduction of African lithosphere at the Hellenic arc, and the possible initiation of southward-directed subduction at the North African margin.

To date, the region has been regarded as one of low and sparse seismicity, mostly because earthquakes are of low magnitude and in general outside the range of regional, land-based networks, and have thus been inadequately monitored and located. With improved monitoring facilities on Malta, a more clear picture is emerging of the seismic activity in the region. The prospect of improved seismic networking in the Central Mediterranean also augurs well for the better constraint on the relations between seismicity and tectonics. Moreover, a better understanding of the earthquake potential of these features will contribute towards improved seismic hazard assessment of the Maltese islands, which have suffered earthquake damage a number of times in the past, and are characterized by significant exposure and building vulnerability in the present day.

Open discussion on the objectives of RELEMR

This session was co-chaired by Mike Foose (USGS) and Badaoui Rouhban (UNESCO).

The first RELEMR meeting was held in Cairo, Egypt, in 1983. Since 1983, despite a lack of long-term funding, 33 RELEMR meetings have been held in many countries in the Mediterranean Region. The major goal of all meetings was to exchange data and information on national and regional earthquakes, seismic networks, engineering issues, and research studies. Most meetings also had, to a greater or lesser extent, a training component generally involving computer software (e.g., SEISAN or HAZUS training). Some meetings had a component involving joint research (e.g., Joint Seismic Observation Period (JSOP) or the Dead Sea explosions). It is generally conceded that RELEMR meetings have had a major impact in improving the understanding and the importance of seismology and earthquake hazard mitigation in the region.

At the Malta 2012 meeting, the discussion focused on two aspects: (1) the definition of short and longer term objectives and (2) the way to develop synergies with on-going initiatives at European and global levels. There was a consensus among the participants that recognized that RELEMR is a unique and very valuable initiative. It is a unique meeting point for the Middle Eastern and Northern African seismological and engineering communities and its duration has allowed the development of exceptional and efficient networks within the region.

As an introduction to the discussion, Rémy Bossu (EMSC) presented a number of projects and initiatives that raised a large interest among the participants. Real time waveform exchange was identified as an objective of interest for a number of partners. A second objective to be refined at a later stage could be the production of an educational map in Arabic.

The next RELEMR meeting will include a workshop on real time waveform exchange organized in collaboration with EMSC and ORFEUS and coordinated with the development of the tsunami warning systems in the Mediterranean region. As a component of data exchange, a training session on SeisComp3 will be conducted. Data used in the training exercises will come from the RELEMR region, in order to make the training more relevant to the region. This workshop will also be the opportunity to develop bilateral collaboration with European partners that have already expressed an interest in participating in RELEMR meetings. The rest of the meeting will remain focused on traditional RELEMR topics.

Contributed Papers

In addition to the two keynote addresses and special sessions on *Paleoseismicity in the Extended Mediterranean Region, Site Effects, Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects*, and open discussions on programs for future RELEMR meetings and school safety, 34 papers were presented on topics including, but not limited to: Structural and non-structural damage and assessments, ambient noise assessments, tsunami vulnerability, national seismic networks, estimation of earthquake risk parameters, recent seismicity in the RELEMR region, seismic hazard and risk assessment and mitigation, site effects, paleoseismology and archeoseismology, seismic risk awareness, induced seismicity, post-earthquake evaluation of structural damage, seismic site response and zonation.

Special Sessions

Three Special Sessions were held during the Malta 2012 RELEMR Workshop: *Paleoseismicity in the Extended Mediterranean Region, Site Effects, and Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects*.

Paleoseismicity in the Extended Mediterranean Region

In many countries of the extended Mediterranean region, there have very extensive studies involving trenching and dating of major earthquakes including many that pre-date instrumental times. Paleo-archeological investigations have also been carried out in some countries. In conducting seismic hazard assessments, the data generated by these studies

is invaluable. We invited participants to give presentations on paleoseismology and paleo-archeology from their countries.

Mohamed Reda Sbeinati: *Timing of Earthquake Ruptures at the Al Harif Roman Aqueduct (Dead Sea fault, Syria) from Archeoseismology and Paleoseismology*

Mohamed Reda Sbeinati and his colleagues studied the timing of earthquake ruptures at the Al Harif Roman Aqueduct (Dead Sea fault, Syria) using archeoseismology and paleoseismology. The Al Harif Roman aqueduct is located on the north-south trending approximately 90-km-long Missyaf segment of the Dead Sea Fault. The study utilized four archeological excavations, three paleoseismic trenches and the analysis of six tufa cores. Damage to the aqueduct wall exhibits successive left-lateral fault offsets that amount 13.6 ± 0.2 m since the aqueduct construction (65 BP). Radiocarbon dating of sedimentary units in the trenches and building cement of the aqueduct wall and tufa cores constrain the late Holocene aqueduct history. Their study infers a lower and upper bound 4.9 – 6.3 mm/yr slip rate along the Missyaf segment of the Dead Sea Fault in Syria. The inferred successive faulting events, fault segment length, and related amount of coseismic slip yield M_w equal to 7.3 - 7.5 for individual earthquakes. The identification of a temporal cluster of large seismic events during the last 3500 years suggests periods of seismic quiescence reaching 1700 years along the Missyaf fault segment.

Rivka Amit: *The Use of Paleoseismic Data for Seismic Hazard Evaluations of the Dead Sea Transform*

The synthesis of paleoseismic data from several segments along the Dead Sea Transform (DST) shows that each segment has a specific pattern of large earthquake distribution. Rivka Amit found that during the last 20 thousand years the segments of the Arava and the Jordan Valley have recurrence intervals of large events of about 1000 years while in the Hula valley the recurrence interval is 350 years and 3-5 thousand years in the Dead Sea segment. The Arava and the Dead Sea segments show a similar change in earthquake pattern over time. The probability of a large earthquake ($M \geq 6$) occurring in both segments decreased gradually with time over the last 100 thousand years. Integration of paleoseismic and historical records of strong earthquakes of the DST segments show that they all lie on the linear extrapolation of the frequency–magnitude relation of the instrumental record.

Stelios Nicolaidis: *Palaeoseismicity of the Cyprus region: the AD 365 Kourion Earthquake*

Cyprus lies within the boundary zone of the Alpine-Himalayan belt where approximately 15% of the global seismic activity occurs (Ambraseys, 1965). The belt extends from the Atlantic along the Mediterranean through Italy, Greece, and Turkey to Iran, India and the Pacific. The tectonic framework of the Eastern Mediterranean is dominated by the collision of the Arabian and African plates with that of Eurasia (McKenzie, 1970). Cyprus is located near the triple junction of the African, Arabian and Eurasian Plates (Papazachos and Papaioannou, 1999) and as a result it has a long history of earthquakes and tsunami activity that affected the island, as noted in written, archaeological and geological records (Ambraseys and Adams, 1993).

Kourion suffered from numerous devastating earthquakes between the 3rd and 4th centuries AD, until a severe seismic event, believed to have occurred at approximately AD 365, had led to its permanent destruction. Evidence that an earthquake may have leveled Kourion first

surfaced in 1934, when the American archaeologist J. F. Daniel uncovered the remains of a Roman house in which he found “fingerprints” of an earthquake. During 1984-1987, the American archaeologist D. Soren and his team discovered that the Kourion area was virtually undisturbed. Kourion had been completely abandoned after the disaster and no one had returned to collect the dead (Soren, 1988; Soren and James, 1988). Soren estimates that 500 people died in the Kourion area, but the toll in all of south-west Cyprus was perhaps in the thousands.

Ryad Darawcheh: *Palaeoseismology along the Levant Fault System in Western Syria and Lebanon: Conclusive Evidence of Large Earthquakes*

Palaeoseismic and geomorphologic investigations were carried out within the last decade along segments and branches of the central and northern parts of the Levant fault system in western Syria and Lebanon in order to understand the earthquake behavior in the Holocene. These studies revealed the following main results: (1) five large historical earthquakes ($M_s \geq 7.0$) have been documented due to the Serghaya branch with a reoccurrence interval of about 1300 years. (2) three large earthquakes ($M_s > 7.0$) occurred along the Messyaf segment with a return period of 550 years; the most recent event corresponds to the 1170 AD earthquake. (3) Ten to thirteen large earthquakes with $M_s \sim 7.5$ have been documented along the Yammouneh segment in the past 12,000 years; the great 1202 earthquake was the most recent one. (4) The Roum branch is the most likely source for the documented 1837 earthquake ($M_s 7.1$). (5) The Hagi Basha segment is responsible for three large historical earthquakes of 859 AD, 1408 and 1872 with a recurrence interval of about 500 years. These seismogenic sources represent a genuine seismic hazard for western Syria and Lebanon.

EI-Sayed Mohamed Salem: *Ancient Tsunami Deposits on the Red Sea Beach, Egypt*

EI-Sayed Mohamed Salem studied the area delineated by latitudes $25^\circ 6' N$ to $25^\circ 9' N$ and longitudes $34^\circ 50' E$ to $34^\circ 53' E$. It covers an elongated area of about 12 Km^2 along the Red Sea coast north of Marsa Alam City. Five wells were drilled to study core samples and well logging measurements and 69 vertical electrical sounding stations were carried out. The studied area and adjacent areas were geologically surveyed to note ancient geological features related to earthquakes.

The dominant rock types at the western portions of the studied area are sandstone, sandy clay, clay, clayey sandstone, and gravels. The beach of the Red Sea indicated that there were several cycles of deposition of Coral Reefs with intercalations of clastic deposits such as clay, sand, sandstone, conglomerate, gravels, pebbles and a lot of fossils and shell fragments. The area includes a large numbers of faults.

The beach of the Red Sea was subjected to ancient tsunamis due to the high seismic activity which left their signature in the geological column, especially at the beach. The observation of some ancient geological features such as liquefaction and landslides indicate the area was subjected to strong earthquakes related to the rifting of the Red Sea.

Site Effects

A comprehensive understanding of the responses of different structural systems in urban and rural areas affected by earthquakes is an important requisite for the reduction of losses during earthquakes. Structural systems dominant in a region may have significant variations

due to local design constraints as affected by the availability of construction materials and economic standards of the population. An additional constraint that affects the built environment is the local geological conditions on which structures are built. Local geology and geotechnical conditions affect the design and analyses of the structures because the geotechnical environment affects the way the structures respond during strong shaking caused by near and distant earthquakes. For example, a 5-story stiff shear wall reinforced concrete building responds in a different way if it is built on a rock site than if it is built on alluvial or softer site conditions.

Thus, it is necessary to fully understand the behavior of different structural types constructed with different local construction materials at sites that vary according to local geology. As a result, two basic subjects must be well understood: (a) structural response of buildings and (b) site response. Numerous methods for the assessment of structural and site responses are available. Such responses may be affected by regional and local constraints and therefore such regional characteristics ought to be exposed and identified.

Avi Shapira: *Questioning the Applicability of Soil Amplification Factors as Defined by NEHR (USA) in the Israel Building Standards*

Modern building codes for seismic design, including the recently updated Israeli Standard (SI 413), adopted new site amplification factors and new procedure for site classification. Two amplitude-dependent site amplification factors are specified: F_a for short period (0.2 sec) and F_v for long period (1 sec) motions. The new site classification system is based on five soil classes, defined in terms of the average shear wave velocity through the top 30 m of the soil profile ($V_{s,30}$).

The Seismology Division of the Geophysical Institute of Israel conducted site investigations in more than 5500 locations, located in 30 towns and neighboring villages. These investigations demonstrate the effectiveness of using the horizontal-to-vertical (H/V) spectral ratios from ambient noise measurements that characterize the sites with respect to their resonance frequencies and the corresponding H/V levels. Data on S-wave velocities obtained from seismic refraction surveys carried out in proximity to boreholes helped building reliable 1-D soil column models of the subsurface that evenly cover the study area. Histograms of site specific parameters that characterize the models demonstrated a high variability in the subsurface condition across a town/city. Soil column models were used to calculate the uniform hazard linear and non-linear site specific acceleration spectra (10% exceedance in 50 years).

Francesco Panzera: *Is the Evaluation of Topographic Effects an Easy Task?*

The effects of topography have been widely studied through several analytical and numerical methods (e.g., Paolucci, 2002); instrumental evidence of topographic effects are however relatively few. Records of explosions and noise measurements can be very useful to estimate site effects. Although such techniques have been rarely used to investigate topographic effects, satisfactory results have been obtained (e.g. Pagliaroli et al., 2007; Panzera et al., 2011). An important aspect, in topographic amplification estimates, concerns the difficulty to distinguish between a purely topographic effect and the influence of different local lithology amplification. In particular, the amplification of seismic motion at the top of a hill might be caused by other phenomena, such as the presence of fractured rock, near surface weathering, low-velocity layers, or fault zones near the site measurements.

Francesco Panzera and his colleagues estimated the seismic site response due to topographic effects of two study areas: the Ortigia peninsula (Siracusa, Italy) and the university campus of Catania (Italy). The Ortigia area represents, because of its geological and morphological setting, a useful test site to perform passive experimental techniques aiming to identify the site response directivity and the fundamental resonant frequency connected to the topographic effects. The lithologic heterogeneities, existing in the Catania area, seem to have a stronger influence with respect to the simple topographic effect. The evaluation of local seismic response of the two study areas was undertaken by integrating different experimental approaches. The data used in this study consist of both noise and earthquake recordings that were processed through horizontal to vertical spectra ratio (HVSr), horizontal to vertical noise spectra ratio (HVNR) and standard spectral ratio techniques considering horizontal (HSSr) and vertical (VSSr) components.

The homogeneity of the carbonate sequence outcropping in the Ortigia peninsula and its simple convex morphology made it ideal for investigate topographic site effects. The HVNR show dominant frequency peaks in the range that is in good agreement with the theoretical resonance frequency of the hill, computed using experimental shear wave velocities. Moreover, both the directional resonance and the polarization analysis confirm the presence of a directional effect having an azimuth transverse to the major axis of the ridge. The investigation on the characteristics of the site response at the university campus of Catania, has instead set into evidence that the complexity of the near-surface geology, as well as the morphology strongly influence the local amplification of the ground motion and the directivity effects.

Finally, a practical implication of the present study shows that the topographic effects cannot be easily evaluated especially when subsurface morphology and lithologic features are predominant.

Marina Gorstein: Some Considerations on Experimental Study of Site Effect Using Ambient Noise Measurements

The necessity for detailed mapping of the earthquake hazard in urban areas stems from the fact that geological inhomogeneity dominates the spatial distribution of the intensity of damage and amount of casualties. Strong motion records are unavailable in Israel and the great variability in the subsurface conditions across a town/city and the relatively high costs associated with obtaining the appropriate information about the subsurface, strongly limit proper earthquake hazard quantification.

Site investigations have been conducted at several thousand sites. These investigations demonstrate the usefulness of using horizontal-to-vertical (H/V) spectra of ambient noise measurements to identify sites with high potential for being vulnerable to amplification effects and characterize the sites with respect to their expected resonance frequencies and the corresponding H/V levels. This information, together with any available geological, geotechnical and geophysical information, helps constructing a reliable model of the subsurface, which is then integrated in the processes of the seismic hazard assessment.

Galina Ataev: Use of H/V Spectral Ratios Measurements of Ambient Noise for Seismic Microzonation and Modeling of the Subsurface.

The H/V spectral ratio analysis of ambient noise was used for reconstruction of the subsurface in a coastal area near Haifa and in the west of Kiryat Shemona town. In the coastal area, Galina Ataev and her colleagues measured ambient noise in 200 locations and

displayed the distribution of the first and the second resonance frequencies and their associated H/V amplitudes. The first peak in the H/V spectrum is associated with a deep bedrock, which is basically the dolomite of Albian age. Its effect is reflected in the frequency map as wide zones with resonance frequencies of 1-3 Hz. They also found some zones where the dominant frequencies are 3-7 Hz which correspond to a change of the main reflector from dolomite of Albian age to dolomite and limestone of Cenoman - Turonian age. This also corresponds to a significant facies changes (chalk to dolomite) in the Cenomanian age. The subsurface models obtained in this research are implemented to assess the seismic hazard in terms of site specific uniform hazard acceleration spectrum.

In the town of Kiryat Shemona we explored the site effects of historical landslides in order to define the site amplification effect at school sites and assessing schools safety.

Sharon Pace: *Site Effects and Earthquake Ground Motion Scenario for the Xemxija Bay Area (Malta)*

The Maltese islands are exposed to a low-to-moderate seismic hazard. Seismic activity around the islands is generally of low magnitude, however more infrequent, large events in Sicily and as far as the Hellenic arc have affected the country in the past and caused considerable damage (Galea, 2007). In spite of this, no comprehensive assessment of seismic risk has so far been carried out. Much of the building stock is of load-bearing unreinforced masonry, and is vulnerable to even moderate ground shaking. This study presents some earthquake simulation in order to have useful elements for estimating the potential damage and seismic risk analysis including local site effects resulting from the particular local sedimentary geology. Ambient noise measurements will be used to infer shallow shear wave velocity structure, for which no systematic data exists on the islands.

The Xemxija area on the NE coast of Malta was chosen as an initial investigation site with a dense microtremor measurement survey carried out using a Tromino® tromograph (Micromed SpA), with about 100 microtremor recordings. HVSR curves obtained from measurements performed in the valley give a large spread of resonant fundamental frequencies ranging between 2 Hz to over 11 Hz due to the variation in soil thickness that overlays the Upper Coralline stratum. On the neighboring hilltop, where no or negligible soil is present, the frequency range is smaller and more stable, spanning 1.19 Hz - 1.56 Hz, with amplification due to an underlying blue clay layer, which also gives rise to velocity inversion.

Preliminary modelling attempts show the complexity and variability of the site's geology. Modelling of HVSR data using ambient noise has been shown to be a useful tool in microzonation studies. The ultimate goal of this paper is to provide earthquake ground motion simulations in order to estimate earthquake scenarios mainly based on the ground motion parameters.

In this paper, Sharon Pace and her colleagues show that in the Xemxija Bay area, Malta, the ground motion from the repeat occurrence of historically recorded earthquakes, coupled with existing geological conditions and building typologies has the potential to cause significant structural damage in the area.

The authors concluded that a well-crafted scenario provides a powerful tool for government officials, decision makers, emergency planners, private industry, and the general public to draft mitigation policies and programs. It will help the community weigh various risks associated with the earthquake and begin to set priorities that will systematically reduce the impact of the likely future event.

Issa El-Hussain: *Seismic Microzonation for Seismic Risk Mitigation in Muscat area, Sultanate of Oman*

The local site effects were performed by determining the resonance frequency of the soft soil layers and by estimating the amplification using local shear wave velocity profiles. The Nakamura technique was used to estimate the resonance frequency of soft soils at 459 sites, characterized by the ratio of the Fourier spectra of the horizontal and vertical components of ambient noise measurements. The soft areas are characterized by resonance frequencies ranging from 1.8 to 6.0 Hz in contrast to hard rock sites that are characterized by higher resonance frequencies (up to 23 Hz).

Shear wave velocity (V_s) has been evaluated using the multichannel analysis of surface waves at 99 representative sites in Muscat. These 99 sites have been investigated with survey lines 51 m in length. 1-D and interpolated 2-D profiles have been generated up to a depth of 30–40 m. The shear wave velocities are used to estimate average shear wave velocity in the upper most 30 m (V_{s30}). Based on the (V_{s30}), the study area is classified according to the NEHRP site classes into B, C, and D site classes. The V_s profiles were then used in the SHAKE91 software in combination with suitable seismic input motion to obtain site response and amplification spectra. Maps of resonance frequency, (V_{s30}), site classification, spectral amplification, earthquake characteristics on the ground surface for peak ground and spectral accelerations at 0.1, 0.2, 0.3, 1.0 and 2.0s, for 475 and 2475 years return periods were presented.

Sebastiano D'Amico: *An Ambient Noise HVSR Survey in Valletta World Heritage Site and the Historical City of Mdina, Malta*

In this paper Sebastiano D'Amico and his colleagues report preliminary results of the measurements of ambient noise on a dense network of measurement sites in and around the cities of Valletta and Mdina; two important historical heritage sites in Malta. The city of Valletta is the present capital of Malta and it is inextricably linked to the history of the military and charitable Order of St John of Jerusalem. Valletta with its 320 monuments is a UNESCO World Heritage site. All the monuments are contained within quite a small area, making it one of the most concentrated historic areas in the world. The city of Mdina is the old capital of Malta. Mdina is situated in the centre of the island and is a medieval town still confined within its walls. It is a small town with rich history, monuments and cultural heritage. The seismic microzonation studies, which have not been previously performed on Malta, are an important component of risk evaluation and the preservation of prominent cultural heritage sites.

The authors used the Nakamura (1989) technique to derive the spectral ratio of horizontal and vertical component (HVSR) of microtremors. SESAME (Site EffectS assessment using AMbient Excitations; <http://sesame-fp5.obs.ujf-grenoble.fr>) guidelines were used to ensure validity of the results. Ambient noise measurements in Mdina and Valletta were conducted in three campaigns in May, September, and November 2011. In total, we acquired data at about 60 locations.

On top of the hill where the city of Mdina is located and where the hard Upper Coralline Limestone (UCL) is outcropping, measurements showed peak amplitudes greater than 2 in most cases. This amplification is likely to be due to the Blue Clay layer underlying the UCL. The Blue Clay layer results in a velocity inversion, which is evident in the HVSR curves obtained at several locations, where the curve drops below 1 over a wide frequency range.

The amplification due to the buried clay layer has important implications in microzonation analysis where the outcropping geology would indicate a hard rock site and hence a zone of no amplification.

Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects

Participants of the second and third session of the United Nations International Strategy for Disaster Reduction (UNISDR) Global Platform for Disaster Risk Reduction in June 2009 and 2011, respectively, committed to assess the level of disaster resilience in all schools in disaster-prone countries, and all related government agencies to develop a national plan for school safety by 2015. The UNISDR Secretariat in Geneva in coordination with the UN Thematic Platform on Knowledge and Education (TPKE), which includes UNISDR, UNESCO, UNICEF, GFDRR, INEE, Plan International and Save the Children, among others, have been working in the preparation of a methodology for assessing school safety.

Djillali Benouar and Mounir Naïli: *Seismic Vulnerability Assessment of Existing School Buildings in Algiers City*

The 21 May 2003 Zemmouri earthquake that struck the Boumerdes region caused damage, disruption and casualties. More than 2000 people were reported killed, 10,147 injured, and 150,000 were left homeless. More than 103 school buildings were classified as destroyed structures and approximately 753 others were classified as seriously damaged.

In order to prevent the likelihood of damage that may occur during future earthquakes, and to ensure life safety and school integrity, the seismic vulnerability of existing school buildings within the vicinity of Algiers city was carried out using the Risk-UE LM1 approach. A sample of 190 school facilities (corresponding to 526 Buildings) located in nine municipalities in the province of Algiers were surveyed in order to identify the general sources of seismic vulnerability. The results are expressed in terms of vulnerability curves that show the relationship between a given seismic input and the expected damage.

It is expected that these results will guide the decision makers in taking practical measures in order to strengthen the surviving school buildings in Algiers and in other cities across the country and implement preventive measures to reduce the seismic risk by reducing the vulnerability.

Adnan Khasawneh: *Structural Assessment of UNRWA Co-Edu School at Irbid*

The Jordanian Ministry of Education has made an early commitment to make schools safer. Part of this commitment was shared with the United Nation Relief and Works Agency for Palestinian Refugees (UNRWA) of Jordan. In 2009 UNRWA initiated a program to rehabilitate a number of its schools throughout Jordan. This case study demonstrates the methodology for strengthening and protecting one of the schools in Irbid city.

The primary objective of the study was to conduct a detailed structural assessment for the school, and more specifically, to find out the nature and severity of corrosion and other and present technical assessment on their causes and treatment. Finally, recommendations for effective repairs and protective solutions for the affected parts of the school were provided.

The study included: (a) performing a comprehensive field inspection, (b) performing a close in-depth inspection of the structural details, (c) preparing as-built drawings of foundations, (d) exploration and testing concrete cores and reinforcement steel, (e) investigating the probability of corrosion, and (f) performing a full structural analysis for different elements of the school. The structural adequacy of the building was then evaluated and recommendations for all necessary repairs and strengthening of deficient elements were presented with full contract documents for rehabilitation including a bill of quantities, drawings, and specifications.

Jalal Al Dabbeek: *Non Structural Seismic Vulnerability Assessment of Hospitals and Health Centers in Palestinian Cities*

Hospitals and health centers have a vital role to play in the event of a disaster, primarily through assisting the disaster victims, and also by organizing the first-response institutions and providing its services after a disaster. Considering this vital role, it is necessary that the hospitals themselves are prepared to withstand the initial damaging effects of a disastrous event. Studies have shown that major parts of hospitals and health centers have a high seismic vulnerability due to a lack of sufficient seismic awareness and a Palestinian Seismic Building Code.

The following investigations and activities have been implemented in order to carry out the study of the three major hospitals and three health centers in the West Bank in the event of a strong or moderately strong earthquake:

- A study to determine the seismic vulnerability (macro-seismic scale) of structural and non-structural elements of the investigated buildings. The study showed that most of the common non-structural components have a high vulnerability. This includes partition walls, ceilings, windows, office equipment, computers, inventory stored on shelves, file cabinets, water tanks, generators, transformers, heating, ventilating, and air conditioning equipment; electrical equipment, furnishings, and lights.
- An assessment of safety conditions and the development of evacuation plans, including a plan of the hospital and its surrounding spaces.
- Meetings and workshops have been organized with decision makers, officials and engineers in the Ministry of Health.

All of the assessed hospitals do not have the necessary safety requirements and need additional external exits and entrances. The hospitals are unevenly distributed and concentrated in certain areas of cities. This centralization of services will result in adverse consequences if subjected to natural or man-made disasters.

Several recommendations, accompanied by clear action plans, have focused on decreasing the seismic vulnerability of non-structural elements and increasing the coping capacity of hospitals and health centers. The conclusions of this study are the same as the challenges that now face the development of the Palestinian health sector, and involve the coupling of disaster risk reduction and sustainable development in accordance with the International Strategy of Disaster Risk Reduction (UN-ISDR), Hyogo Framework for Action 2005-2015 and Arab Strategy for Disaster Risk Reduction 2011 – 2020.

Jair Torres: *Methodology for Assessing School Safety – Educational, Scientific and Engineering aspects*

Participants of the second and third session of the United Nations International Strategy for Disaster Reduction (UNISDR) Global Platform for Disaster Risk Reduction, held in June 2009 and 2011, committed to assess the level of disaster resilience in all schools in disaster-prone countries and urged all relevant government agencies to develop a national plan for school safety by 2015. The UNISDR Secretariat in Geneva in coordination with the UN Thematic Platform on Knowledge and Education, which includes UNISDR, UNESCO, UNICEF, GFDRR, INEE, Plan International and Save the Children, among others, have been working on the preparation of a methodology for assessing school safety.

A draft methodology for assessing school safety was presented to the RELEMR participants. Comments on educational, scientific and engineering aspects concerning school safety will be welcome in order to strength and validate the methodology.

Closing Session

In the Closing Session, participants gave thanks to UNESCO, the USGS, and the University of Malta for their cooperation in the implementation of the workshop. The commitment and hospitality of the University of Malta made the workshop a successful event. Participants also gave their special appreciation to Dr. Charles V.Sammut, Dean, Faculty of Science, Dr. Pauline Galea, and Dr. Sebastiano D'Amico for their attention before, throughout, and after the workshop.

Fieldtrip: Geology and Neotectonics of Malta

The field trip was planned to observe the geology and neotectonics of the south coast of Malta and to visit two of the most beautiful Neolithic temples on the islands. It also included a visit to one of the oldest cities in Malta – Vittoriosa – lying on one side of the Grand Harbour, opposite Valletta, and finish with dinner at a waterfront restaurant.

[Ed.note: Inclement weather forced a modification of the itinerary.]

A brief overview of Maltese geology

Stratigraphy

All the rocks which outcrop on the Maltese islands were originally deposited at the bottom of a warm shallow sea, at various depths and distances from land, during the Oligocene-Miocene period of the Tertiary era. They form a simple stratigraphic sequence, which has however undergone a great deal of tilting, bending and brittle deformation through tectonic activity that affected the whole of the Sicily Channel.

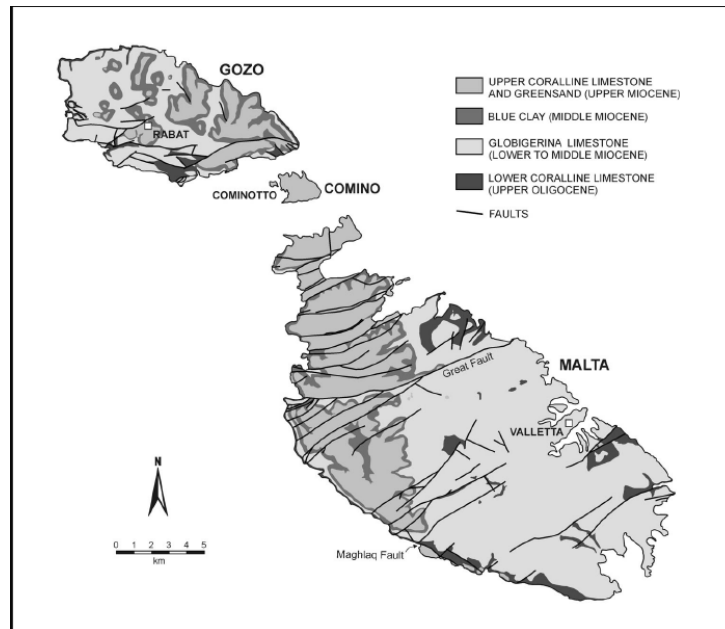
In the chronological order of their deposition, the five local sedimentary rock formations that make up the Maltese geological succession are

- i. the Lower Coralline Limestone (LCL) - Oligocene (Chattian), green on map
- ii. the Globigerina Limestone (GL) - Miocene (Aquitanian to Early Langhian), yellow
- iii. the Blue Clay (BC) - Miocene (Langhian to Tortonian), blue
- iv. the Greensand (GS) - Miocene, (Tortonian)
- v. the Upper Coralline Limestone (UCL) - Miocene (Late Tortonian to Early Messinian), pink

The whole geological succession can be viewed at Dingli Cliffs, standing on the UCL plateau and looking down at the cliff section. As can be seen in the geological map of Malta, 5-layer succession is preserved in the west of the island but has been partly eroded in the eastern half, where the GL outcrops almost everywhere.

The Lower Coralline Limestone

The LCL is the oldest formation (Upper Oligocene) exposed at the surface of the Maltese islands. It is a formation of variable lithology, composed mainly of massive white limestone beds of shallow marine origin, containing remains of calcareous algae, corals, bryozoa, brachiopods, mollusks and echinoderms. Any particular horizon may vary from hard, compact and well-cemented, to a soft, rubbly chalk. The hard variety was formerly extensively used for paving and monuments, since it takes a good polish. It is now quarried for construction material and spalls. The LCL in the southern half of Malta contains the Main Sea Level Water Table, in which fresh rainwater that has percolated down through the limestone floats on the denser seawater. The LCL is exposed through a thickness of up to 120m in the vertical sea cliffs along the western coasts of Malta and Gozo.



(Zammit-Maempel, G., 1977, Outline of Maltese Geology)

The Globigerina Limestone

The GL outcrops widely in the southeastern part of Malta, extending over two-thirds of the island's area. Its maximum thickness is about 250m. The formation is named after the abundance of the shells of the foraminifer *Globigerina*, indicating deposition in deep water. It is divided into the Lower, Middle and Upper Globigerina, which have different lithological properties. The three layers are separated by thin beds of phosphoritic conglomerates, or pebble beds. The Lower GL is still extensively quarried for building blocks, and is valued for the ease with which it can be hand carved and sculpted.

The Blue Clay

The BC layer actually includes a wide variety of argillaceous beds which vary in colour and composition depending on their content of lime. The formation attains a thickness of more than 70m in northern Gozo, but between these points it may thin to less than 25m. The BC produces 45° slopes and taluses that tend to slide down over the underlying GL. The clays form an impervious base to the overlying aquifers, and are important for the formation of a "perched" freshwater table in the upland regions of the islands (Gozo and north-west Malta).

The Greensand

This formation consists of relatively thin layers of glauconitic limestone, which in some places are almost pure glauconite sand. The formation is not always present between the BC and the UCL. The maximum thickness, 16m, has been measured in Gozo.

The Upper Coralline Limestone

The UCL is the youngest of the Tertiary formations of the Maltese islands. It is made up of mostly shallow marine sediments, some characteristic of intertidal environments, representing the initial stages of uplift of the islands above sea-level. The "coralline" element is made up by coral-like calcareous red algae, indicating the very shallow, and well-lit nature

of the depositional environment. The thickness on the plateaus in the north west of Malta is generally less than 30m.

Tectonic Activity

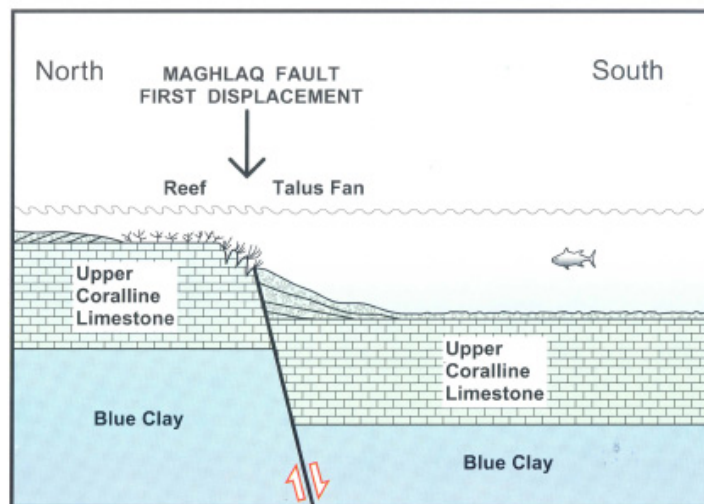
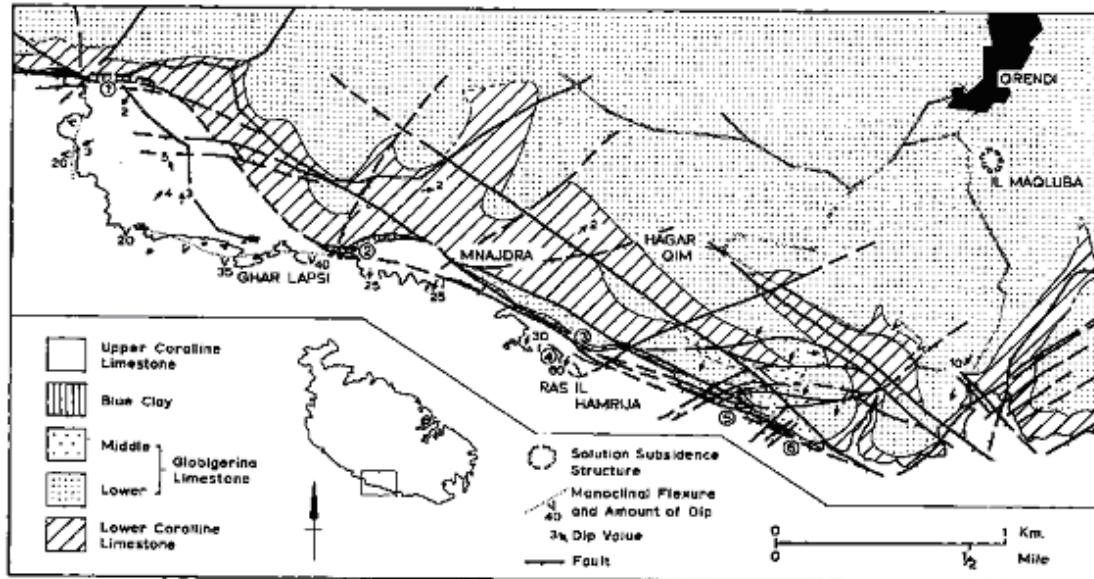
Syn-sedimentary features indicate that normal faulting started to affect the geological succession as early as the Early Miocene, during deposition of the Lower GL. This system of faulting eventually produced the NE-SW trending block faulting pattern that dominates the topography of the Maltese islands between the Great Fault (which traverses the island of Malta from end to end) and the south of Gozo. During the deposition of the UCL, another, almost orthogonal, system of normal faulting commenced. This trends NW – SE and is related to the extensional system that forms the Pantelleria rift (or Sicily Channel Rift Zone). The Maghlaq fault, the major fault that bounds the southwest coast of Malta, is considered as one of the master faults of the rift zone. It has produced a vertical downthrow of more than 240m on the seaward side, leaving the island of Filfla, made entirely of UCL, visible to the south as the highest point of the downthrown block.

The Maghlaq Fault

The Maghlaq fault is the most prominent normal fracture with a NW-SE trend within the Maltese islands and may be followed along strike in this section of coastline. At Ix-Xaqqa, west of Ghar Lapsi (Lapsi Cave), the fault is displayed in a spectacular manner as a smooth, almost vertical slickensided surface going down to sea level. The fault carries UCL down against LCL. East of Ghar Lapsi, the UCL bedding on the seaward edge shows evidence of a fringing reef abutting onto a submarine fault scarp (see figure below). Further east, the Ras il-Hamrija peninsula is an UCL downthrown block, lying against the vertical slickensided surface of the Maghlaq fault scarp. Further east, the Maghlaq fault appears as a number of minor faults converging at the embayment, and weakening the limestone.

The Neolithic Temples of Hagar Qim and Mnajdra

Several thousand years before the arrival of the Phoenicians, the Maltese islands were home to a remarkable culture. These people acquired the skills, and had the strength of spiritual devotion, to mobilise men and resources to build megalithic structures and hew out living rock into burial chambers. This culture vanished from the Islands for a reason still unknown. Malta's temples and the Hypogeum are designated UNESCO World Heritage sites. They are considered to be among the oldest free-standing structures in the world.



(Pedley, M. 2002, Geological Itineraries in Malta and Gozo)

The temple of Hagar Qim was excavated for the first time in 1839, and dates from the Ġgantija phase (c. 3600 - 3200 BC). It stands on a hilltop overlooking the sea and the islet of Fila and lies some 2km south-west of the village of Qrendi. A number of important artefacts have been unearthed from Hagar Qim notably a decorated pillar altar, two table-altars and some of the 'fat lady' statues which are now on display at the National Museum of Archaeology, Valletta.

Mnejdra lies tucked in a hollow in the cliffs on Malta's southern coast. The site is probably the most atmospheric of all Malta's temples. It lies in an isolated position on a rugged stretch

of coast overlooking the isle of Fifla. Mnajdra is a complex site consisting of three temples overlooking an oval forecourt. The first and oldest temple is a simple three-apsed building and dates to the Ggantija phase (3600-3200 BC). The small rubble walls are a modern reconstruction but the small uprights, with their pitted decoration, are original. The most impressive of the Mnajdra temples is the third, with its largely intact façade and bench constructed in the early Tarxien phase (3150 – 2500 BC). Both temples are built of Lower Globigerina Limestone, most probably obtained from local hillside outcrops.

Vittoriosa (Birgu)

Vittoriosa (Birgu) is a very old locality on the south side of the Grand Harbour in Malta. The city occupies a promontory of land with Fort St Angelo at its head and extensive fortifications on its landward side. The oldest recorded use of Birgu was a Phoenician shrine to the goddess Astarte at the tip of the peninsula. This was succeeded by Greek and Roman temples to the Hera and Juno. The Arabs later built a fortress over the same site in 828 AD. Since medieaval times it has developed a long history of maritime, mercantile and military activities, being occupied by Venetians, Pisans, Genoans, Aragonese and Castilians. The church of St. Lawrence, facing the sea, was the first parish in Malta in 1090. Prior to the establishment of Valletta as capital and main city of Malta, military powers that wanted to rule the Maltese islands would need to obtain control of Birgu due to its significant position in the Grand Harbour. When the Knights of the Order of St. John arrived in Malta in 1530, they made Birgu the capital city of Malta, since the former capital, Mdina, was inland and did not suit their naval requirements. The Order built eight Auberges, an armoury and hospital in Birgu. The city was fortified in 1551 and strengthened in 1554 in preparation for an attack by the Ottoman Empire. This included the construction of Fort St Angelo, a large fortification separated from the city by a narrow channel. The castle was connected to the city by means of a drawbridge, and was the residence of Grand Master L'Isle Adam. Birgu was the site of a major battle between the Knights and the Ottoman Empire during the Siege of Malta in 1565 and was recaptured by the Knights under Grand Master Jean Parisot de la Valette. After the Siege, Birgu was given the title *Città Vittoriosa*, Italian for "victorious city". In 1571, the Knights transferred their convent and seat to the new capital of Valletta.

Birgu was extensively bombarded and damaged during the Second World War, when fort St. Angelo served as the Royal Navy's Headquarters of the British Fleet in the Mediterranean. Today, fort St. Angelo is once more the official residence of the Order of the Knights of St. John's representative in Malta. Birgu today houses a maritime museum, and is rich with fine examples of medieaval architecture, especially round the *Collachio*. Historic buildings along the waterfront, where we shall be stopping for dinner, have been restored and the area given a new life of commercial and leisure activities.

Results and Conclusions

Sixty (60) participants from the following UNESCO Member States attended the Malta 2012 workshop: Algeria, Cyprus, Egypt, France, Iraq, Israel, Italy, Jordan, Lebanon, Libya, Malta, Morocco, Oman, Palestine, Saudi Arabia, Spain, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, and the United States.

The first keynote address was presented by Professor Ruben Borg from the Department of Civil and Structural Engineering, Faculty for the Built Environment, University of Malta: *Seismic Damage Assessment of Structures: Case Study of the Abruzzo 2009 Earthquake*. The second keynote address was presented by Professor Pauline Galea from the Physics Department, University of Malta: *The Maltese Islands - Tectonic Environment, Seismicity and Hazard*.

Three Special Sessions were held during the Malta 2012 RELEMR Workshop: *Paleoseismicity in the Extended Mediterranean Region, Site Effects, and Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects*.

In addition to the two keynote addresses, 34 papers were presented on topics including, but not limited to: Structural and non-structural damage and assessments, ambient noise assessments, tsunami vulnerability, national seismic networks, estimation of earthquake risk parameters, recent seismicity in the RELEMR region, seismic hazard and risk assessment and mitigation, site effects, paleoseismology and archeoseismology, seismic risk awareness, induced seismicity, post-earthquake evaluation of structural damage, seismic site response and zonation.

An open discussion on the objectives of RELEMR was co-chaired by Mike Foose (USGS) and Badaoui Rouhban (UNESCO). The discussion focused on two aspects: (1) the definition of short and longer term objectives and (2) the way to develop synergies with on-going initiatives at European and global levels. There was a consensus among the participants that recognized that RELEMR is a unique and very valuable initiative. Rémy Bossu (EMSC) presented a number of projects and initiatives that raised a large interest among the participants. Real time waveform exchange was rapidly identified as an objective of interest for a number of partners. A second objective to be refined at a later stage could be the production of an educational map in Arabic. The next RELEMR meeting will include a 1-2 day workshop on real time waveform exchange organized in collaboration with EMSC and ORFEUS and coordinated with the development of the tsunami warning systems in the Mediterranean region.

The field trip was planned to observe the geology and neotectonics of the south coast of Malta and to visit two of the most beautiful Neolithic temples on the islands. It also included a visit to one of the oldest cities in Malta – Vittoriosa – lying on one side of the Grand Harbour, opposite Valletta. Because of inclement weather, many geologic stops could not be visited.

Annex A

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

List of Participants

Algeria

Djillali Benouar

Professor & Consultant
Director, Built Environment Res.
Lab.(LBE)
University of Bab Ezzouar (USTHB)
Faculty of Civil Engineering,
BP 32 El-Alia/ Bab Ezzouar,
Algiers 16111, Algeria
Tel : +213 21 247 914
Mobile: +213 771 842 428
E-mail: dbenouar@yahoo.com
dbenouar@gmail.com
Website : www.ibe.usthb.dz

Mohamed Hamdache

Senior Researcher
CRAAG
BP63 Bouzaréah 16348
Algiers, Algeria
Tel: +21 90 44 54/55
Fax: +21 90 44 58
E-mail: mhamdache@hotmail.com
m.hamdache@craag.dz

Mounir Naili

Centre National de Recherche Appliquée
en Génie Parasismique, CGS
Rue Kaddour Rahim, BP. 252, Hussein
Dey, Alger, Algérie.
Tel: +213 21 49 55 41
Fax: +213 21 49 55 36
E-mail: mnaili@cgs-dz.org

Cyprus

Eleni Georgiou Morisseau

Director
Geological Survey Department
1415 Nicosia, Cyprus
Tel: +357 224 09213
Fax: +357 223 16873
E-mail: director@gsd.moa.gov.cy

Stelios Nicolaides

Senior Geological Officer
Geological Survey Department
1415 Nicosia, Cyprus
Tel: +357-22409260
Fax: +357 223 16873
E-mail: snicolaides@gsd.moa.gov.cy

Egypt

Raafat El-Shafei Fat-Helbary

Prof. of Seismology & Engineering
Seismology
National Research Institute of Astronomy
and Geophysics (NRIAG)
Director of Aswan Earthquake Research
Center
Aswan Earthquake Research
Center, P.O.Box 152, Aswan, Egypt
Tel: +20 97 3481008 (fax)
Mobile: +20 10 3416008
E-mail: fat_helbary@yahoo.com

El-Sayed Mohamed Salem

Egyptian Geological Survey and Mining
Authority
3 Salah Salem Road
Abbasiya, Cairo 11517, Egypt
Tel: +202 682 8013
E-mail: sayedsalem2000@hotmail.com
Sayedsalem2000@yahoo.com

France

Remy Busso

Secretary General
European-Mediterranean Seismological
Centre
c/o CEA, Bt. Sables
Centre DAM - Ile de France
Bruyères le Châtel
91297 Arpajon Cedex
France
Tel: +33 169267814
E-mail: bossu@emsc-csem.org

Iraq

Dawood Shakir Mahmood

Director General
Iraqi Meteorological Organisation and
Seismology
Baghdad, Iraq
E-mail: dawoodmehmood55@yahoo.com

Israel

Avi Shapira

Chairman
National Steering Committee for
Earthquake Preparedness
Prime Minister's Office
Jerusalem, Israel
Tel: (+972)-(0)8-9192501
Mobile: +972 (0) 50 6206028
Fax: +972 (0) 8 9192511
E-mail: avisha@pmo.gov.il

Rivka Amit

Geological Survey of Israel
30 Malkhe Israel St.
Jerusalem, 95501
Israel
Tel: +972 2 5314271
Fax: +972 2 5380688
Mobile: +972 50 6234535
E-mail: rivka@gsi.gov.il

Marina Gorstein

Geophysical Institute of Israel (GII)
P.O. Box 182
HaBaal Shem-Tov St,
North Industrial Zone
Lod 71100, Israel
Tel: +972 8 9785888; +972 8 9785800
Fax: +972 8 9208811
E-mail: marina@seis.mni.gov.il

Galina Ataev

Geophysical Institute of Israel (GII)
P.O. Box 182
HaBaal Shem-Tov St,
North Industrial Zone
Lod 71100, Israel
Tel: +972 8 9785888; +972 8 9785800
Fax: +972 8 9208811
E-mail: galina@seis.mni.gov.il

Italy

Marco Mucciarelli

Associate Professor
Department of Structural Engineering,
Geotechnical Engineering, Engineering
Geology
Stanza 14 piano 3 Ingegneria
University of Basilicata
Viale dell'Ateneo Lucano
Potenza, Italy
Tel: +39 971205094
Fax: + 39 971205070
Mobile: +39 3293606180
E-mail: marco.mucciarelli@unibas.it

Jordan

Hanan Al-Nimry

Assistant Professor of Structural
Engineering
Department of Civil Engineering,
Faculty of Engineering
Jordan University of Science and
Technology
P.O Box 3030 Irbid 22110,
Jordan
Tel: +962 2 720 1000 Ext. 22110
Fax: +962 2 720 1074
E-mail: hsnimry@just.edu.jo

Adnan S. Khasawneh

Acting Executive Director UCC
Civil Engineering
Royal Scientific Society
Tel: + 962 6 5344701 ext 2447
Fax: +962 6 5347399
Mobile: +962777422016
E-mail: adnankh@rss.gov.jo
Website: www.rss.gov.jo

Mahmoud Al-Qaryouti

Earthquake & Active Faults Research
Seismology Division, Natural Resources
Authority (NRA)
P.O. Box (7), Amman 11118, Jordan
Tel: +962 (06) 5504390 ext. 1444
Fax: + 962 6 5811866
Mobile: +962 (07) 77330572
E-mail: qaryouti@nra.gov.jo
alqaryoutimy@yahoo.com



UNIVERSITY OF MALTA
L-Università ta' Malta

Galal Mohammed Al-Mekhlafi
Structural Engineer, M.Sc student
Department of Civil Engineering,
Faculty of Engineering
Jordan University of Science and
Technology
Irbid 22110, P.O Box 3030
Jordan
E-mail: jalaltaher84@yahoo.com

Lebanon

Fadi Geara
Doyen de la Faculté d'Ingénierie:
ESIB – ESIA-M - INCI
Université Saint-Joseph de Beyrouth:
USJ – LIBAN
Campus des Sciences et Technologies,
Mar Roukos, Mkalles
B.P. 11-514, Riad El Solh, Beyrouth, 1107
2050 Liban
Tel : +961 1 421355
Fax: +961 4 532651
E-mail: fadi.geara@usj.edu.lb
Website: <http://www.fi.usj.edu.lb>

Libya

Abdala Elmelade
Head of Department
Department of Researches and Field
Studies
Libyan Center for Remote Sensing and
Space Science (LCRSSS)
Libyan National Seismological Network
Tripoli, Libya
Mobile: +218 913 361701
E-mail: abmiladi@yahoo.com

Abdal-Monam Swissi
Department of Researches and Field
Studies
Libyan Center for Remote Sensing and
Space Science (LCRSSS)
Libyan National Seismological Network
Tripoli, Libya
Mobile: +218 913 229406
E-mail: najeamer11@yahoo.com

Malta

Pauline Galea
Department of Physics
Faculty of Science
University of Malta
Msida MSD 2080, Malta
Tel: +356 2340 2101
Fax: +356 21312110
E-mail: pauline.galea@um.edu.mt

Sebastiano D'Amico
Department of Physics
Faculty of Science
University of Malta
Msida MSD 2080, Malta
Tel: +356 2340 2101
Fax: +356 21312110
E-mail: sebdamico@gmail.com

Francesco Panzera
Department of Physics
Faculty of Science
University of Malta
Msida MSD 2080, Malta
Tel: +356 2340 2101
Fax: +356 21312110
E-mail: panzerafrancesco@hotmail.it

Sharon Pace
Department of Physics
Faculty of Science
University of Malta
Msida MSD 2080, Malta
Tel: +356 2340 2101
Fax: +356 21312110
E-mail: spac0010@um.edu.mt

Ruben Borg
Department of Civil and Structural
Engineering
Faculty for the Built Environment
University of Malta
Msida MSD 2080, Malta
Tel: +356 2340 2101
Fax: +356 21312110
E-mail: ruben.p.borg@um.edu.mt



UNIVERSITY OF MALTA
L-Università ta' Malta

Morocco

Tadili Ben Aissa

Directeur
Laboratoire de physique du Globe
Institut Scientifique
Rabat, Maroc
Tel: +212 661401188
E-mail: tadili@yahoo.com

Nacer Jabour

Laboratoire de Géophysique
Centre National de Recherches
Scientifiques et Techniques
Rabat,
Morocco
Tel: +212 53 7778674
Fax: +212 53 7778678
E-mail: jabour@cnrst.ma

Palestine

Mutaz A. Al-Qutob

Head of the Department of Environment
and Earth Studies
Faculty of Science and Technology
Al-Quds University
PO Box 19164
Jerusalem
E-mail: mkutob@science.alquds.edu

Ayman Mohsen

Earth Sciences and Seismic Engineering
Center
An-Najah National University
P.O. Box: 7
Nablus, West Bank, Palestine
E-mail: ayman_mohsen@najah.edu

Radwan EI-Kelani

Associate Professor
Faculty of Science
An-Najah National University
P.O. Box 7
Mobile: +970 569 840 535
Nablus, Palestine
Email: radwan.kelani@gmail.com

Jalal Al Dabbeek

ESSEC Director
Earth Sciences and Seismic Engineering
Center
Nablus, West Bank, Palestine
Tel: +970 92344121
Fax: +970 92345982
Mobile: + 970 599336061
E-mail: seiscen@najah.edu

Portugal

Luis Matias

Instituto Dom Luís – IDL
Faculdade de Ciências
Universidade de Lisboa
Campo Grande, Edifício C8, piso 3
1749 - 016
Lisbon, Portugal
Tel: +351 217500000
Fax: +351 217500000
E-mail: lmurias@fc.ul.pt

Oman

Issa EI-Hussain

Director, Earthquake Monitoring Center
Sultan Qaboos University
P.O.Box 50, Al-Khoudh
PC 123, Muscat,
Sultanate of Oman
Tel: +968 2414 2642
Fax: +968 2441 3137
E-mail: elhussain@squ.edu.om

Saudi Arabia

Tariq Mansoob

Seismologist
Saudi Geological Survey (SGS)
P.O.Box 54141
Jeddah 21514, Saudi Arabia
Tel: +966 2 6195000 Ext. 2678, 2679
Fax: +966 2 6199924
Mobile: +966 505583565
+966 554786905
E-mail: Mansoob.TA@sgs.org.sa



UNIVERSITY OF MALTA
L-Università ta' Malta

Khalid H. Yousef

Seismologist
Saudi Geological Survey SGS
KSA - Jeddah
P.O. Box 31216
Jeddah 21497
Mobile: 0500004846
E-mail: Yosef.KH@sgs.org.sa
Yousef.H.KH@gmail.com

Mansour K. Alotaibi

Geophysics Research Institute
King Abdulziz City for Science and
Technology
Geophysics Research Institute
P.O Box 6086, Riyadh 11442,
Saudi Arabia
Tel: +966 1 4814539
Fax: +966 1 4813526
Móbile: +966 555679667
E-mail: mkotaibi@kacst.edu.sa
Website : <http://www.kacst.edu.sa>

Spain

María José Jiménez

Spanish Council for Scientific Research
Institute of Geosciences
IGEO (CSIC-UCM)
C/ José Gutiérrez Abascal, 2
E-28006 Madrid, Spain
Tel: +34 914111328
Fax: +34 915644740
E-mail: mj.jimenez@csic.es

Sudan

Indira Mohamed Mahmoud

Geological Research Authority of Sudan
PO Box 410
Khartoum, Sudan
Tel: + 249 912553711
E-mail: mohamedindira@hotmail.com

Syrian Arab Republic

Ryad Darawcheh

Department of Geology
Syrian Atomic Energy Commission
Damascus, Syrian Arab Republic
P.O.Box 6091
Tel: +963-11-2132580
Fax: +963-11-6112289 -
E-mail: rdarawcheh@aec.org.sy

Mohamed Reda Sbeinati

Department of Geology
Atomic Energy Commission
Damascus
Syrian Arab Republic
E-mail: sbeinati@scs-net.org

Tunisia

Chedly Ben M'hamed

Director
Geophysics and Astronomy Department
National Meteorological Institute (INM),
Tunis-Carthage,
Tunisia
E-mail: ben_mhamed@meteo.tn

Najla Bouden Romdhane

Professor
Scientific Senior Councilor
Ministry of Higher Education, Scientific
Research and Technology of Tunisia
Tel: +216 71 800 724
Mobile: +216 97 193 407
E-mail: najlaromdhane@hotmail.fr

Atef Bouallegue

Geophysical Engineer
Institut National de la Meteorologie
Tunis-Carthage,
Tunisia
E-mail: atef.bouallegue@gmail.com



UNIVERSITY OF MALTA
L-Università ta' Malta

Turkey

Kerem Kuterdem

Geological Engineer
Prime Ministry, Disaster and Emergency
Management Presidency
Earthquake Department
Earthquake Risk Management Group
Eskisehir Yolu, Lodumlu,
Ankara, Turkey
Tel: +90 312 2872680/1576-1570
Fax: +90 312 287 93 70
E Mail: kuterdem@depem.gov.tr
kerem.kuterdem@afad.gov.tr
Website: <http://www.depem.gov.tr>
<http://www.afad.gov.tr>

Demir Akin

Prime Ministry Office
Disaster and Emergency Management
Presidency
Earthquake Department
Earthquake Risk Management Group
Eskisehir Yolu, Lodumlu,
Ankara, Turkey
Tel: +90 312 287 26 80
Fax: +90 312 287 93 70
E-mail: akin@depem.gov.tr
Website: <http://www.depem.gov.tr>
<http://www.afad.gov.tr>

Niyazi Türkelli

Department of Geophysics
Kandilli Observatory
Earthquake Research Institute
Bogazici University
34684 Cengelkoy
Istanbul, Turkey
Tel: +90 216 3082711
E-mail: turkelli@boun.edu.tr

Ebru Harmandar

Bogazici University
Kandilli Observatory and Earthquake
Research Institute
Department of Earthquake
Engineering
34684 Cengelkoy
Istanbul, Turkey
E-mail: ebru.harmandar@boun.edu.tr

United Arab Emirates

Abdallah Shanableh

Chairman,
Department of Civil and
Environmental Engineering
University of Sharjah
P.O.Box 27272
Sharjah, United Arab Emirates
E-mail: shanableh@sharjah.ac.ae

United States of America

Michael P. Foose

Regional Specialist for Africa and the
Middle East
International Programs
U.S. Geological Survey National Center,
MS 917, 12201 Sunrise Valley Drive
Reston, VA 20192-0002, USA
Tel: +1 703 648 6055
Fax: +1 703 648 6075
E-mail: mfoose@usgs.gov

Hanan Mahdi

Graduate Institute of Technology
University of Arkansas at Little Rock
Little Rock, AR, USA
E-mail: hmahdi@ualr.edu

Haydar Al-Shukri

Associate Dean for Research and
Graduate Education,
Professor and Chair Dept of App. Science
College of Science and Mathematics
University of Arkansas at Little Rock
2801 South University, ETAS 3000
Little Rock, AR 72204-1099, USA
Tel: +1 501 569 8000
Fax: +1 501 569 8020
E-mail: hjalshukri@ualr.edu
Website: <http://quake.ualr.edu/hja/hja.htm>

Keith Nakanishi

Seismologist
1644 Frankfurt Way
Livermore, CA 94550, USA
Tel: +1-925-422-3923
E-mail: keith.nakanishi@gmail.com



UNIVERSITY OF MALTA
L-Università ta' Malta

Rengin Gök
Seismologist
Lawrence Livermore National Laboratory
7000 East Avenue, L-046
Livermore, CA 94551, USA
Tel: +1 925 423 1563
E-mail: gok1@llnl.gov

Stephen Herzog
National Nuclear Security
Administration
U.S. Department of Energy
1000 Independence Ave, S.W.
Washington, DC 20585
U.S.A.
E-mail: Stephen.Herzog@NNSA.Doe.Gov

Yemen

Jamal M. Sholan
Seismological and Volcanological
Observatory Center
Dhamar, Republic of Yemen
E-mail: sholan20@hotmail.com

UNESCO

Badaoui Rouhban
Director
Unit for Natural Disasters
Natural Science Sector
UNESCO
1 rue Miollis
75732 Paris Cedex 15, France
Tel + 33 1 45 68 41 20
Fax + 33 1 45 68 58 21
E-mail: b.rouhban@unesco.org
Website : <http://www.unesco.org/disaster>

Frederick O. Simon
Consultant
11813 Stuart Mill Road
Oakton, Virginia 22124
United States of America
Tel: +1 703 620 2772
Fax: +1 703 620 3043
E-mail: fredericksimon@msn.com

Jair Torres
Consultant
Unit for Natural Disasters
Natural Science Sector
UNESCO
1, rue Miollis, B3.23
75732 Paris Cedex 15, France
Tel: +33 (0)1 45 68 41 22
Fax: +33 (0)1 45 68 58 21
E-mail: j.torres@unesco.org
Website : <http://www.unesco.org/disaster>

Yue Yu Zou
Unit for Natural Disasters
Natural Science Sector
UNESCO
1, rue Miollis, B3.23
75732 Paris Cedex 15, France
Tel: +33 (0)1 45 68 39 65
Fax: +33 (0)1 45 68 58 21
E-mail: yy.zou@unesco.org

Annex B

International Workshop on Seismicity and Earthquake Engineering in the Extended Mediterranean Region

Sliema, Republic of Malta
13 – 16 February 2012

Final Program

Sunday, 12 February 2012

Participants arrive in Malta

Monday, 13 February 2012

09:00 – 09:30 Registration

Opening Ceremony

09:30 – 10:30 Opening Ceremony,

Chair: Dr. Pauline Galea

- Dr. Pauline Galea, University of Malta
- Dr. Michael Foose, USGS
- Dr. Badaoui Rouhban, UNESCO
- Prof. Charles V. Sammut, Dean, Faculty of Science
- Hon. Dr. Ray Bondin, Maltese Amb. to UNESCO

Introduction of Participants

Logistical announcements

10:30 – 11:00 Coffee/tea break

First Session

11:15 – 13:00 Keynote Presentations

Chair: Charles V. Sammut

11:15 – 12:00 Ruben Borg

Seismic damage assessment of structures: Case Study of the L'Aquila 2009 earthquake

12:00 – 12:45 Pauline Galea

The Maltese Islands: Tectonic Environment, Seismicity and Hazard.

13:00 – 14:30 Lunch

Second Session

14:30 – 16:00 Special Session on Paleoseismicity in the Extended Mediterranean Region-I: Chair: Eleni Georgiou-Morrisseau

In many countries of the extended Mediterranean region, there have very extensive studies involving trenching and dating of major earthquakes including many that pre-date instrumental times. Paleo-archeological investigations have also been carried out in some countries. In conducting seismic hazard assessments, the data generated by these studies is invaluable. We invite participants to give presentations on paleoseismology and paleo-archeology from their countries.

14:30 – 15:00 Mohamed Reda Sbeinati

Timing of Earthquake Ruptures at the Al Harif Roman Aqueduct (Dead Sea fault, Syria) from Archeoseismology and Paleoseismology

15:00 – 15:30 Rivka Amit

The Use of Paleoseismic Data for Seismic Hazard Evaluations of the Dead Sea Transform.

15:30 – 16:00 Stelios Nicolaidis, Sylvana Pilidou and Eleni Georgiou-Morrisseau

Palaeoseismicity of the Cyprus region: the AD 365 Kourion Earthquake

16:00 – 16:30 Coffee/tea break

Third Session

16:30 – 17:30 Special Session on Paleoseismicity in the Extended Mediterranean Region-II: Chair: Mohamed Reda Sbeinati

16:30 – 17:00 Ryad Darawcheh

Palaeoseismology along the Levant Fault System in Western Syria and Lebanon: Conclusive Evidences of Large Earthquakes

17:00 – 17:30 El-Sayed Mohamed Salem

Ancient Tsunami Deposits on the Red Sea Beach, Egypt

Fourth Session

17:30 – 18:30 Open discussion on the objectives of RELEMR

Chairs: Mike Foose and Badaoui Rouhban

18:30 – Free Night

Tuesday, 14 February 2012

Fifth Session

09:00 – 10:40 Contributed Papers: Chair: Hanan S. Al-Nimry

09:00 – 09:20 Niyazi Türkelli

The October Mw=7.2 and the November Ml=5.6 Van Earthquakes, Their Aftershock Sequence and Prior Seismicity

09:20 – 09:40 Demir Akin

23 October 2011 Van Earthquake Mw=7.0

09:40 – 10:00 T.A. Mansoob

Recent Earthquake Activity along Western Saudi Arabia

10:00 – 10:20 Haydar Al-Shukri

Induced Seismicity a Result of Fluid Injection and Oil Shale Fracking

10:20 – 10:40 María José Jiménez

11 May 2011 M 5.1 Lorca (Spain) Earthquake: A Big Shock

10:40 – 11:10 Coffee/tea break

Sixth Session

11:10 – 12:50 Contributed Papers: Chair: Dawood Shakir Mahmood

11:10 – 11:30 Jamal M. Sholan and Ismail Al-Ganad

Earthquakes Activity in the Gulf of Aden and Southern Red Sea (2005-2011) in Connection with Recent Zubair Volcanic Eruption

11:30 – 11:50 Raafat E. Fat-Helbary

Seismicity and Seismic Hazard in Aswan Area, Egypt

11:50 – 12:10 Ebru Harmandar

A Framework for Istanbul Earthquake Early Warning and Rapid Response System: Current Status and Perspectives

12:10 – 12:30 Marco Mucciarelli

An Example of International Project Aimed to Seismic Risk Reduction with Low-Budget Strategy: The ASSAS-BV Project

12:30 – 12:50 Hanan S. Al-Nimry

Seismic Fragility Curves for Stone-Concrete Buildings in Jordan

13:00 – 14:30 Lunch

Seventh Session

14:30 – 16:10 Contributed Papers:

Chair: Issa El Hussain

14:30 – 14:50 Galal Mekhlafi and Hanan S. Al-Nimry

Estimation of Maximum Inelastic Displacement Demand for Stone-Concrete Buildings in Jordan

14:50 – 15:10 Luis Matias

Evaluation of Tsunami Impact and Vulnerability: an Example from Portugal and Morocco

15:10 – 15:30 Ayman Mohsen

Crustal Structure of the Dead Sea Basin (DSB) from a Receiver Function Analysis

15:30 – 16:10 Avi Shapira

Probability based estimation of Earthquake Risk Parameters to be used in Earthquake Preparedness Operations

16:10 – 16:40 Coffee/tea break

Eighth Session

16:40 – 18:00 Contributed Papers:

Chair: María José Jiménez

16:40 – 17:00 Mohamed Hamdache

Correlating Spanish IGN and Algerian CRAAG Magnitudes for Northern Algerian Earthquakes

17:00 – 17:20 Dawood Shakir Mahmood

An Overview of Iraqi Seismological Network (ISN)

17:20 – 17:40 Abdala Elmelade

General Information about Seismicity and Seismotectonics of Libya

17:40 – 18:00 Kerem Kuterdem

National Earthquake Strategy and Action Plan (NESAP-2023): A Road Map in Order to Reduce Earthquake Hazards

18:00 – Free Night

Wednesday, 15 February 2012

09:00 – 12:30 Special session on site effects

Chair: Sebastiano D'Amico

A comprehensive understanding of the responses of different structural systems in urban and rural areas affected by earthquakes is an important requisite for the reduction of losses during earthquakes. Structural systems dominant in a region may have significant variations due to local design constraints as affected by the availability of construction materials and economic standards of the population. An additional constraint that affects the built environment is the local geological conditions on which structures are built. Local geology and geotechnical conditions affect the design and analyses of the structures because the geotechnical environment affects the way the structures respond during strong shaking caused by near and distant earthquakes. For example, a 5-story stiff shear wall reinforced concrete building responds in a different way if it is built on a rock site than if it is built on alluvial or softer site conditions.

Thus, it is necessary to fully understand the behavior of different structural types constructed with different local construction materials at sites that vary according to local geology. As a result, two basic subjects must be well understood: (a) structural response of buildings and (b) site response. Numerous methods for the assessment of structural and site responses are available. Such responses may be affected by regional and local constraints and therefore such regional characteristics ought to be exposed and identified.

An introduction to data analysis for evaluating site effects and building response will be presented followed by sessions of getting acquainted with the software and with data processing, analysis, and interpretation using existing data files. Participants are urged to bring laptops so that software can be installed. Participants will be allowed to take the software with them when they return to their home countries.

09:00 – 10:00 Avi Shapira

Questioning the Applicability of Soil Amplification Factors as Defined by NEHR (USA) in the Israel Building Standards

10:00 – 10:30 Francesco Panzera

Is the Evaluation of Topographic Effects an Easy Task?

10:30 – 11:00 Coffee/tea break

11:00 – 12:00 Marina Gorstein

Some Considerations on Experimental Study of Site Effect Using Ambient Noise Measurements

12:00 – 12:30 Galina Ataev

Use of H/V Spectral Ratios Measurements of Ambient Noise for Seismic Microzonation and Modeling of the Subsurface.

12:20 – 13:45 Lunch



UNIVERSITY OF MALTA
L-Università ta' Malta

14:00 – 20:00 Field trip (Including geology/archaeology/cultural heritage)

20:00 – 23:00 Workshop dinner hosted by the University of Malta

Thursday, 16 February 2012

09:00 – 10:40 Contributed Papers on Site Effects: Chair: Marco Mucciarelli

09:00 – 09:20 Sharon Pace

Site Effects and Earthquake Ground Motion Scenario for the Xemxja Bay Area (Malta)

09:20 – 09:40 Issa El-Hussain

Seismic Microzonation for Seismic Risk Mitigation in Muscat area, Sultanate of Oman

09:40 – 10:00 Sebastiano D'Amico

An Ambient Noise HVSR Survey in Valletta World Heritage Site and the Historical City of Mdina, Malta

10:00 – 10:30 Open discussion on site effects Discussion Leader: Marco Mucciarelli

10:30 – 11:00 Coffee/tea break

11:00 – 13:00 Methodology for Assessing School Safety – Educational, Scientific and Engineering Aspects Chair: Fadi Geara

Participants of the second and third session of the United Nations International Strategy for Disaster Reduction (UNISDR) Global Platform for Disaster Risk Reduction in June 2009 and 2011, respectively, committed to assess the level of disaster resilience in all schools in disaster-prone countries, and all related government's agencies to develop a national plan for school safety by 2015. The UNISDR Secretariat in Geneva in coordination with the UN Thematic Platform on Knowledge and Education (TPKE), which includes UNISDR, UNESCO, UNICEF, GFDRR, INEE, Plan International and Save the Children, among others, have been working in the preparation of a methodology for assessing school safety.

11:00 – 11:30 Djillali Benouar and Mounir Naïli

Seismic Vulnerability Assessment of Existing School Buildings in Algiers City

11:30 – 12:00 Adnan Khasawneh

Structural Assessment of UNRWA Co-Edu School at Irbid

12:00 – 12:30 Jalal Al Dabbeek

Non Structural Seismic Vulnerability Assessment of Hospitals and Health Centers in Palestinian Cities



UNIVERSITY OF MALTA
L-Università ta' Malta

12:30 – 13:00 Jair Torres

Methodology for Assessing School Safety – Educational, Scientific and Engineering aspects

13:00 – 14:30 Lunch

14:30 – 15:00 Open discussion on methodologies for assessing school safety

Discussion Leaders: Jair Torres, Djillali Benouar, Adnan Khasawneh

Closing session

15:00 – 16:00 Closing Session: Chairs: Mike Foose, Pauline Galea and Badaoui Rouhban

Friday, 17 February 2012

Departure from Malta



UNIVERSITY OF MALTA
L-Università ta' Malta

Annex C

Seismicity and Earthquake Engineering in the Extended Mediterranean Region

**Sliema, Republic of Malta
13 – 16 February 2012**

Abstracts

Seismic Damage Assessment of Structures: Case Study of the Abruzzo 2009 Earthquake

Ruben Borg

Department of Civil and Structural Engineering, Faculty for the Built Environment
University of Malta, Msida, Malta

The Abruzzo earthquake hit the city of L'Aquila and its surroundings on the 6th April 2009. A magnitude $M_w=6.3$ ($M_s=6.3$, $M_L=6.2$, INGV) normal faulting earthquake struck the Abruzzo Region located in the central part of Italy, with an epicentre of shallow focal depth (9.5 km, coordinates 42.348 N, 13.380 E) very close to L'Aquila, a city of about 73,000 inhabitants. This main event was the strongest of a sequence which had started a few months earlier, releasing 23 earthquakes of $M_w>4$ between March 30th, 2009 and April 23rd, including major aftershocks.

The earthquake struck during the night, when most people were sleeping. The death toll was dreadfully high with 305 people killed, another 1500 approximately injured, and many people homeless (more than 24,000, but with the temporary evacuation of 70,000-80,000 residents in the first months after the disaster). A wide area, including the historic centre of L'Aquila, the suburbs and some villages around, was affected by the seismic event. This resulted in vast damage and collapse of several buildings, affecting not only old Un-Reinforced Masonry (URM) constructions, but also multi-storey reinforced concrete structures. Furthermore, neighbouring historic towns and villages far enough from the epicentre, as Castelvechio Subequo, experienced heavy damage.

The earthquake caused extensive losses and about 18,000 unusable buildings were recorded in the epicentral area. A total of 90 municipalities were affected by the earthquake with a Mercalli-Cancani-Sieberg (MCS) damage intensity higher than VVI up to a maximum X level (INGV). Many of cultural sites in the region were badly damaged or destroyed, including Romanesque churches, historic buildings, and other monuments dating from the Middle Ages to the Renaissance and Baroque period.

An overall review of the 2009 Abruzzo earthquake was carried out including an overview of the dynamic characteristics of the earthquake and the seismic history of the region. In addition, an extensive damage survey was completed during the post-earthquake emergency activity. The seismic performance of buildings was assessed on the basis of both the experience in the City of L'Aquila and the village of Castelvechio Subequo, during the post-emergency support to the Italian Department of Civil Protection (Dipartimento della Protezione Civile), and the detailed field investigation which was carried out with the patronage of the EU Action C26 and the cooperation of the PLINIVS Centre of the University of Naples in three areas of the old city of L'Aquila.

The aim of the activity was to analyze the technical features of buildings, in particular Un-Reinforced Masonry (URM) buildings and assess their seismic behaviour during the Abruzzo 2009 seismic event. The damage induced in the URM constructions of L'Aquila and the suburbs was severe and several such buildings collapsed. The activity included the analysis of the performance of URM buildings in the areas investigated and the assessment of the most common damage or collapse mechanisms. The main characteristics of URM buildings,



UNIVERSITY OF MALTA
L-Università ta' Malta

the building behaviour and damage were described and reviewed with due respect to the characteristics of the earthquake, as well as with reference to the structural and non-structural characteristics of buildings. The AeDES results (post-earthquake damage assessment in Italy, AeDES 2010) and the MEDEA methodology (MEDEA 2005), both developed in the framework of the Italian Civil Protection activities, were adopted during the assessment.

The Maltese Islands - Tectonic Environment, Seismicity and Hazard

Pauline Galea

Physics Department, University of Malta, Msida, Malta

The Maltese islands lie in the Sicily Channel, on a shallow submarine platform that extends northwards to southeast Sicily. Geologically, the islands are very similar to the Ragusa platform in the SE corner of Sicily. The Malta-Ragusa plateau is bounded to the east by the spectacular and seismically active Sicily-Malta escarpment that drops down steeply to the Ionian basin and to the north by the Hyblean mountain range. To the south and west, the Sicily Channel plateau is interrupted by a series of tectonic features – most prominently the three grabens of the Sicily Channel Rift Zone, trending NW – SE and active since the Late Miocene, inter-related by a number of transform lineaments.

The tectonics of the Sicily Channel, and in particular, the dynamics that control the extension of the grabens, are still under discussion. They are necessarily related to major tectonic readjustments that have taken place, and are still occurring, in the Central Mediterranean region – the northwesterly rotation of the African plate relative to Europe, the retreat and slowing down of subduction at the Calabrian arc, the north-easterly directed subduction of African lithosphere at the Hellenic arc, and the possible initiation of southward-directed subduction at the North African margin. The understanding of the relation between these processes and the crustal extension that has produced the grabens, could in principle be enhanced by studying the spatial patterns and mechanisms of seismicity occurring along the grabens and other features. To date, the region has been regarded as one of low and sparse seismicity, mostly because earthquakes are of low magnitude and in general outside the range of regional, land-based networks, and have thus been inadequately monitored and located. With improved monitoring facilities on Malta, a more clear picture is emerging of the seismic activity in the region. The prospect of improved seismic networking in the Central Mediterranean also augurs well for the better constraint on the relations between seismicity and tectonics. Moreover, a better understanding of the earthquake potential of these features will contribute towards improved seismic hazard assessment of the Maltese islands, which have suffered earthquake damage a number of times in the past, and are characterized by significant exposure and building vulnerability in the present day.

Timing of Earthquake Ruptures at the Al Harif Roman Aqueduct (Dead Sea fault, Syria) from Archeoseismology and Paleoseismology*

Mohamed Reda Sbeinati¹ &², Meghraoui Mustapha², Suleyman Ghada³, Francisco Gomez⁴,
Grootes Pieter⁵, Nadeau Marie-Josée⁵, Haithem Al Najjar¹, & Riad Al-Ghazzi⁶

¹Department of Geology, Atomic Energy Commission, Damascus, Syria

²Laboratory of Active Tectonics, Institut de Physique du Globe, Strasbourg, France

³Directorate General of Antiquities and Museums, Damascus, Syria.

⁴Department of Geological Sciences, Missouri University, USA.

⁵Leibniz-Labor für Altersbestimmung und Isotopenforschung, Kiel University, Germany.

⁶Higher Institute for Applied Sciences and Technology, Damascus, Syria

We study the faulted Al Harif Roman aqueduct located on the north-south trending and ~ 90-km-long Missyaf segment of the Dead Sea Fault (DSF) using 4 archeological excavations, 3 paleoseismic trenches and the analysis of 6 tufa cores. Damage to the aqueduct wall exhibits successive left-lateral fault offsets that amount 13.6 ± 0.2 m since the aqueduct construction younger than BC 65. Radiocarbons dating of sedimentary units in trenches, building cement of the aqueduct wall and tufa cores constrain the late Holocene aqueduct history. The building stone types, related cement dating and tufa deposits of the aqueduct indicate 2 reconstruction-repair episodes in AD 340 ± 20 and AD 720 ± 20 . The combined analysis of trench results, successive building and repair of aqueduct wall, and tufa onsets, growths and interruptions suggests the occurrence of 4 faulting events in the last ~ 3500 years with a cluster of 3 events in AD 160 - 510, AD 625 – 690 and AD 1010 - 1210, the latter being correlated with the 29 June 1170 large earthquake. Our study provides the timing of late Holocene earthquakes and infers a lower and upper bound 4.9 – 6.3 mm/yr slip rate along the Missyaf segment of the Dead Sea Fault in Syria. The inferred successive faulting events, fault segment length and related amount of coseismic slip yield $M_w = 7.3 - 7.5$ for individual earthquakes. The identification of the temporal cluster of large seismic events suggests periods of seismic quiescence reaching 1700 years along the Missyaf fault segment.

*Submitted to the Geological Society of America Bulletin, Special Volume on “Ancient Earthquakes”, Accepted April 2010, Published December 2010.

The Use of Paleoseismic Data for Seismic Hazard Evaluations of the Dead Sea Transform.

Rivka Amit

Geological Survey of Israel, Jerusalem, Israel

Synthesis of paleoseismic data of several segments along the Dead Sea Transform (DST) show that each has a specific pattern of large earthquake distribution. It was found that during the last 20 ky the segments of the Arava and the Jordan valley have recurrence intervals of large events of about 1 ky while in the Hula valley the recurrence interval is 350 yr and 3-5 ky in the Dead Sea segment. However, beside the differences between the segments some similarities can be shown, especially in the large time frame. At least two segments, the Arava and the Dead Sea, show a similar change in earthquake pattern over time. It was found that in both segments the probability of a large earthquake ($M \geq 6$) occurring decreased gradually with time over the last 100 ky. In the southern Arava the magnitude range of earthquakes that occurred between 80 ka and 20 ka is $M6.7 - M7$ with average recurrence intervals of 2.8 ± 0.7 ky, whereas the magnitude range during the last 20 ky is $M5.9 - M6.7$ with average recurrence intervals of 1.2 ± 0.3 ky. In addition it was found that over the last 100 ka the magnitude of the large events along the Dead Sea Transform ranges mainly between $M5.9$ and $M7.5$. It appears that there is an upper limit to the magnitude of the events that can be produced by the DST. It is suggested that this magnitude limit is an inherent characteristic of the DST which is controlled by the structure and the dimension of its segments. Integration of paleoseismic and historical records of strong earthquakes of the DST segments show that they all lie on the linear extrapolation of the frequency–magnitude relation of the instrumental record. The calculated b-values for the segments are between 0.85 and 1, similar to other major strike-slip faults in the world. It is concluded that the Gutenberg–Richter distribution is a stable mode in the tectonic setting of the Dead Sea fault during the past 60,000 yr.



UNIVERSITY OF MALTA
L-Università ta' Malta

Evidence of a Large Prehistoric Earthquake in Kuwait and Implications for the Seismic Vulnerability of the Arabian Gulf Countries

Firyal Bou-Rabee, Yin Lu Young and Erik VanMarcke

Kuwait University, Safat, Kuwait

This paper presents and analyzes paleo liquefaction features found in the State of Kuwait. The features are cemented sand and gravel filled dikes of Pleisto-Holocene age with appearance and composition similar to typical “sandstone pipes”. The significant age difference between the cemented dikes and the surrounding loose sand, the size and spatial distribution of the dikes, and the local geologic and hydrologic setting all suggest that the event is probably caused by a single large event of seismic origin. Likely hypotheses include shaking of large earthquakes and seiching of tsunami-like waves. Additional research is needed to identify the exact cause of these dike formations, which is important for the purpose of improving seismic risk and vulnerability assessment of the Arabian Gulf countries. The search may also help to explain the disappearance of an ancient civilization that lived in the same region approximately seven thousand years ago.

Palaeoseismicity of the Cyprus Region: the AD 365 Kourion Earthquake

Stelios Nicolaides, Sylvana Pilidou and Eleni Georgiou-Morisseau

Geological Survey Department, Nicosia, Cyprus

Cyprus lies within the boundary zone of the Alpine-Himalayan belt where approximately 15% of the global seismic activity occurs (Ambraseys, 1965). The belt extends from the Atlantic along the Mediterranean through Italy, Greece, and Turkey to Iran, India and the Pacific. The tectonic framework of the Eastern Mediterranean is dominated by the collision of the Arabian and African plates with that of Eurasia (McKenzie, 1970). Cyprus is located near the triple junction of the African, Arabian and Eurasian Plates (Papazachos and Papaioannou, 1999) and as a result it has a long history of earthquakes and tsunami activity that affected the island, as noted in written, archaeological and geological records (Ambraseys and Adams, 1993). Historically, tsunamis have also affected the Mediterranean region and in particular the Eastern Mediterranean (Altinok and Ersoy, 2000; Papadopoulos, 2001; Fokaefs and Papadopoulos, 2007; Salamon et al., 2007; Shaw et al., 2008). The aim of this paper is to present the seismic history of Cyprus, based on historic records and archaeological findings, with particular reference to the AD 365 Kourion earthquake.

Historic references as well as archaeological discoveries testify that Cyprus has been affected many times in the past by strong earthquakes that destroyed its towns and settlements such as Pafos, Salamina, Kition, Amathus and Kourion. It is believed that between 26 BC and AD 1896, when instrumental recording began, Cyprus has been affected by sixteen disastrous earthquakes. Among the most catastrophic earthquakes was the 15 BC earthquake that destroyed the town of Pafos, the AD 76 earthquake that destroyed Salamina and Kition and the AD 365 earthquake that destroyed the village of Kourion.

Kourion suffered from numerous devastating earthquakes between the 3rd and 4th centuries AD, until a severe seismic event, believed to have occurred at approximately AD 365, had led to its permanent destruction. Archaeological excavations have shown that at the time many ancient towns in Sicily, Greece, Libya, Cyprus and Egypt were hit and destroyed, possibly by a sequence of destructive earthquakes along the Hellenic and Cyprus Arcs. Evidence that an earthquake may have leveled Kourion first surfaced in 1934, when the American archaeologist J. F. Daniel uncovered the remains of a Roman house in which he found "fingerprints" of an earthquake. During 1984-1987, the American archaeologist D. Soren and his team discovered that the Kourion area was virtually undisturbed. Kourion had been completely abandoned after the disaster and no one had returned to collect the dead (Soren, 1988; Soren and James, 1988). The team felt like a rescue team arriving 16 centuries too late. Soren estimates that 500 people died in the Kourion area, but the toll in all of south-west Cyprus was perhaps in the thousands.

Palaeoseismology along the Levant Fault System in Western Syria and Lebanon: Conclusive Evidence of Large Earthquakes

Ryad Darawcheh

Department of Geology, Atomic Energy Commission of Syria, Damascus, Syria

Palaeoseismic and geomorphologic investigations carried out within the last decade along the different segments and branches of the central and northern parts of the Levant fault system in western Syria and Lebanon for understanding the earthquake behaviors of these segments in the Holocene reveal the following main results: (1) five large historical earthquakes ($M_s \geq 7.0$) have been documented due to the Serghaya branch with a main return time of about 1300 yr; (2) three large palaeoeartquakes ($M_s > 7.0$) have been ruptured from the Messyaf segment with 550 yr as a return period, the most recent event corresponds to the 1170 AD earthquake; (3) ten to thirteen large palaeoearthquakes with $M_s \sim 7.5$ have been documented along the Yammouneh segment in the 12,000 years, the great 1202 earthquake was the most recent one; (4) the Roum branch is the most likely source for the documented 1837 earthquake ($M_s 7.1$); and (5) the Hagi Basha segment is responsible for three large historical earthquakes of 859 AD, 1408 and 1872 with a recurrence interval of about 500 yr. These seismogenic sources represent genuine seismic hazard for western Syria and Lebanon.

Ancient Tsunami Deposits on the Red Sea Beach, Egypt

El-Sayed Mohamed Salem

Egyptian Geological Survey, Cairo, Egypt

The studied area is delineated by latitudes 25° 6' N & 25° 9' N and longitudes 34° 50' E & 34° 53' E, it covers an elongate area of about 12 Km², along the Red Sea coast, North Marsa Alam City.

For evaluation the area a lot of information allows us to interpret the conditions prevailing during deposition of the sediments especially at the coast. To achieve the target 5 wells were drilled to study core samples, well logging measurements and 69 Vertical Electrical Sounding stations were carried out. The studied area and adjacent areas were geologically surveyed to note ancient geological features related to earthquakes.

From geological and geophysical studies, the dominant rock types at the western portions of the studied area are sandstone, sandy clay, clay, clayey sandstone, and gravels, at the middle portion of the studied area the rocks are hard, but the eastern side of the area especially, at the beach of the Red Sea several cycles of depositions of Coral Reefs occurred with intercalations of clastic deposits such as clay, sand, sandstone, conglomerate, gravels, pebbles and a lot of fossils and shell fragments. The rocks are characterized by heterogeneous properties and ill-sorted. The area includes large numbers of faults due to highly tectonism of the area. The results indicated that the area has lateral variation of sediments. The carbonate rocks at the beach contain clastic fragments and carbonate blocks are included within clastic rocks, with increasing the distance from the beach to the west the sediments are less heterogeneous. The beach of the Red Sea was subjected to ancient tsunami waves due to highly seismic activity which left their signature in geological column especially at the beach. The observation of some ancient geological features such as liquefaction and landslides indicate the area subjected to strong earthquakes related to rifting of the Red Sea.



UNIVERSITY OF MALTA
L-Università ta' Malta

On the importance of developing synergies between RELEMR and other initiatives

Rémy Bossu

European-Mediterranean Seismological Centre, Arpajon, France

JSOP and RELEMR initiatives have been instrumental in developing parametric data exchange and availability in the Mediterranean region. It remains today the unique regular meeting point of the Mediterranean seismological community. As such RELEMR has the possibility to develop synergies with other independently funded initiatives for joint benefit while maintaining its own specificities.

Past experiences in this domain, like the EERWEM workshops (San Fernando, Rabat), invitation of RELEMR participants to the ESC2010 (Montpellier), or the upgrade of the national network in Tunisia will be presented to illustrate such possibilities.

We will then present for discussion what could be possible new objectives for RELEMR taking into account a more general context and the existence of initiatives and projects such as EPOS, NERA or GEM. Is also contributing in improving waveforms availability.

This presentation intends to give an overview of the different roles EMSC has been playing in the RELEMR/JSOP initiatives since 1996. It will present how participants can benefits from it services and what could be the synergies with connected initiatives and explore what could be its future involvement.

The October Mw=7.2 and the November Ml=5.6 Van Earthquakes, Their Aftershock Sequence and Prior Seismicity

Niyazi Türkelli

Department of Geophysics, Kandilli Observatory and Earthquake Research Institute,
Bogazici University, Istanbul, Turkey

The Mw=7.2 earthquake occurred on October 23, 2011 in Eastern Turkey in the province of Van, 16 km north-northeast of the city of Van, killing around 700 people and leaving few thousand homeless. A few days later, on November 09, 2011, an Ml=5.6 earthquake followed the main shock causing more deaths and damage. The location of the Ml=5.6 earthquake is in the town of Edremit which is about 16 km to the south of the Van city center. The source parameters of the main shock are given by different institutions below.

A significant aftershock activity is still ongoing in the earthquake region since 23 October 2011 and the number of aftershocks exceeded 5 000 within one month. The epicenters of the Van sequence define a rupture zone ~30 km in length, oriented NE-SW. The main shock epicenter is at the NE edge of this zone. The pattern of epicenters and depths support a rupture model with slip on the northwest-dipping nodal plane. The average depth of the seismicity associated with the October 23, 2011 event is about 24 km, with a range of 13-30 km.

The Van Earthquake focal mechanism indicates oblique thrust faulting, consisting with the Bitlis-Zagros Fault Zone. On the other hand, the Edremit-Van earthquake has a dominantly strike-slip mechanism. This earthquake took place on a blind fault similar to the event of 23 October 2011.

In the area of the earthquake, the Arabian Plate is colliding with Eurasia and the tectonics in the area dominated by the Bitlis Suture Zone, the Zagros fold and thrust systems.

M_w	M_l	Depth [km]	Coordinates	Institution
	6.7	19.02	38.68 N 43.47 E	Disaster and Emergency Management Presidency (AFAD)
7.2	6.6	5	38.758 N 43.360 E	Kandilli Observatory (KOREI)
7.1		16	38.691 N 43.497 E	U.S. Geological Survey (USGS)
7.2		10	38.86 N 43.48 E	European-Mediterranean Seismological Centre (EMSC)
7.1		15	38.67 N 43.58 E	Earthquake Information Service, Postdam (GEOFON)
7.3		10	38.86 N 43.48 E	Swiss Seismological Service (SED)

23 October 2011 Van Earthquake Mw=7.0

Demir Akin, Kerem Kuterdem and Murat Nurlu

Earthquake Department, Disaster and Emergency Management Presidency of Turkey

A destructive earthquake occurred 20 km. North of Van City Center near Kasımoğlu Village (West of Erçek Lake) on 23 October 2011 at 13:41 local time. According to the National Seismological Observation Network, operated by Prime Ministry Disaster and Emergency Management Presidency (AFAD) magnitude of earthquake is $M_l:6.7$ and the depth is 19.07 km. Epicentral coordinates are determined as 38.68N-43.47E. After comprehensive calculations, moment magnitude is calculated as $M_w:7.0$ for this earthquake. Immediately after the event, all necessary information about the earthquake was transmitted to National Crisis Management Center established at AFAD headquarters and to high level local authorities of Van. Team of AFAD Earthquake Department reached to Van with Deputy Prime Minister responsible from disaster and emergency management 4 hours after the event and contributed to crisis management at Van. Field studies also initiated immediately after the AFAD Team reached to Van and Ercis.

Focal mechanism solutions of $M_w: 7.0$ earthquakes reveal East-West oriented thrust fault mechanism. Since there were no evidence to thrust faulting in the field as fault rupture, morphological indicators, secondary effects of earthquake like mass movements show that east-west oriented thrust fault named as "Everek Fault" is the primary source of this event. The location of the event also supports this relation. During field studies performed around Van and Ercis, several earthquakes triggered secondary events like landslides, rockfalls, liquefaction and lateral spreading were observed. The first earthquake occurred on 23 October 2011 is named as Van-Merkez Earthquake and this cannot be described as shallow earthquake. It was expected from past experiences of previous big earthquakes that Magnitude $M_w: 7.0$ earthquake would have generated ruptures with some kilometres long on the surface and more distributed damage must have been observed since the magnitude and loose sedimentary units dominate around the earthquake area. However, earthquake with 19.02 km. depth prevented such features to be observed. 23 October 2011 Van-Merkez earthquake is unique from several aspects. Very high number of aftershocks within short period after the event was not experienced previously. Within the first week of the earthquake, there happened 114 earthquakes with magnitudes between 4.0 and 4.9 and 7 earthquakes with magnitudes bigger than $M_l: 5.0$. Within the first month after the event daily average aftershock number is around 180 earthquakes. By 09 December 2011, the number of aftershocks reached to 6284.

Focal mechanism solutions of 160 earthquakes after 23 October and 09 November earthquakes were analyzed and correlated with regional fault maps of the region in order to reveal their occurrence mechanisms. The amount of energy released after 23 October 2011 earthquake is calculated as 2.09×10^{15} Joule which is 33.2 times bigger than the amount of atom bomb released to Hiroshima-Japan. When considering the aftershocks, the amount increases to 2.36×10^{15} Joule which is equal to 37 atom bombs.

According to the information given by AFAD, 644 people lost their lives and 252 people were saved alive from the debris. AFAD informed that, by 09 December 2011, 17005 dwelling units were determined as collapsed and/or heavily damaged in Van City Center, Ercis and villages.

Recent Earthquake Activity along Western Saudi Arabia

El-Hadidy, S.Y., Zaharn., H.M. , Mansoob T.A

National Center for earthquakes and Volcanoes, Jeddah, Saudi Arabia

Earthquakes are an important natural hazard in many regions, sometimes with severe effects on the environment, human life and infrastructure. Assessment of earthquake occurrence parameters for any area plays an important role in establishing measures to minimize earthquake damage and in anticipating the future risk during development for strategic projects. Studying seismic activity is the key to understand the seismo-tectonic setting of any region.

Recently the Saudi National Seismic Network (SNSN) has recorded considerable seismic activity in the western part of the Kingdom throughout 2009 up to 2011. These earthquakes were felt by residents, and hence have been studied by SGS. The recorded waveform data were analyzed using Atlas software from the Nanometrics Corporation in order to obtain the earthquake parameters

On 19/4/2009 an earthquake swarm has been occurred, 43000 events have been recorded , 210 of this swarm have been felt up to 210 km, the magnitude ranges from 3 to 5.39 on Richter scale (5.7 MW).

The interpreted of structural model at harrat al-shaqa, where the magma chamber is moving up and stressing on the surrounding rock and faulting the rock to produce half graben, where the displacement is not equal at both side of subsidence areas.

The In SAR data showing the major deformation during the earthquake swarm.

There are two Uplifted areas having graben between them where the majority of earthquakes have been located. Also, it is clear that the major fracture is parallel to the main Dyke having NW-SE Direction.

Two Earthquakes have been occurred in 27/8/2009 and 28/8/2009 with 5.1 and 3.8 on Richter magnitude scale, respectively, they are located about 45 km. to the north of Badr city and 65 km east of Yanbu city. They are located along the NW-SE fault. The first event was felt up to Madinah and other surroundings cities causing a slight damage in some buildings at Badr city. The moment tensor inversion of the largest event show normal faulting, the preferred fault plane solution is that having NW-SE which in a good agreement with the existing fault having NW-SE trend.

Another earthquake activity started on 29 August to 31 August 2011 north east of Al-Qunfidah, Makkah Municipality, where four earthquakes have been occurred with MI ranging from 4.4 to 0.97. The main shock and the three aftershocks were felt in many places and villages. The maximum intensity was reported to be 5 at al-Masaheir and Al-Huliyayfa, , it was felt up to Al-Qunfidah where the intensity is 3 and to Baljurashi and AL-Baha where the intensity is 2. The waveform of the main shock and aftershocks show a strong two phases within 4 seconds after the p- phase which need to be identified using inversion technique, it might be due to source effect or it is strong converted or reflected phase due to existing structure.



UNIVERSITY OF MALTA
L-Università ta' Malta

However, given the potential for future events which may be damaging, it is certainly worthwhile to monitor the area more intensively. Additional more detailed data on the earthquake activity would help to locate the events more accurately and possibly enable them to be correlated with known geological structure. A more quantitative estimate of earthquake risk or hazard should also be of considerable importance in any engineering activities in the region. The data indicate the need for more detailed geological investigations and a more careful analysis of earthquake risk along the western KSA.

It is proposed that additional seismographs should be established in order to obtain improved coverage with better determination of earthquake source parameters and statistics.

Induced Seismicity a Result of Fluid Injection and Oil Shale Fracking

Haydar Al-Shukri, Hanan Mahdi, and Najah Abd

University of Arkansas at Little Rock, Arkansas, USA

For the last few years, the widespread oil shale in the central United States has been heavily prospected as a major source for hydrocarbon energy. The natural gas from the impermeable shale is extracted by increasing its permeability such that the natural gas slowly begins to flow and collect at the surface. This is accomplished through a process called hydrofracturing (fracking) of the shale. Water mixed with toxic chemicals and sandy particles is pressured into the shale to fracture it allowing the natural gas to seep through the permanently opened crack. In Arkansas, hundreds of these wells have been drilled following strict rules and regulations and carefully monitored by the Arkansas Oil and Gas Commission. The toxic byproduct fluids of the fracking process must be carefully disposed of or treated. One method of disposing of these byproducts is to inject them deep into the subsurface in zones that are substantially deeper than the oil shale formations. A requirement for the fluid injection permit was to monitor the possibility of induced seismicity. The reason for such a requirement was that the region has experienced a number of naturally occurring swarms of earthquakes, some of them of magnitudes as high as 4.5. The first monitored swarm took place in 1982 and lasted for a few years; the second swarm occurred in 2001.

Large numbers of deep wells have been used to inject the toxic fluids into permeable formations at depths ranging from about 1.5 to more than 3 kilometers. An impermeable formation is placed over the permeable one to prevent the fluids from seeping back to the surface. A seven element high-frequency array was installed to supplement the existing permanent regional stations. Each element consisted of three-component 4.5 Hz geophone. The array has an aperture of 3 kilometers and is centered on a disposal well located 5 kilometers from the historic natural seismicity. In addition to the well that the array monitors, there are five more disposal wells located to the west and north of the array within a distance of 10 kilometers. After the injection started in these wells, over 10,000 earthquakes took place over a period of about 18 months. The magnitude range for these events was between -1.5 to 4.7. Human analysts located more than 3500. To improve location accuracy, earthquakes of magnitude 2.0 and larger were again located using other stations in the area. A linear narrow feature of seismicity that extends in a northeast – southwest direction located about 10 kilometers to the northwest of the array became clearly visible. The pressured fluids seem to have made their way to a critically stressed fault, causing the pore pressure in the fault area to be substantially changed. The earthquake activity immediately reduced from hundreds per month to only a few after the injections in two wells were suspended. Earthquake data clearly indicate that only a few injection wells triggered the induced seismicity. Recently, a similar seismicity induced in the state of Oklahoma, including a 5.6 magnitude earthquake which produced a considerable and widespread damage.

11 May 2011 M 5.1 Lorca (Spain) Earthquake: A Big Shock

M.J. Jiménez and M. García-Fernández

IGEO/CSIC-UCM, Madrid, Spain

On 11 May 2011, an earthquake of magnitude Mw 5.1 shook Lorca (Murcia region, SE-Spain) causing strong damage, 9 fatalities and more than 300 were injured in the town of Lorca with a population of around 90000. Nearby towns and provinces were not seriously affected. The main shock took place at 16:47:25 UTC and was preceded by a large Mw 4.5 foreshock at 15:05:13 UTC. The strongest aftershock at 20:37:45 UTC reached Mw 3.9.

Earthquakes are not infrequent in this region. Several events in the historical record reached intensity VIII (e.g. 1674 and two in the 1911 sequence), while in the last 10 years a number of events have occurred in the same region in 1999, 2002, and 2005 of magnitudes 4.8, 5.0, and 4.7 respectively. These three events reached intensities EMS92 VI-VII causing damage and economic losses in several towns in the region.

The 11 May 2011 Lorca earthquake, although of very moderate magnitude caused a huge shock in the whole country since no fatalities were caused by earthquakes in the XX century but for two events in 1956 (11 fatalities) and 1969 (4 fatalities).

Damage was concentrated in several areas of the town where around 40% of buildings were damaged. In the historical center 16% of buildings were damaged. Historical heritage was severely affected including old churches and medieval wall towers.

Teams from different institutions in Spain visited the earthquake area in the aftermath of the main shock. A summary on reconnaissance observations on damage and recorded strong motions together with ongoing work on possible side effects and modeling of observed motions will be presented.



UNIVERSITY OF MALTA
L-Università ta' Malta

Earthquakes Activity in the Gulf of Aden and Southern Red Sea (2005-2011) in Connection with Recent Zubair Volcanic Eruption

Jamal M. Sholan¹ and Ismail Al-Ganad²

¹Seismological & Volcanological Observatory Center, Dhamar, Yemen

²Geological Survey & Mineral Recourses Board, Sana'a, Yemen

The western part of Gulf of Aden and southern portion of the Red Sea is usually figured with Triple Junction of African-Arabian-Somalia plates. Tectonic situation in this area has been reported via different studies and structure maps in NW-SE and NE-SW lineaments which generally agreeable with Danakil block motion, pull-apart of Arabian Plate and Gulf of Aden transform fault. Earthquakes activity (2005-2010) have been locally observed by Yemen seismological network particularly indicated Gulf of Aden, southern portion of the Red Sea as the a major earthquake prone-zones in south western corner of Arabian plate. Based on annual seismic bulletins for seven years records, corner percentage of 50% is located from Gulf of Aden, the maximum earthquake depth observed in western part not exceeded 70 km, where 5-35 km an average depths of hypocenters has been detected from well located earthquakes. A new volcanic island has been formed in the northern part of Zubair island group due to December 2011- January 2012 submarine volcanic eruption. Volcanic ash, scoria and some volcanic bombs is mainly exposed in fresh outcrops with maximum 650, 80 meters of width and height respectively.



UNIVERSITY OF MALTA
L-Università ta' Malta

Seismicity and Seismic Hazard in Aswan Area, Egypt

Raafat E. Fat-Helbary

National Research Institute of Astronomy and Geophysics
Aswan Regional Earthquake Research Centre, Aswan, Egypt

Aswan region is represented by a long sequence of aftershocks followed the main shock of November 14, 1981 (ML = 5.6). It includes the immediate aftershocks and continuation of Aswan activity until the present time in the area of the main shock and other locations around the northern part of Lake Nasser. The seismic activity in this area is continued. The relation between geology and structures with seismicity showing that there are several active faults in this area such as Kalabsha fault, Sayal fault, Kurkur system faults and Khor Elramla fault. The space distribution of earthquakes was used for constructing the seismicity map of Aswan area. The seismicity is concentrated into five main clusters or zones. The relation between water level in Lake Nasser and the seismic activity in the area could be observed and recorded during the period from 1981 to 2010, whereas it's not clear in late stages. Due to the activity in Aswan area and other active zones in Upper Egypt, many studies was proposed to assess expected hazard and risk in Aswan area to provide the engineers with the expected ground acceleration and its exceedance probability, and to develop earthquake hazard mitigation schemes in order to insure the structural safety of structures and the residential buildings.

Deaggregation of Seismic Hazard for Two Megacities of Iran: Tehran and Kermanshah

Noorbakhsh Mirzaei¹, Elham Shabani¹ and Fatemeh Abdi²

¹Institute of Geophysics, University of Tehran, Tehran, Iran

²Science and Research Branch, Islamic Azad University, Tehran, Iran.

Tehran, capital city of Iran, is bordered by several active faults, such as North Tehran, Mosha, Parchin and Kahrizak, which are capable to generate earthquakes with magnitude greater than 7. Also, Kermanshah is settled in the most earthquake-prone part of western Iran, which includes Dinavar and Sahneh Fault segments of the well-known Zagros Main Recent Fault in the boundary zone of the Zagros and Central-East Iran seismotectonic provinces.

Seismic hazard deaggregation has become a standard part of probabilistic seismic hazard assessment (PSHA). The first product of PSHA is calculation of the likely severity of ground motion at a given range of annual probability levels, and this is extremely important for seismic design of structures. However, for full analysis of proposed structural designs, engineers also need to examine scenario events to produce detailed time histories.

Probabilistic seismic hazard assessments for two cities of Iran; Tehran in north-central Iran and Kermanshah in western Iran are conducted. Spectral accelerations for %2, %10 and %63 probabilities of exceedance in 50 years are performed to examine in detail the hazard for the above urban centers. The results have been deaggregated to investigate what earthquake magnitude and distance combinations have contributed most to the hazard levels for the different probabilities and structural periods. The scenario earthquakes are characterized by bins of magnitude, M and source-to-site distance, R . The deaggregation results show that in Tehran and Kermanshah, earthquakes of larger size occurring at slightly shorter distances dominate. In other words, as the MRP increases, the controlling earthquakes become larger in M and occur closer to the site investigated.



UNIVERSITY OF MALTA
L-Università ta' Malta

A Framework for Istanbul Earthquake Early Warning and Rapid Response System: Current Status and Perspectives

Ebru Harmandar and Mustafa Erdik

Department of Earthquake Engineering,
Kandilli Observatory and Earthquake Research Institute,
Bogazici University, Istanbul, Turkey

Rapid urbanization, the interconnection of economies and increasing dependence on technology makes modern society more vulnerable to natural disasters with the growth of metropolitan areas like Istanbul. This has led to the recognition of the importance of early warning and rapid response systems which means of mitigating the potential human and economic losses resulting from natural disaster. In this context, Istanbul Earthquake Early Warning System provide first information on forthcoming ground shaking prior to the arrival of seismic waves at potential user sites. Also, Istanbul Earthquake Early Warning allows for emergency shutdown of critical facilities susceptible to damage such as power stations. In addition, Istanbul Earthquake Rapid Response System provide the assessments of the distribution of strong ground motion (ShakeMaps), building damage and casualties within a short time after an earthquake. Limited number of accelerometers or difficulty of monitoring at unreachable locations often has a negative impact on the generation of these maps of shaking after an earthquake. A methodology is generated based on data recorded by Istanbul Earthquake Rapid Response System to estimate properly-correlated peak ground acceleration at an arbitrary set of closely-spaced points, in a way that is statistically compatible with known or prescribed peak ground acceleration at other locations. This methodology has the potential of being used in shakemap applications. Additionally, rapid loss estimation after potentially damaging earthquakes is critical for effective emergency response and public information. For this purpose, Earthquake Loss Estimation Routine (ELER) has been developed within NERIES project JRA3 workpackage. The code has two modules of analysis which are EHA (Earthquake Hazard Assessment) and ELA (Earthquake Loss Assessment). The software generated to estimate the near real time losses after a major earthquake consists of rapid estimation of the ground motion distribution using the strong ground motion data; update of the ground motion estimations as earthquake parameters become available, and estimation of building damage and casualties based on estimated ground motions and intensities. In addition to all these, an ongoing project carried out in conjunction with IGDAS (Istanbul Gas Company) provides to establish 100 additional accelerometers within Istanbul Earthquake Early Warning and Rapid Response System. This will ensure more accurate estimations due to inclusion of more observed data to the analysis.



UNIVERSITY OF MALTA
L-Università ta' Malta

An Example of International Project Aimed to Seismic Risk Reduction with Low-Budget Strategy: the ASSAS-BV Project

Marco Mucciarelli

Department of Structural Engineering, Geotechnical Engineering, Engineering Geology
University of Basilicata, Potenza, Italy

Recent examples from worldwide earthquakes showed that the resonance between soil and building may enhance earthquake damage, and even buildings designed as seismic resistant did suffer more damage than expected when resonance occurred. Using an up-to-date digital, wireless technology transferred to partner countries, the NATO Science for Peace project ASSAS-BV undertook very dense and detailed measurements of soil and building frequencies using ambient vibration. In urban areas, both soil and buildings are permanently experiencing micro-motions due to the propagation of seismic waves generated by human activities. Processing this kind of data gave precise insight on the dynamic behavior of structures, without the need of waiting for earthquakes to be recorded. It was possible to identify the more vulnerable buildings and also to point out possible construction defects.

The strong points of the project were the adequate institutional layout for assuring successful project implementation, the high professional capability in partner countries (FYROM, Slovenia and Croatia), the transfer of a low-cost, up-to-date technology (instruments, software, know-how), the enhancement of partner countries capacity in the field of earthquake damage mitigation. Finally, the availability of a large data base of building dynamic characteristics will allow the use of acquired data for rapid post-damage building diagnosis, even in the case that damage occurred for causes different from earthquakes.

Seismic Fragility Curves for Stone-Concrete Buildings in Jordan

Hanan S. Al-Nimry

Civil Engineering Department, Faculty of Engineering
Jordan University of Science and Technology, Irbid, Jordan

The most common type of residential construction in Jordan utilizes thin limestone masonry units backed with plain concrete for the exterior walls. The structural system associated with stone-concrete walls changed over the past three decades from the bearing wall construction which was dominant prior to 1985 to the more recent gravity load designed RC frame system with stone-concrete infills.

To derive seismic fragility curves for stone-concrete residential buildings dominating the local building stock, one-third scale bearing wall specimens and infilled frames were tested using quasi-static experimentation. Test specimens were subjected to reversed cyclic lateral loading and constant axial loading. The parameters investigated included the presence of openings, the level of axial loading and the connection between the infill panel and the bounding frame. Test results were used to calibrate and model the effect of the exterior stone-concrete walls on the performance of two and four story buildings.

Nonlinear static (pushover) analysis was used to arrive at the capacity curves of the two generic building types namely; bearing wall construction and RC infilled frames. Five damage states were considered: none, slight, moderate, extensive and complete. Damage state thresholds were determined in terms of the yield and ultimate spectral displacements. Fragility curves were developed using the lognormal probability density function. These curves will serve as the basis for earthquake risk assessment studies in Jordan and its locality.



UNIVERSITY OF MALTA
L-Università ta' Malta

Estimation of Maximum Inelastic Displacement Demand for Stone-Concrete Buildings in Jordan

Galal Mekhlafi, Hanan Al-Nimry

Civil Engineering Department, Faculty of Engineering
Jordan University of Science and Technology, Irbid, Jordan

Reinforced concrete buildings with limestone masonry facades dominate the residential building stock in Jordan. The seismic response of this type of construction is not well-defined. The study reported herein is concerned with evaluation of seismic response of dominant residential buildings in Jordan using static nonlinear analysis. Eighteen representative buildings are investigated. The parameters considered include the building area, height, structural system and the presence of a soft story. Pushover analysis of three-dimensional structural models of the representative buildings is used to arrive at their capacity curves. Four approximate techniques are then implemented to estimate the maximum inelastic displacement demand of the buildings under consideration when subjected to earthquake excitation.

Evaluation of Tsunami Impact and Vulnerability: An Example from Portugal and Morocco

Luis Matias¹, Rachid Omira^{2,1}, and Maria Ana Baptista¹

¹Instituto Dom Luiz - IDL, Lisbon, Portugal

²Instituto de Meteorologia – IM, Lisbon, Portugal

Although less frequent than in the Pacific and Indian Ocean tsunamis can hit the Mediterranean and North East Atlantic coastal areas (the NEAM region) causing extensive loss of lives and properties. In fact, 10% of all tsunamis worldwide occur in this region. Major tsunamis with ten-thousands of casualties and severe damage to coastal cities happened for example in 1650 (Santorini), in 1775 (Lisbon) or in 1908 (Messina). Even recently, the 1999 (Izmit), the 2002 (Stromboli) or the 2003 (Algeria) tsunamis, inundated and impacted coasts. On average, one disastrous tsunami takes place in the NEAM region every century. Tsunamis in the Mediterranean and North East Atlantic are caused by the collision between the European and the African plates that comprises a number of geodynamic regions affected by different seismic activity extended from West to East. Furthermore volcanic and geomorphologic processes can also be at the origin of tsunamis in the area.

Destructive tsunamis are unpredictable by nature but society needs to prepare for the next one. Given the large return period expected for these extreme events, it is not possible to avoid or attenuate human occupation and it may be not feasible to build large sea-defences against tsunamis, as it is done currently in Japan. What is needed is to have a good estimate of the tsunami impact in each coastal area at risk and to assess the vulnerability of buildings and constructions exposed to the tsunami inundation. This knowledge provides the basic information to conduct public policies on integrated coastal area management (ICAM) and to prepare the emergency response for a destructive event.

The coastal areas of the countries surrounding the Gulf of Cadiz, Portugal, Spain and Morocco, were struck by a destructive tsunami the 1st November 1755, generated by an M~8.7 earthquake. Geological evidence suggests that in the last 4000 years, other energetic events occurred in the area. The tsunami catalogue in the area comprises a number of smaller magnitude events that, if occurring today, could disrupt harbour operations and require evacuation of beaches in the high tourist season. Recognizing this hazard, a considerable research activity has been conducted in the last 20 years, firstly directed to the knowledge of the tectonic sources for large earthquakes and tsunamis, secondly dedicated to the evaluation of the impact of scenario events.

The first lesson to be learned is that only hydrodynamic modelling from credible tsunami scenarios can generate the inundation maps required for coastal management or the design of evacuation plans. Tsunamis are generated in deep water but their impact depends very strongly on the details of the coastline and the shallow water slope. The second lesson to be learned is that the tsunami impact on people, but also on buildings and constructions, depends not only on the wave height (or flow depth) but also on the current speed. The flow speed estimated at the time of maximum inundation is an essential parameter to evaluate the impact of a tsunami. We will show in this communication several examples of inundation maps for the coasts of Portugal and Morocco. Finally, we will present a simple approach on the evaluation of tsunami vulnerability of buildings and show its application to the Casablanca coastal area.



UNIVERSITY OF MALTA
L-Università ta' Malta

Crustal Structure of the Dead Sea Basin (DSB) from a Receiver Function Analysis

Ayman Mohsen

Earth Sciences and Seismic Engineering Center,
An-Najah National University, Nablus, West Bank, Palestine

The Dead Sea Transform (DST) is a major left-lateral strike-slip fault that accommodates the relative motion between the African and Arabian plates, connecting a region of extension in the Red Sea to the Taurus collision zone in Turkey over a length of about 1100 km. The Dead Sea Basin (DSB) is one of the largest basins along the DST. The DSB is a morphotectonic depression along the DST, divided into a northern and a southern sub-basin, separated by the Lisan salt diapir. We report on a receiver function study of the crust within the multidisciplinary geophysical project, DEad Sea Integrated REsearch (DESIRE), to study the crustal structure of the DSB. A temporary seismic network was operated on both sides of the DSB between October 2006 and April 2008. The aperture of the network is approximately 60 km in the E-W direction crossing the DSB on the Lisan peninsula and about 100 km in the N-S direction. Analysis of receiver functions from the DESIRE temporary network indicates that Moho depths vary between 30-38 km beneath the area. These Moho depth estimates are consistent with results of near-vertical incidence and wide-angle controlled-source techniques. Receiver functions reveal an additional discontinuity in the lower crust, but only in the DSB and west of it. This leads to the conclusion that the internal crustal structure east and west of the DSB is different at the present day. However, if the 107 km left-lateral movement along the DST is taken into account, then the region beneath the DESIRE array where no lower crustal discontinuity is observed would have lain about 18 Ma ago immediately adjacent to the region under the previous DESERT array west of the DST where no lower crustal discontinuity is recognized.

Quantification of Earthquake Risk Parameters to Be Used in Earthquake Preparedness Operations

Avi Shapira

National Steering Committee for Earthquake Preparedness
Prime Minister's Office, Jerusalem, Israel

One of the major problems in addressing the issue of earthquake preparedness is the question to what event (earthquake scenario) we should refer and be ready for. One approach, commonly used, is to define an earthquake of magnitude M and location X which corresponds to a certain probability of occurrence and prepare for dealing with its consequences, i.e., defining a reference event to yield a reference scenario (using e.g. HAZUS). When following this approach we tend to forget that we do not really know, at least in Israel, what is the probability of having magnitude M earthquake at location X in the next T years. We know that earthquakes of magnitude M will occur at location X but we can't tell when.

When considering preparedness on a national or regional level, there is usually no one reference event that should be applicable for all sites (settlements) in the country.

To overcome those shortages, we developed a new approach in which we aim at assessing the probability of having damages (earthquake risk) from any earthquake within a certain time exposure and aiming at preparing with the consequences of those earthquake risks that correspond to a predefined acceptable probability.

This approach is probably known in other topics, such as the insurance industry but not widely spread among seismologists and disaster managers.

The obtained results provide a uniform risk reference to be targeted in preparedness and readiness operations. It has to be emphasized that those risk parameters are not predictions of damages likely to occur in any single earthquake. In most cases they will be lower than those estimated from a maximum probable earthquake.

Correlating Spanish IGN and Algerian CRAAG Magnitudes for Northern Algerian Earthquakes

M. Hamdache¹, J.A. Peláez^{2,3} and J.M. Martínez Solares^{4,5}

¹Departement Études et Surveillance Sismique, CRAAG, Algiers, Algeria.

²Department of Physics, University of Jaén, Jaén, Spain.

³Andalusian Research Group on Seismic Risk and Active Tectonics, University of Jaén, Jaén, Spain.

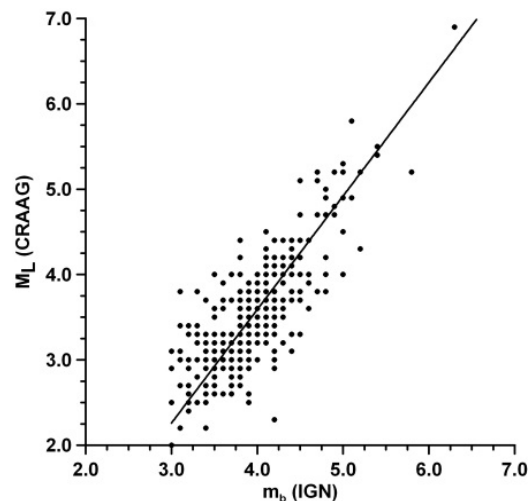
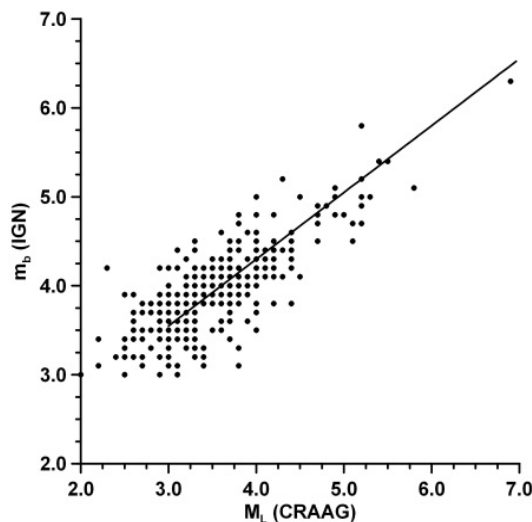
⁴Section of Geophysics, IGN, Madrid, Spain.

⁵Department of Geophysics and Meteorology, Complutense University of Madrid, Madrid, Spain.

It is useful to establish the relationship between magnitudes provided by two different seismological networks for the same region, both when calibrating the computed magnitudes by one of them, such as when completing and homogenizing seismic catalogs, usually in order to carry out seismic hazard studies.

The latter has been the main objective has led us to undertake this work. In this study, we present a work concerning the relationship between magnitudes computed for Northern Algerian earthquakes by the Spanish Instituto Geográfico Nacional (IGN) and by the Algerian Centre de Recherche en Astronomie, Astrophysique et Géophysique (CRAAG). The obtained relationships using the double regression or OLS bisector method are the following:

$$\begin{aligned} m_b &= 0.75 (\pm 0.08) \cdot M_L + 1.30 (\pm 0.09) & [3.0 \leq M_L \leq 6.9] \\ M_L &= 1.33 (\pm 0.26) \cdot m_b - 1.73 (\pm 0.18) & [3.0 \leq m_b \leq 6.3] \end{aligned}$$





UNIVERSITY OF MALTA
L-Università ta' Malta

308 main earthquakes with depths $h \leq 30$ km located by both seismological networks from 1997 to 2010 were used. Moreover, we analyzed the differences found between locations and origin times computed by both institutions.

Differences between these computed parameters show that, at first, they do not depend on the location, that is, they do not appear to be a function of the distance between epicenters and the Spanish network. Concerning magnitude residuals, a latter analysis showed that values ranging between 0.5 and 1.0 degrees appear somewhat more concentrated in the central and eastern parts of the studied area, and less on the extreme western part, close to the Spanish network.



UNIVERSITY OF MALTA
L-Università ta' Malta

An Overview of Iraqi Seismological Network (ISN)

Dawood Shakir Mahmood

Iraqi Meteorological Organization and Seismology, Baghdad, Iraq

Baghdad Observatory was a first seismological permanent station in Iraq. It was founded in 1977. During the period of 1982-1984, a new generation of highly sophisticated instruments was purchased from Lenartz Company to establish Iraqi Seismological Network (ISN). The data of ISN was used to draw the seismicity of Iraq and surrounding. A number of researches related to hazard and risk assessment of Iraq was published and applied in the preparation of Iraqi seismic design code for building in 1997. Recently an upgrading was made to ISN with brand new Kinmetric instruments where, 5 new observatories were constructed and occupied with new instruments by using V-SAT to transmit the triggered events to the central station in Baghdad.

General Information about Seismicity and Seismotectonics of Libya

Abdala Elmelade

Libyan Center for Remote Sensing and Space Science (LCRSSS)
Libyan National Seismological Network (LNSN), Tripoli - Libya

Libyan national seismological network is constituted of 15 seismological stations, of which 3 very broad band STS2 seismometers and 12 broad band trillium seismometers. The network is capable to detect local, regional and tele-seismic events. Libya is located at the northern margin of the African continent, which is bordered by the Alpine tectonic belt of the Atlas Mountain and by the active belt beneath the southern Mediterranean. Libya underwent many episodes of Orogenic activity of the Caledonian and Hercynian in the Paleozoic during Cretaceous, Middle Tertiary, and Holocene time. These Results of the Fault plain solutions suggest a change in stress regime as we go from the western to the eastern part of the area under investigation. While normal faulting is dominant in the western part, strike slip faulting is dominant in the eastern part. Episodes of orogenic activity affected the region and shaped the geological setting of the Country As a result a number of sedimentary basins were formed separated by intervening arches.

Most of the earthquake activity is concentrated in the north part of Libya. Geological information and historical seismicity shows that Hun graben area is the most active and hazards region because of its location near to the big cities (Musurath, Tripoli), where the more dense population and most important industrial activity is concentrated. The geological information in Green mountain area also shows a very high seismological activity, and it is also hazards because of the location of the second biggest city (Benghazi) in Libya, some seismological activity is related to the subduction region at Crete island offshore of Green mountain. The south part of Libya has also some historical seismological activity, but due to the desertation and wide spread of cities the hazard could be less important. Information about Seismicity of south of Libya is not accurate enough because of the Lack of seismological stations in the past.

Geophysical Constraints on the Arabian Plate Eastern versus Western Terranes

Ali Ibrahim Al-Lazki

Department of Earth Sciences, Sultan Qaboos University, Alkhod, Oman

The formation of present day Arabia is the result of complex tectonic events, which took place in different times in the geologic history of the Arabian plate. These events varied between compressional and extensional events since the Precambrian times.

Terrane accretion in the Precambrian period is responsible for the build up of the Arabian shield that is partly outcropping in central Saudi Arabia, Yemen and Oman. This event was followed by two extensional events during the periods Late Devonian-Mid Permian and Mid Permian-Late Cretaceous. The latter two events led to the formation of the northeast Arabian margin and the neo-Tethyan Ocean. Closure of the neo-Tethyan ocean began in the Late Cretaceous and continued until present time Arabia-Eurasia continent-continent collision. The Middle Cenozoic, Red sea and Gulf of Aden opening represent the latest extensional event that led to complete separation of an Arabia plate from Africa.

In this study we analyze new Pn tomography models of Arabia and surrounding in the context of newly available and published geophysical data that includes gravity, Moho depths, and seismic anisotropy of Arabia plate.

The collective analysis and interpretation of the different geophysical and geological data reveals considerable lateral variation of lithospheric structure and rheology of the Arabian plate. This variation cannot be attributed solely to temperature variation, but may represent compositional variation. These variations represent contiguous lithospheric bodies that make up the (proto) Arabia lithosphere.

On one hand, we find in this study eastern Arabia is underlain by a lithospheric mantle that is fast and low density (perhaps depleted mantle lithosphere) resembling in characteristics old and stable craton. The eastern boundary of the latter eastern Arabia high velocity anomaly, clearly demarcate the Arabia-Eurasia plates boundary. On the other hand, western Arabia lithospheric mantle shows low velocity that is partly attributed to the opening of the Red Sea. Furthermore, this Pn-tomography outlines a very low velocity zone running east and parallel to the Red Sea. This anomaly is perhaps indicating a shift of rifting processes east of the Red Sea.

National Earthquake Strategy and Action Plan (NESAP-2023): A Road Map in Order to Reduce Earthquake Hazards

Kerem Kuterdem, Demir Akin and Murat Nurlu

Earthquake Department, Disaster and Emergency Management Presidency of Turkey

Earthquake Advisory Board, which acts under Disaster and Emergency Management Presidency (AFAD) in Turkey due to Law 5902 adopted in its meeting to urgent need for a national scaled plan for the purpose of preventing the earthquakes, reducing the damage of earthquakes, proposing suggestions for required actions after earthquakes and definition of priorities and policies involving earthquake studies. Under the scope of this process, and also considering the background documents prepared by several stakeholders, sub-commissions established namely;

- Commission A: Earthquake information infrastructures,
- Commission B: Earthquake hazard analysis and maps,
- Commission C: Earthquake mitigation plans (scenario-risk analysis's),
- Commission D: Earthquake safe settlement and construction,
- Commission E: Training, education and public awareness,
- Commission F: Protection of historical and cultural heritage,
- Commission G: Legislation and financial regulations,
- Commission H: Crisis management.

Each group prepared a report and submitted to AFAD. These reports have been found appropriate and applicable in the fourth DDK meeting which has been performed in December of 2010 a sub group established in order to prepare the draft of the strategy document by using the reports of commissions. The responsible organizations and realization periods for each action determined and submitted to responsible organizations for their confirmation and approval. Finally, after being discussed at "Ministerial Level Disaster and Emergency High Board" final draft of NESAP was approved and promulgated in official letter on 18 August 2011. NESAP officially announced to public by Deputy Prime Minister at the 3rd meeting of Earthquake Advisory Board on 17 August 2011.

The main philosophy of "National Earthquake Strategy and Action Plan-2023" is to prevent or reduce the effects of physical, economic, social, environmental and political losses which may result by earthquakes, and to create new living environments which are prepared and sustainable. The strategy document includes 3 main axes, 7 aims, 29 strategies and 87 actions. 13 responsible institutions will be in charge of the implementation of Actions under the coordination of AFAD. Each responsible organization is expected to collaborate with all levels of community including non-governmental organizations, private sector, academic community, etc.

Main axes of the strategy are:

- Knowing Earthquakes,
- To Establish an Earthquake Safe Settlement and Construction,
- Coping with the Effects of Earthquakes.



UNIVERSITY OF MALTA
L-Università ta' Malta

In order to effectively implement and monitor the applicability of NESAP, a commission namely "Commission for the Implementation and Monitoring of NESAP" was established. The commission consists of 7 members and will convene two times a year and will implement the status reached by responsible organizations after every six months period.

Questioning the Applicability of Soil Amplification Factors as Defined by NEHR (USA) in the Israel Building Standards

A. Shapira¹, Y. Zaslavsky², M. Gorstein², N. Perelman², G. Ataev², and, T. Aksinenko²

¹National Steering Committee for Earthquake Preparedness
Prime Minister's Office, Jerusalem, Israel

²Seismology Division, Geophysical Institute of Israel, Lod, Israel

Modern building codes for seismic design, including the recently updated Israeli Standard (SI 413), adopted new site amplification factors and new procedure for site classification. Two amplitude-dependent site amplification factors are specified: F_a for short period (0.2 sec) and F_v for long period (1 sec) motions. The new site classification system is based on five soil classes, defined in terms of the average shear wave velocity through the top 30 m of the soil profile ($V_{s,30}$).

In the last decade, the Seismology Division of the Geophysical Institute of Israel launched a number of projects to identify and map urban areas where seismic ground motions are expected to be amplified. In those studies, we conducted site investigation in more than 5500 locations, located in 30 towns and neighboring villages. These investigations demonstrate the effectiveness of using the horizontal-to-vertical (H/V) spectral ratios from ambient noise measurements that characterize the sites with respect to their resonance frequencies and the corresponding H/V levels. Data on S-wave velocities obtained from seismic refraction surveys carried out in proximity to boreholes helped building reliable 1-D soil column models of the subsurface that evenly cover the study area. Histograms of site specific parameters that characterize the models demonstrated a high variability in the subsurface condition across a town/city. For example; the depth to the bedrock may vary from 10 to 800 m, the average shear wave velocity of the whole soil deposits column ranges from 200 to 900 m/s, the average shear wave velocity of the upper 30 m appears to be 100 m/s to 900 m/s, the seismic impedance ratios range between 2 and 8 and the expected fundamental period of the soil column varies from 0.1 to 1.5 sec.

Soil column models were used to calculate the uniform hazard linear and non linear site specific acceleration spectra (10% exceedance in 50 years). Computations are made, as in series of the previous studies, using the SEEH procedure (SEEH – Stochastic Estimation of the Earthquake Hazard) developed by Shapira and van Eck [Natural Hazard 8, 201-215, 1993].

Site corrections Q_a and Q_v , defined as the ratio between the maximum ordinate of the non-linear acceleration spectrum at the surface to the acceleration spectrum on bedrock at the same period. Q_a and Q_v are calculated from synthetic accelerograms that served as input to the 1-D multi-layers soil column model, in two period ranges: 0.1-0.7 sec (corresponds to the period of 0.2 sec) and 0.8-1.2 sec (corresponds to the period of 1.0 sec).

Our study has demonstrated that the geology across is complex and highly variable over short distances. Our findings suggest that F_a and F_v values that appear in e.g. the American codes are not necessarily applicable in Israel for soils of the same class. Additional soil parameters may strongly affect amplification effects.

Is the Evaluation of Topographic Effects an Easy Task?

F. Panzera^{1,2}, G. Lombardo¹, S. D'Amico² and P. Galea²

¹Dipartimento Scienze Biologiche, Geologiche e Ambientali, Università di Catania, Italy

² Department of Physics, University of Malta, Msida, Malta

The effects of topography have been widely studied through several analytical and numerical methods (e.g., Paolucci, 2002), instrumental evidences of topographic effects are however relatively few. Experimental techniques for investigating the topographic effects are quite expensive since they require the setting down and operation of the instruments for an undefined period of time to acquire earthquakes. For this reason, records of explosions and noise measurements can be very useful to estimate these site effects. Although such techniques have been rarely used to investigate on topographic effects, rather satisfactory results have been obtained (e.g. Pagliaroli et al., 2007; Panzera et al., 2011).

An important aspect, in topographic amplification estimates, concerns the difficulty to distinguish between a purely topographic effect and the influence of different local lithology amplification. In particular, the amplification of seismic motion at the top of a hill might be caused by other phenomena, such as the presence of fractured rock, near surface weathering, low-velocity layers, or fault zones near the site measurements.

The aim of present study is to estimate the seismic site response due to topographic effects of two study areas the Ortigia peninsula (Siracusa, Italy) and the university campus of Catania (Italy). The Ortigia area represents, because of its geological and morphological setting, an useful test site to perform passive experimental techniques aiming to identify the site response directivity and the fundamental resonant frequency connected to the topographic effects. It is formed by a carbonate sequence whose dynamic properties were investigated through non-invasive techniques (MASW and ReMi). The university campus of Catania, on the contrary, has a gentle topography with a flat surface at the top and it is characterized by a complex sedimentary sequence laying between a clayey basement and an upper volcanic formation. The lithologic heterogeneities, existing in the Catania area, seem to have a stronger influence with respect to the simple topographic effect.

The evaluation of local seismic response of the two study areas was undertaken by integrating different experimental approaches. The data used in this study consist of both noise and earthquake recordings that were processed through horizontal to vertical spectra ratio (HVSR), horizontal to vertical noise spectra ratio (HVNR) and standard spectral ratio techniques considering horizontal (HSSR) and vertical (VSSR) components. Experimental spectral ratios (HSSR, HVSR, HVNR) were also calculated after rotating the NS and EW components of motion by steps of 10 degrees starting from 0° (north) to 180° (south). This approach, firstly applied to earthquake recordings in studying the directional effects due to topographic irregularities at Tarzana, California (Spudich et al., 1996), has been also widely adopted, for similar purposes, using ambient noise signals (Del Gaudio et al., 2008; Burjaneek et al., 2010; Panzera et al., 2011). A direct estimate of the polarization angle, for both earthquakes and noise data, was achieved by using the covariance matrix method (Jurkevics, 1988). This technique is very efficient in overcoming the bias linked to the denominator behavior that could occur in the H/V's technique.



UNIVERSITY OF MALTA
L-Università ta' Malta

The homogeneity of the carbonate sequence outcropping in the Ortigia peninsula and its simple convex morphology made it ideal for investigate topographic site effects. The HVNR show dominant frequency peaks in the range that is in good agreement with the theoretical resonance frequency of the hill, computed using experimental shear wave velocities. Moreover, both the directional resonance and the polarization analysis confirm the presence of a directional effect having an azimuth transverse to the major axis of the ridge. The investigation on the characteristics of the site response at the university campus of Catania, has instead set into evidence that the complexity of the near-surface geology, as well as the morphology strongly influence the local amplification of the ground motion and the directivity effects.

Finally, as a practical implication of present study it can be set into evidence that the topographic effects cannot be easily evaluated especially when subsurface morphology and lithologic features are predominant.

Some considerations on Experimental Study of Site Effect Using Ambient Noise Measurements

Gorstein, M., Zaslavsky, Y., Ataev, G., Aksinenko, T. Kalmanovich, M. and Perelman, N.

Seismology Division, Geophysical Institute of Israel, Lod, Israel

The necessity for detailed mapping of the earthquake hazard in urban areas stems from the fact that geological inhomogeneity dominates the spatial distribution of the intensity of damage and amount of casualties. In most cities around the world direct information from strong motion recordings is usually unavailable. Such is the situation in Israel, where the great variability in the subsurface conditions across a town/city and the relatively high costs associated with obtaining the appropriate information about the subsurface, strongly limit proper earthquake hazard quantification.

Over the years, we have conducted site investigations in several thousands of sites. These investigations demonstrate the usefulness of using horizontal-to-vertical (H/V) spectra of ambient noise measurements to identify sites with high potential for being vulnerable to amplification effects and characterize the sites with respect to their expected resonance frequencies and the corresponding H/V levels. This information, together with any available geological, geotechnical and geophysical information, helps constructing a reliable model of the subsurface, which is then integrated in the processes of the seismic hazard assessment.

In our presentation we focus on experimental aspects of the site effects analysis observation of ambient noise measurements and processing, influence of different factors on the reliability and applicability of fundamental frequency and H/V spectral function of soil, stability of H/V spectral ratio, its variations with different geology. We compare H/V spectral ratios obtained from ambient noise and seismic events generated by different sources of excitation (earthquakes and explosions) recorded by different sensors (accelerometers and seismometers).

Use of H/V Spectral Ratios Measurements of Ambient Noise for Seismic Microzonation and Modeling of the Subsurface

Ataev G., Zaslavsky Y., Gorstein M., and Kalmanovich M.

Seismology Division, Geophysical Institute of Israel, Lod, Israel

The H/V spectral ratio analysis of ambient noise was used for reconstruction of the subsurface in a coastal area near Haifa and in the west of Kiryat Shemona town. In the coast area we measured ambient noise in 200 locations and display the distribution of the first and the second resonance frequencies and their associated H/V amplitudes. The first peak in the H/V spectrum is associated with a deep bedrock, which is basically the dolomite of Albian age. Its effect is reflected in the frequency map as wide zones with resonance frequencies of 1-3Hz. We also find some zones where the dominant frequencies are 3-7Hz which correspond to a change of the main reflector from dolomite of Albian age to dolomite and limestone of Cenoman - Turonian age, which follows significant facies changes (chalk to dolomite) in the Cenomanian age. The second peak in the H/V ratios is a product of the seismic impedance between the alluvial sediments and calcareous sandstone of Pleistocene age (on the west side of the study area) and the chalk of Cenomanian age on the eastern side.

In the town of Kiryat Shemona we explored the site effects of historical landslides in order to define the site amplification effect at school sites and assessing schools safety.

Using V_s values, obtained from seismic refraction survey and available geological information, we could build soil column models for each of the H/V measurement sites displaying the depth to the main reflector and the thickness of the sedimentary layers. Observed rapid changes in the models were used to trace yet un-mapped faults. We present some schematic cross-sections, which yield a better understanding of the subsurface structure in the study areas.

The subsurface models obtained in this research are implemented to assess the seismic hazard in terms of Site Specific Uniform Hazard Acceleration spectrum.

Site Effects and Earthquake Ground Motion Scenario for the Xemxija Area (Malta)

S. Pace¹, S. D'Amico¹, P. Galea¹, F. Panzera^{1,2}, and G. Lombardo²

¹Department of Physics, University of Malta, Msida, Malta

²Dipartimento di Scienze Biologiche, Geologiche e Ambientali, University of Catania, Italy

The Maltese islands are exposed to a low-to-moderate seismic hazard. Seismic activity around the islands is generally of low magnitude, however more infrequent, large events in Sicily and as far as the Hellenic arc have affected the country in the past and caused considerable damage (Galea, 2007). In spite of this, no comprehensive assessment of seismic risk has so far been carried out. Much of the building stock is of load-bearing unreinforced masonry, and is vulnerable to even moderate ground shaking. This study will present some earthquake simulation in order to have useful elements for estimating the potential damages and seismic risk analysis including local site effects resulting from the particular local sedimentary geology. Ambient noise measurements will be used to infer shallow shear wave velocity structure, for which no systematic data exists on the islands.

The Xemxija area on the NE coast of Malta was chosen as an initial investigation site with a dense microtremor measurement survey carried out using a Tromino® tromograph (Micromed SpA), with about 100 microtremor recordings. HVSr curves obtained from measurements performed in the valley give a large spread of resonant fundamental frequencies ranging between 2 Hz to over 11 Hz due to the variation in soil thickness that overlays the Upper Coralline stratum. On the neighbouring hilltop, where no or negligible soil is present, the frequency range is smaller and more stable, spanning 1.19 Hz - 1.56 Hz, with amplification due to an underlying blue clay layer, which also gives rise to velocity inversion. Preliminary modelling is performed at several points using the modelHVSr program (Herak, 2008). When modelling the resonance curve, a trade-off exists between the shear wave velocity and the thickness of the low velocity layer, therefore some form of initial constraint must be applied. In this case, we use geotechnical studies undertaken over the island, as well as borehole logs from Xemxija to obtain approximate values of layer thicknesses and rock densities. Seismic velocity values were also utilised from a separate preliminary study undertaken in the same area utilising the ReMi®, MASW and Refraction methods (Panzera et al., 2011).

Preliminary modelling attempts show the complexity and variability of the site's geology. Modelling of HVSr data using ambient noise has been shown to be a useful tool in microzonation studies. The ultimate goal of this paper is to provide earthquake ground motion simulations in order to estimate earthquake scenarios mainly based on the ground motion parameters. It has been proven that it is possible to make predictions for regions where strong-motion data are lacking or where even data for moderate and large earthquakes are not available (D'Amico et al. 2011). In order to predict the expected ground motion parameters in terms of peak ground acceleration (PGA) peak ground velocity (PGV), and Spectral Acceleration (SA) as a function of distance and magnitude we used the latest version of EXSIM program (Boore, 2010). The simulations were carried out by using the regional propagation parameters for southeast Sicily (Scognamiglio et al. 2005) and rectangular faults having length and width proportional to the moment magnitude according the relationship proposed by Wells and Coppersmith (1994). In particular, we selected three



UNIVERSITY OF MALTA
L-Università ta' Malta

potential faults - one located on the Hyblean-Malta Escarpment, one at about 20 km south of Malta, and one at about 30 km east of Malta.

The knowledge of generic site response of different soil kinds allows taking into account for the different kind of lithologies. The simulation of the site effects at a specific location are very important and may be used even for engineering goals. In conclusion, despite certain uncertainties mostly due to source complexity, stochastic finite-fault modeling based on a dynamic frequency approach proves to be a reliable and practical method to simulate ground motion records of moderate and large earthquakes especially in regions where structural damage is expected but sparse ground motion recordings are available. In this paper, we show that in the Xemxija Bay area, Malta, the ground motion from the repeat occurrence of historically recorded earthquakes, coupled with existing geological conditions and building typologies has the potential to cause significant structural damage in the area. These preliminary results motivate us to carry out more detailed studies, in particular of a comprehensive microzoning exercise with respect to shallow structure and ground response, and the formulation of a framework for the functional seismic vulnerability assessment. We can conclude saying that a well-crafted scenario provides a powerful tool for members government officials, decision makers, emergency planners, private industry, and the general public to begin to draft mitigation policies and programs. It will help the community weigh various risks associated with the earthquake and begin to set priorities that will systematically reduce the impact of the likely future event.

Seismic Microzonation for Seismic Risk Mitigation in Muscat area, Sultanate of Oman

El-Hussain¹, I., Deif^{1&4}, A., Al-Jabri², K., Sundararajan³, N., Al-Hashmi¹, S., Al-Toubi¹, K., Al-Saifi¹, M., and., Al-Habsi¹, Z., Mohamed⁴, A.E.M., El-Hady, S⁴

¹Earthquake Monitoring Center, Sultan Qaboos University, Oman

²Department of Civil and Architectural Engineering, Sultan Qaboos University, Oman.

³Earth Science Department, Sultan Qaboos University, Oman

⁴National Research Institute of Astronomy and Geophysics, Helwan, Egypt

The local site effects are performed by determining the resonance frequency of the soft soil layers and by estimating the amplification using local shear wave velocity profiles. The Nakamura technique (Nakamura, 1989) is used to estimate the resonance frequency of soft soils at 459 sites, characterized by the ratio (H/V) of the Fourier spectra of the horizontal and vertical components of ambient noise measurements. The soft areas are characterized by resonance frequencies ranging from 1.8 to 6.0 Hz in contrast to hard rock sites that characterized by higher resonance frequencies (up to 23 Hz).

Shear wave velocity (V_s) has been evaluated using the multichannel analysis of surface waves at 99 representative sites in Muscat. These 99 sites have been investigated with survey lines of 51 m in length. 1-D and interpolated 2-D profiles have been generated up to a depth of 30–40 m. The shear wave velocities are used to estimate average shear wave velocity in the upper most 30 m (V_{s30}). Based on the (V_{s30}), the study area is classified according to the NEHRP site classes into B, C, and D—site classes. The V_s profiles were then used in the SHAKE91 software in combination with suitable seismic input motion to obtain site response and amplification spectra. Maps of resonance frequency, (V_{s30}), site classification, spectral amplification, earthquake characteristics on the ground surface for peak ground and spectral accelerations at 0.1, 0.2, 0.3, 1.0 and 2.0s, for 475 and 2475 years return periods have been presented.

An Ambient Noise HVSR Survey in Valletta World Heritage Site and the Historical City of Mdina, Malta

S. D'Amico¹, R. Gallipoli², P. Galea¹, F. Panzera^{3,1} and G. Lombardo³

¹Department of Physics, University of Malta, Msida, Malta

²Istituto di Metodologie per l'Analisi Ambientale, C.N.R., Tito Scalo (PZ), Italy

³Dipartimento di Scienze Biologiche, Geologiche e Ambientali, University of Catania, Italy

In this paper we report preliminary results of the measurements of ambient noise on a dense network of measurement sites in and around the cities of Valletta and Mdina; two important historical heritage sites in Malta. The city of Valletta is the present capital of Malta and it is inextricably linked to the history of the military and charitable Order of St John of Jerusalem. Valletta with its 320 monuments is a UNESCO World Heritage site. All the monuments are contained within quite a small area, making it one of the most concentrated historic areas in the world. The city of Mdina is the old capital of Malta. Mdina is situated in the centre of the island and is a medieval town still confined within its walls. It is a small town with rich history, monuments and cultural heritage. The seismic microzonation studies, which have not been previously performed on Malta, are an important component of risk evaluation and the preservation of prominent cultural heritage sites.

The seismic history of the Maltese islands is adequately documented since around 1500 (Galea, 2007). In the past, Malta has been struck by several earthquakes. The largest intensity (VII – VIII) was experienced on 11 January 1693, from the magnitude 7.4 event most likely originating on a NNW-SSE trending fault segment of the Hyblean-Malta escarpment offshore Syracuse. Extensive damage was reported in almost all built up areas of the time, including partial collapse of the Mdina cathedral and structural damage to many buildings (Azzopardi, 1993). Significant damage was also reported in the area of Valletta and several induced landslides and rock falls are documented.

We used the Nakamura (1989) technique to derive the spectral ratio of horizontal and vertical component (HVSR) of microtremors. The great advantage of the method is that it offers valuable data on soil properties at very low-cost. We used the SESAME (Site EffectS assessment using AMbient Excitations; <http://sesame-fp5.obs.ujf-grenoble.fr>) guidelines to ensure validity of the results. Ambient noise measurements in Mdina and Valletta were conducted in three campaigns in May, September, and November 2011. In total, we acquired data at about 60 locations using a portable 3-component seismometer Tromino® manufactured by Micromed. Each measurement lasted for 20 minutes and the three orthogonal components of the noise were recorded at 128sps. The records were processed using the Grilla® software. Several points were located in the urban areas of Valletta and Mdina, where the urban noise (transient) is quite high during the day time. For this reason we performed several measurements during the night to considerably improve the quality of the data.

One of the important aspects of ambient noise measurements is the modelling of the wave field to establish a link between the observations and the subsoil structure. For this purpose we used the ModelHVSR Matlab routines (Herak, 2008). The program allowed us to verify existing geotechnical models by comparing theoretical HVSR to the observed one and we also obtained the most likely preliminary geotechnical models of the soil. In order to perform



UNIVERSITY OF MALTA
L-Università ta' Malta

the modelling we used the velocity values for the different Maltese geological formations proposed by Panzera et al., (2011) and obtained by applying ReMi®, MASW and Refraction methods.

We processed the data considering the SESAME criteria highlighting the main features of the sites in terms of predominant frequency and amplitude of the spectral ratio. Several sites show flat HVSR curves, whereas clear peaks were obtained at other locations. This is consistent with the underlying geology of the investigated sites. In particular, on top of the hill where the city of Mdina is located and where the hard Upper Coralline Limestone (UCL) is outcropping, measurements showed peak amplitudes greater than 2 in most cases. This amplification is likely to be due to the Blue Clay layer underlying the UCL. The Blue Clay layer results in a velocity inversion, which is evident in the HVSR curves obtained at several locations, where the curve drops below 1 over a wide frequency range. The amplification due to the buried clay layer has important implications in microzonation analysis where the outcropping geology would indicate a hard rock site and hence a zone of no amplification.

Seismic Vulnerability Assessment of Existing School Buildings in Algiers City

D.Benouar¹, A.Meslem² and M.Naïli³

¹Built Environment Laboratory, Faculty of Civil Engineering,
University of Science and Technology, Algiers, Algeria.

²Department of Architecture & Civil Engineering, University of Bath,
Bath and North East Somerset, United Kingdom

³Division of Earthquake Engineering, National Centre for Applied Research in Earthquake
Engineering Centre, Algiers, Algeria

The 21st May Zemmouri earthquake of 2003 that struck Boumerdes region and its vicinity caused several damage, disruption and casualties to human life and to different type of construction. More than 2000 people were reported dead, 10,147 wounded and 150,000 homeless.

Like other recorded damage observed on residential buildings, school buildings have suffered considerable damage too. More than 103 school buildings were classified as destroyed structures and approximately 753 others as seriously damaged.

In order to prevent likelihood damage which may occur during future earthquake, and to ensure life safety and school integrity, the seismic vulnerability of existing school buildings within the vicinity of Algiers city was carried out using the Risk-UE LM1 approach.

In this respect, a sample of 190 school facilities (corresponding to 526 Buildings) located in nine municipalities in the province of Algiers were surveyed for identifying the general sources of seismic vulnerability. The results are expressed in terms of vulnerability curves that show the relationship between a given seismic input and the expected damage.

It is expected that these results will guide the decision makers to take practical measures in order to strengthen the surviving school buildings in Algiers; or in other cities across the country and implement preventive measures to reduce the seismic risk by reducing the vulnerability.

Case Study for UNRWA Co-Edu School in Jordan

Intesar Bataeneh, Sami Hababbeh, Amer Hijazi and Adnan Khasawneh

Royal Scientific Society, Amman, Jordan

There is nothing more important than the safety of students in Jordan. That's why the government (Ministry of Education (MOE)) has made an early commitment to make schools safer. Part of this commitment was shared with the United Nation Reliefs and works Agency for Palestinian Refuge (UNRWA) of Jordan. In 2009 for example UNRWA initiated a program to rehabilitate a number of its schools throughout Jordan. This case study, demonstrates the methodology for strengthening & protecting one of (UNRWA) Schools at Irbid city.

The primary objective of the study was to conduct a detailed structural assessment for the School, and more specifically, to find out the nature and severity of corrosion and other defects observed on some parts of the school and present technical judgment on their causes and treatment, and finally, to provide efficient repair and protective solutions for the defected parts.

The study included, performing a comprehensive field inspection, Collecting data and performing close (In – Depth) inspection of the structural details, preparing as-built drawings of foundations, exploration and testing concrete core and reinforcement steel, investigating probability of corrosion, and performing full structural analysis for different elements of the school.

The structural adequacy of the building was then evaluated and all necessary for repairing strengthens deficient members were presented.

With full Contract Documents for rehabilitation works including a bill of quantities (B.O.Q), drawings and specifications.

Non-Structural Seismic Vulnerability Assessment of Hospitals and Health Centers in Palestinian Cities

Jalal Al Dabbeek

Urban Planning and Disaster Risk Reduction Center
An Najah national University, Nablus, Palestine

Hospitals and health centers have a vital role to play in the event of a disaster, primarily through assisting the disaster victims, and also by organizing the first-response-institutions and providing its services after such a disaster. Considering this vital role, it is necessary that the hospitals themselves are prepared to withstand the initial damaging effects of a disastrous event. Therefore this study has targeted hospitals and health centers in Palestine as an important subject of emergency preparedness and thus promotes the “safe hospitals” concept in disaster risk reduction.

Given that Palestine lack both sufficient seismic awareness and a Palestinian Seismic Building Code, large amounts of activities, research and assessments have found that major parts of hospitals and health centers have high seismic vulnerability. This is of particular importance given the region is subjected to strong or moderately strong earthquakes. Therefore, considering the vital importance of keeping medical buildings safe and fully functional during disasters, nonstructural and structural damages should be avoided.

Several actions have been initiated in order to carry out the study of the major hospitals (three hospitals) and three health centers in the West Bank in the case of a strong or moderately strong earthquake. The following investigations and activities have been implemented:

- A study to determine the seismic vulnerability (macro-seismic scale) of structural and non-structural elements of the investigated buildings. The study showed that most of the common non-structural components have high vulnerability, this includes partition walls, ceilings; windows; office equipment; computers; inventory stored on shelves; file cabinets; water tanks; generators; transformers; heating, ventilating, and air conditioning (HVAC) equipment; electrical equipment; furnishings; lights etc.
- An assessment of safety conditions and a development of evacuation plans, including a plan of the hospital and its surrounding spaces.
- Meetings and workshops have been organized with decision makers, officials and engineers in the Ministry of Health (MoH).

All of the assessed hospitals do not have the necessary safety requirements and need additional external exits and entrances. The hospitals are unevenly distributed and concentrated in certain areas of cities. This centralization of services will result in adverse consequences if subjected to natural disasters or war.

In light of studies, the local challenges, and the economic and political situation in Palestine, several recommendations accompanied by clear action plans have been advanced. These recommendations have focused on decreasing the seismic vulnerability of non-structural



UNIVERSITY OF MALTA
L-Università ta' Malta

elements and increasing the coping capacity of hospitals and health centers in the oPt. The conclusions of this study are the same as the challenges that now face the development of the Palestinian health sector, and involve the coupling of disaster risk reduction and sustainable development in accordance with the International Strategy of Disaster Risk Reduction (UN-ISDR), Hyogo Framework for Action 2005-2015 and Arab Strategy for Disaster Risk Reduction 2011 – 2020.

Remarks: *This project comes under the auspices of the USAID-funded “Flagship project” that is reforming and developing the Palestinian healthcare sector. A strong component of the state of a health care sector is its ability to respond to and ameliorate the effects of a disaster.*



UNIVERSITY OF MALTA
L-Università ta' Malta

Methodology for Assessing School Safety Educational, Scientific and Engineering Aspects

Jair Torres

Section for Disaster Reduction, Natural Science Sector, UNESCO, Paris, France

Participants of the second and third session of the United Nations International Strategy for Disaster Reduction (UNISDR) Global Platform for Disaster Risk Reduction in June 2009 and 2011, respectively, committed to assess the level of disaster resilience in all schools in disaster-prone countries, and all related government's agencies to develop a national plan for school safety by 2015. The UNISDR Secretariat in Geneva in coordination with the UN Thematic Platform on Knowledge and Education (TPKE), which includes UNISDR, UNESCO, UNICEF, GFDRR, INEE, Plan International and Save the Children, among others, have been working in the preparation of a methodology for assessing school safety.

A draft methodology for assessing school safety will be presented to the RELEMR participants. Comments on educational, scientific and engineering aspects concerning school safety will be welcome in order to strength and validate the methodology.



United Nations
Educational, Scientific and
Cultural Organization



UNIVERSITY OF MALTA
L-Università ta' Malta