ID27-TECHNOLOGICAL AND INFRASTRUCTURE COLLABORATIVE SEISMIC RESEARCH IN WESTERN MEXICO

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Abstract – In February and March 2014, Spanish, Mexican and British scientists and technicians explored the western margin of Mexico, a region with a high occurrence of large earthquakes (> Mw = 7.5) and tsunami generation, on board the British Royal Research Ship James Cook. This successful joint cruise, named TSUJAL, was made possible thanks to a cooperative agreement between NERC and CSIC as part of the Ocean Facilities Exchange Group (OFEG), a major forum of European oceanographic institutions for the exchange of ship time, equipment and personnel. A dense geophysical data set was acquired using for the first time 6 km length seismic streamer facilities from Spain's Consejo Superior de Investigaciones Cientificas (CSIC), usually operating in the Spanish RV Sarmiento de Gamboa, onboard the British RRS James Cook by solving all mechanical, electrical and electronic problems. The RRS James Cook in turn provides the seismic source and the acoustic, hullmounted echosounder operated by the British Natural Environment Research Council (NERC). Multiscale seismic and echosounder images unravel the subduction geometry, nature of the crust, and evidence faults and mass wasting processes. The data are crucial to estimating fault seismic parameters, and these parameters are critical to carrying out seismic hazard in Mexico, especially when considering large-magnitude earthquakes (Mw 8.0), and to constrain tsunami models.

Keywords – Seismic and tsunami hazards, Collaborative research, OFEG, multichannel seismic, Rivera Plate, technology, Mexico

I. INTRODUCTION

The Rivera plate is particularly a region where large earthquakes have occurred with very destructive consequences, including the generation of big tsunamis, e.g. the Mw>8.0 1932 and 1995, demonstrating that the Jalisco Block is a zone of high seismic potential as a consequence of the subduction dynamics. Research in subduction zones includes several geophysical techniques such as multichannel reflection seismic and high resolution bathymetry. To understand the processes involved in the subduction of the Rivera Plate and to solve the lack of seismic imaging and bathymetry information in the area, a multidisciplinary geophysical approach has been performed to characterize the area from the surface, to the deep zones. These data, of unprecedented quality, were recently acquired in the framework of the TSUJAL (TSU-nami and JAL-isco) project [1,2].
The unprecedented quality of the data provides a brand new seismic image of the internal structure of the Rivera Subduction Zone beneath the North American plate from which the geodynamic context can be inferred. Furthermore, the characteristics of the interaction between the Jalisco Block and the sediments thickness of the trench clearly indicate the probability of the occurrence of large earthquake. This information will be of paramount importance for future seismic hazard assessment.

II. EARTHQUAKE HISTORY OF THE JALISCO REGION

The macroseismic history of the Jalisco region dates back to the year 1544. In the last 120 years, 10 major earthquakes were reported with magnitude of Ms >= 7.5, including those occurring on June 3 and 18, 1932 in Jalisco with Ms = 8.2 and 7.8, respectively, and having maximum tsunami run-up height of 3 m, causing 400 casualties. The recurrence time estimated for earthquakes similar to the 1932 event on the coast of Jalisco is 77 years. Considering that the earthquake of 1995 was generated with the rupture of only the southern half of the rupture area in 1932, the likelihood of an event occurring similar to 1995 is very high in the northern coast of Jalisco. This means an area of high potential seismic hazard, also known as the Vallarta Gap, which includes Bahia de Banderas, where the tourist city of Puerto Vallarta is located

III. OFEG: EUROPEAN MARINE ALLIANCE

The TSUJAL project was originally scheduled to use the Spanish RV Sarmiento de Gamboa, which was 6,000 naut. mi. from the work site. It was rescheduled to use the English ship RSS James Cook instead, already conveniently located in the Caribbean Sea. The data gathering was successfully accomplished between February 17 and March 19, 2014, led by Dr. Rafael Bartolome (CSIC) under a barter agreement between NERC and CSIC.
This project was conducted under the auspices of OFEG, a forum of Europe's leading oceanographic research organizations for a global- and ocean-class research fleet aiming to maximize overall scientific output using stateof- theart marine facilities in support of the European oceanographic community. The main aim of OFEG is to reduce the operating costs of marine vessels, maintaining or even improving the quality of scientific work in ocean matters, giving scientists the opportunity to use the most appropriate and advanced oceanographic research equipment. The use of large offshore installations requires a fluid exchange of information on scenarios and geographical areas of work among members, who meet twice a year to plan future exchanges. These include joint cruises, exchange of existing instrumentation and ship time, and exchange of engineers and technicians. No money changes hands, and the arrangements do not provide extra "free" ship time for any country/institution. Members, as per 2014, are: France (Ifremer), Germany (University of Hamburg, GEOMAR and Alfred Wegener Institute), Netherlands (NIOZ), Norway (Institute of Marine Research-IMR), Spain (CSIC), and the U.K. (NERC).
The OFEG fleet includes 21 research vessels from six countries and marine facilities include ROVs, AUVs, submersibles, and large multichannel seismic and mobile compressors. To arrange specific barter, interested marine scientists should contact the representatives in their own country, who will act on behalf of the marine community to negotiate barters as required.

IV. METHODS: A COLLABORATIVE CHALLENGE WELL RESOLVED

The integration of different types of multiscale acoustic and high-resolution data allows detailed mapping of active faults and submarine landslides to assess potential earthquake (and tsunamigenic) hazard and risk by constraining seismic parameters, such as geometry, slip rate, frequency, maximum magnitude, recurrence period, etc. These parameters are critical for assessing seismichazard models, especially when considering largemagnitude earthquakes, and for constraining tsunami models.
seismic (WA) data between 18° N and 22° 30′ N, and 103° 30′ W and 107° 30′ W, mainly at the Rivera Plate. The MCS experiment used, for the first time, the 6-km-long digital seismic streamer of the Spanish RV Sarmiento de Gamboa aboard the RSS James Cook, acquiring a total of 1,524 km of deep multichannel seismic data. The resulting 15 MCS profiles show the structure of the Rivera Plate with unprecedented resolution and penetration, from the oceanic domain up to the Continental Shelf.
For MCS data acquisition, we used an airgun array as a seismic source, with a four-airgun string, totaling 12 BOLT guns towed at 8-m depth, recorded with a 5.85 km streamer at 12.5-m group distance (468 channels) towed at 10-m depth. We completed 27,000 airgun shots, one every 50 m. Seismic source ranges from 5800 c.i. to 3540 c.i. depending on the profile. Nine profiles of wide angle seismic have been acquired as well, coincident with MCS data, in order to investigate the structure and nature of the lithosphere. A total of 970 km have been sounded at sea with the help of 16 OBS from the UTM-CSIC pool deployed two times during the survey, and 100 land stations. Wide angle seismic source ranges from 11 to 14 airguns BOLT ranging between 6800-8000 c.i.,rich in low frequency, working at 15 m depth and fired every 120 s. Concurrently with the seismic survey, approximately 5,438-km swath bathymetry, acoustic backscatter, subbottom profiler, gravity and magnetics data were collected, providing complementary information of the seafloor morphology, subseafloor deformation and crustal structure. To accurately measure water velocity, one XBT (expendable bathythermograph) per day was launched during the survey, whose values were integrated into the echosounder acquisition program.

V. RESULTS

Processed seismic data obtained during this geophysical survey show images of the Rivera and Cocos Plates crustal structure subducting beneath the North American (NA) Plate, where the active subduction can trigger significant earthquakes and tsunamis. Data illustrate an oceanic domain dominated by subduction-accretion processes along the lower slope of the Jalisco margin (20°N, 106°W) with a subparallel sediment thickness of up to (approx.) 2 km in the Middle American Trench. Further, from these data the region appears to be prone to giant earthquake production. The top of the oceanic crust (intraplate reflector) is very well imaged almost continuous with a gentle dip (<10°); however, it is disrupted by normal faulting resulting from the bending of the plate during subduction [3]. The continental crust presents a welldeveloped accretionary prism consisting of highly deformed sediments with prominent slumping towards the trench that may be the result of past tsunamis (Figure 1)

VI. CONCLUSIONS

The TSUJAL project was conducted as a result of the fruitful collaboration between NERC and CSIC, leading to the acquisition of new geophysical data. By using bartering, the geographical location of OFEG ships can be linked to science requirements, thus increasing research efficiency and saving time and money for the whole OFEG fleet. The exchange involves solving a set of technical issues that must be resolved for the perfect equipment integration between infraestructures. This open exchange provides scientists with the opportunity to access larger geographical areas and state-of-the-art equipment, thus improving the quality of science.

Although TSUJAL data processing is ongoing, first MCS processed data defines the structure of the crust in different areas of the Mexican margin. In addition to MCS data, seafloor and subseafloor information from multibeam and parametric echosounder images allow identifying and characterizing mass transport deposits and submarine landslides associated with active faults, emphasizing the ones that can generate earthquakes and tsunamis. Future analysis, modeling and interpretation of seismic data provided by wide-angle data at sea (via 16 OBS) and onshore (via 100 portable seismic stations) will allow resolving the velocity/depth structure and geometry of the Rivera oceanic crust subducting beneath the NA Plate along the active margin of Mexico at various locations.

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