Project IGCP 740 West Makran Paleo-tsunami Investigation Tsunami and Earthquake Research Centre (TERC), University of Hormozgan, Iran

It is always the history that gives us prospect to plan the future, based on past experiences, to make it better. Similarly, to apprehend the future losses from the disasters like earthquakes and tsunamis, studying the past events using geological evidences gives us the best opportunity to plan the mitigation. Especially in case of trans-oceanic tsunamis, which are rare, the only evidence we found earlier in many cases is historical documents. The past occurrence of such large tsunamis is usually preserved by geological features/structures at coasts. The geological evidence not only gives insight into the past to understand what has had happened, it also helps us preparing for the future, including the fine-tuning of standard operating procedures for unexpected events and planning & designing of infrastructure for the development of a particular region. The long-term geologic records provide opportunities to assess tsunami hazards more copiously. A more refined understanding of the long-term variations in time and the recurrence of giant tsunamis is essential for producing realistic vulnerability assessments for coastal communities.

The recent instrumental observations from geodesy and seismology together with historical earthquake and tsunami data has profound impact on understanding of rupture patterns of large earthquakes and tsunami events. Nonetheless, the devastation caused by the 2004 Indian Ocean tsunami made it clear that estimates of earthquake size and tsunami potential are woefully inadequate. If earthquake similar to 1945 Makran occurs again, it will cause huge destruction at rapidly growing coastal cities of Iran, Pakistan, India, North of Oman sea Yemen and UAE. During recent years, several studies in Oman, Pakistan, India and Indonesia focused on North West Indian ocean tsunamis but Makran is one of the noted places which has deficient in data on tsunami size and frequency. No large-magnitude earthquake is known in the western Makran where the recorded seismicity is sparse. By contrast, large-magnitude and frequent earthquakes characterize the eastern Makran. This geographical dissimilarity in seismicity is attributed to a hypothetical segmentation of the subduction zone or to a locked plate boundary that experiences great earthquakes with long repeat times in the west.

We now propose to utilize the comprehensive coastal geology to understand the earthquake and tsunami potential of one of the least understood sources of Indian Ocean tsunamis “the Makran Subduction Zone

(MSZ)". The uplifted terraces, subsided lowlands or sand blows that record the paleoearthquakes may be associated with paleotsunami deposits of this region. The countries bordering northern Indian Ocean, Iran, India, Oman, Pakistan, Yemen and UAE are right places to look for such evidences. Using simplified models (sea level rise/or assumed run up for Oman sea) we propose 5 sites from each country for examination of evidences.

The project will be executed in **3-phases**. **Phase-1** will be for technical meetings from all participating countries to kick-off the project and collect and prepare a database of the existing data from each country. Also, common methodology will be finalized based on accepted international standards for site selection, making trenches, collecting, preserving and transporting samples, analysis methods etc. In **Phase-2** major field work will be carried out at each country starting with Iran, from in-kind support of local government/agency. At least 20 sites will be selected for trenching from 5 sites and samples will be collected. The collected samples will be sent to different agencies for further analysis such as Institute of Seismological Research in India for OSL dating. Under **Phase-3,** the results of coastal geology field work, sediment and stratigraphy analysis, micropaleontology, geochemistry, heavy mineral and OSL/AMS dating will be interpreted as part of the final geodynamic modelling together with the result of recent active seismic data acquisition. The final report will be prepared from interpreted results and will be presented at technical meetings.

Tentative project execution duration will be 20 months with expert teams' participation from Iran, India, Pakistan, Oman, ICG/IOTWMS and other interested experts from Makran region and International agencies. The local and active "Tsunami and Earthquake Research Center (TERC)" in western Makran will do its utmost to coordinate the task in Iran in Phase-1, similar nodal agencies will be identified by respective countries.

Why Makran Subduction Zone?

Makran subduction zone is one of the noted places as deficient in data on tsunami size and frequency. Logistical constraints have made much of the Makran essentially inaccessible in recent years, curtailing earlier field investigations (Penney, et. al, 2017). North-dipping subduction of the Arabian plate beneath the Central Iran and Afghan blocks is believed to have begun during the Cretaceous and is still going on. GPS measurements document a nearly NE convergence rate of ca 20 mm/a between the Arabian and Eurasian plates at the longitude of the Gulf of Oman. The toe of the Makran wedge has migrated southward at ~ 1 cm/a since the Pleistocene. Current motions recalculated from seafloor spreading rates and fault azimuths for the major plates account for convergence rates increasing from 35.5–36.5 mm/a in western Makran to 40–42 mm/a in the east. This is apparently corroborated by anticlockwise rotation

of the rigid Arabian plate with respect to Eurasia around a vertical axis located somewhere in Kurdistan. Seismicity differs in the eastern and western parts of the Makran subduction zone, with a boundary at about the Iran/Pakistan border. No large-magnitude earthquake is known in the western Makran where the recorded seismicity is sparse. By contrast, large-magnitude and frequent earthquakes characterize the eastern Makran. This geographical dissimilarity in seismicity is attributed to a hypothetical segmentation of the subduction zone at ca 62°E longitude or to a locked plate boundary that experiences great earthquakes with long repeat times in the west. The 1945 earthquake rupture, if 150 km in maximum dimension, it spans one-fifth the length of the subduction zone. The faulting caused uplift at Ormara and the tsunami attained reported heights of 12-15 m in Pasni, east of Ormara, and caused fatalities as far south as present Mumbai, India.

Makran and its Seismic Historical Background raises many questions: the relation between great earthquakes and associated tsunamis, duration of the tsunami recurrence, probability of it happening in populated places, most affected places, extent of the potential damage, the time is needed for tsunami hazard alert, the probability of major earthquakes occurrence.

Proposed methodology