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POTENTIAL GEO-HAZARDS: THE TECTONIC THREAT TO THE PAKISTAN–IRAN COAST

Mohammad Jahangir Khan

Namal University Mianwali, Pakistan

jahangir.khan99@gmail.com

Abstract

The coastal belt of the Pakistan-Iran margin in the northern Arabian Sea represents a complex tectonic junction governed by the active lithospheric convergence of the Arabian, Eurasian, and Indian plates. Dominated by the ~1,000 km-long Makran Subduction Zone (MSZ), the Murray Ridge, and the Owen Fracture Zone, this region represents a critical economic corridor for international trade and energy infrastructure. However, it also presents severe exposure to low-frequency, high-impact submarine geohazards, including megathrust earthquakes, tsunamis, seafloor slope failures, mud diapirism, and shallow gas escapes. With nearly eight decades elapsed since the devastating 1945 Mw 8.1 Makran earthquake and tsunami, the region is approaching the 100-year recurrence window, making hazard assessment and monitoring an urgent priority. This keynote talk synthesizes recent offshore geophysical findings, onshore field investigations, and seismicity dynamics along the Pakistan-Iran coast. Offshore marine seismic reflection profiles identify key geophysical signatures including gas chimneys, cold seeps, and the first discovery of double Bottom Simulating Reflectors (BSRs) associated with vast gas hydrate reserves. Onshore field observations in critical coastal nodes like Gwadar demonstrate severe localized hazards, including active ground fissure development, mudstone instability, surface displacement, and mud diapirism leading to the emergence of temporary offshore islands. Furthermore, recent hydrodynamic tsunami modeling demonstrates that extreme subduction rupture scenarios (Mw 8.1–9.0) could

generate tsunami wave heights reaching 10 to 18 meters, potentially inundating over 80% of Gwadar's urban area and 60% of Pasni.

To safeguard coastal communities and strategic infrastructure, a coordinated regional framework is essential. To balance economic development with risk mitigation, following strategic initiatives are suggested:

- **Seismic & Geodetic Networks:** *Establishing integrated networks of active seismic monitoring stations and continuous geodetic receivers along the Pakistan-Iran coastline.*
- **Early Warning Systems:** *Deploying offshore real-time tsunami early warning monitoring stations across the Arabian Sea.*
- **Deep Lithospheric Imaging:** *Executing wide-angle deep seismic reflection surveys to delineate subsurface blind faults and brittle lithospheric deformation.*
- **Structural Regulation & Policy:** *Modernizing structural building codes with vigilant enforcement while fostering cross-border geopolitical and scientific collaboration.*

Ultimately, bridging the gap between geoscientific insight and geopolitical planning is vital to building long-term coastal resilience in the northern Arabian Sea.

Keywords:

Makran Subduction Zone, Submarine Geohazards, Tsunami Hazard Assessment, Gas Hydrates and Seafloor Instability, Coastal Resilience and Risk Mitigation