ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2521-0920 (Print)
ISSN: 2521-0602 (Online)
CODEN: MJGAAN

Malaysian Journal of Geosciences (MJG)

DOI: http://doi.org/10.26480/mjg.01.2021.01.05

CrossMark

REVIEW ARTICLE

IS MAKRAN A SEPARATE MICROPLATE? A SHORT REVIEW

Muhammad Imran Hafeez Abbasi

COMSATS Institute of Information Technology - Abbottabad Campus, Abbottabad, Khyber Pakhtunkhwa PAKISTAN.
****Corresponding Author Email: emraan@hotmail.co.uk***

ARTICLE DETAILS

Article History:

Received 18 September 2020
Accepted 20 October 2020
Available online 19 November 2020

ABSTRACT

Makran Subduction Zone (MZS) is important as this region lies on both sides of the border of Iran and Pakistan along the coastline. Makran Subduction complex has pervasive seismicity and diverse focal mechanism solutions and being in the vicinity of Triple Junction where three major Tectonic plates; Arabian, Eurasian and Indian plates are connecting. Both of Chabahar and Gwadar ports are located in this vicinity, on which China is investing for CPEC, Belt and Road Initiative. The whole world is looking at these projects of Makran, as this may define and transform the future of trade. Hence Geoscience point of view is notable as well in consideration for the successful execution of these projects. Several Microplates/blocks have been proposed around the vicinity MSZ and Indian-Eurasian Plate boundary including the Ormara microplate, Lut Block, Helmand Block, and Pakistan-Iran Makran microplate (PIMM). The purpose of this review is to shed light on PIMM. Despite previous researches related to Makran, still many researchers are working to solve puzzles related to the complexity of MSZ. It is divided into Eastern and Western Makran due to seismicity and North to South into four parts based on stratigraphy, thrusts and folds. This review aims to give suggestions for the hypothesis on PIMM which was inferred as a separate microplate.

KEYWORDS

PIMM, Earthquake Seismology, MSZ, Gwadar and Chabahar ports.

1. INTRODUCTION

MSZ is known to have complex tectonic settings being near to the Triple Junction, where three tectonic plates (i.e. Eurasian, Indian and Arabian) are interacting (Curray et al., 1982; Mokhtari et al., 2019). Through previous studies of tectonic reconstruction, it was inferred that the subduction was originated in the Late Cretaceous (McCall and Kidd, 1982; McCall, 2002). Since Early Eocene, a massive accretion is being build-up towards the southwestern part of the Eurasian plate (McCall et al., 1982; Ellouz-Zimmermann et al., 2007). This plate is categorized as a typical fold and thrust belt, where landward extension of thrust followed by a very high accumulation of sediments at the frontal wedge, with uplifting and thickening of accretionary complex, then dip angle of MSZ is very low (almost 2-3^0) (Schlüter et al., 2002; Ellouz-Zimmermann et al., 2007; Heidarzadeh et al., 2008; Harms et al., 1984). The collision between the Arabian oceanic plate and the Eurasian continental plate at MSZ caused the growth of long spread Thrust and fold belt of Zagros ranges, which is about 1500 km widespread in Northwest of Makran (Kashfi, 1976; Jenkins et al., 2013).

MSZ area lies at the west (left side) of the Left lateral Chaman strike-slip fault, Ornach-Nal fault (C-OFS), and Sonne pas fault (SPF), which is intersecting the wedge and extending in an abyssal plane (Kukowski et al., 2000). In Iran, MSZ is at South East of Right lateral Zendan strike-slip fault, bounded towards North by Jiroft Fault (ophiolites) and towards the south by Oman trench of this subduction zone in the offshore (Figure) (Minshull et al., 1992; Siddiqui and Jadoon, 2012).

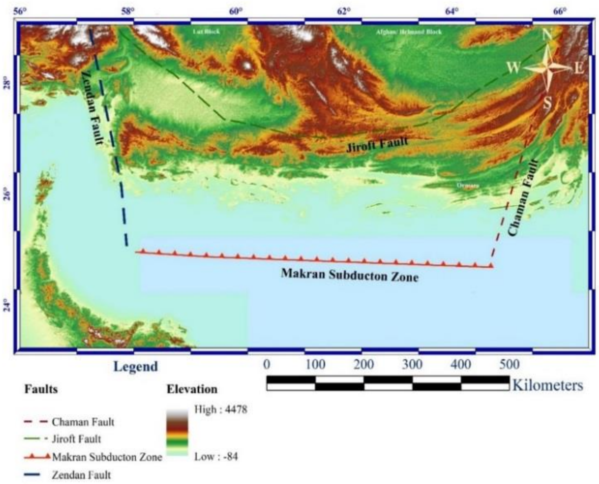

Figure 1: Tectonic setting along proposed Pakistan-Iran Makran Microplate

Chaman fault is originally a transform fault due to left lateral movement, with almost North-South orientation (Khan et al., 1991). Hoshab Fault has

Quick Response Code	Access this article online	
	Website: www.myjgeosc.com	**DOI:** 10.26480/mjg.01.2021.01.05

Cite the Article: Muhammad Imran Hafeez Abbasi (2021). Is Makran A Separate Microplate? A Short Review. *Malaysian Journal of Geosciences, 5(1): 01-05.*

the same sense of motion as C-OFS and is located at its southern section, although in a curved form (Avouac et al., 2014). The surface of the accretionary prism of Makran is marked by steep and asymmetrical folds with imbricate thrust wedges. These folds are mainly striking East to West and almost parallel to these fold axes, there are reverse faults that are roughly dipping from North to West (Ahmed, 1969). Normal faults in the Chabahar region (Figure 1) are dipping towards the headland (Normand et al., 2019).

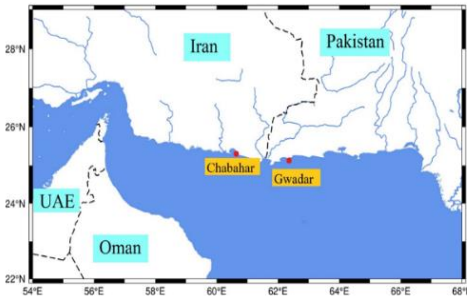

Figure 2: Location Map for Chabahar and Gwadar ports

The paleo-stress inversion is suggesting an N-S extension along the subduction zone rather than compression. MSZ is produced by the subduction of the Arabian oceanic Plate under the Eurasian continental plate with an average speed of 40 mm/yr (Siddiqui and Jadoon, 2012; Smith et al., 2012). MSZ can be distributed into Eastern and Western Makran because of its different seismicity patterns at both sections separated by a sinistral fault (SPS) (Figure) (Mokhtari et al., 2019). PIMM has been designated as a separate microplate after interpreting Tectonics of Indian and Eurasian plates (Siddiqui and Jadoon, 2012). So, in this review paper, we are trying to see aspects behind this hypothesis (Siddiqui and Jadoon, 2012). And we have come out with some recommendations to support this hypothesis by scientific evidence.

2. Seismicity

MSZ is complex and active subduction zone, situated near a triple junction but still exhibits comparatively low seismicity than other subduction zones of the World (Mokhtari et al., 2008). The Eastern side of Makran seems activate in recent historical times, while the other side which is termed as Western Makran (WM) tends to be aseismic (Figure 3) (Jacob and Quittmeyer, 1979; Musson, 2009; Rajendran et al., 2013). By observing previous work, we can infer three things about the WM:

1. Along with the WM, the subduction tends to be locked and pending the potential of a great magnitude earthquake.

2. WM/Zargos is subducting virtually aseismically having anticlockwise motion with respect to its Northwards drift and low seismicity.

3. Subduction seems to be diminished in the WM (Masson et al., 2005; Paul et al., 2006).

Around Zagros ranges in Southern Iran, the seismicity seems to be restricted to upper Crust only (depth of < 20 KMS) (Maggi et al., 2000).

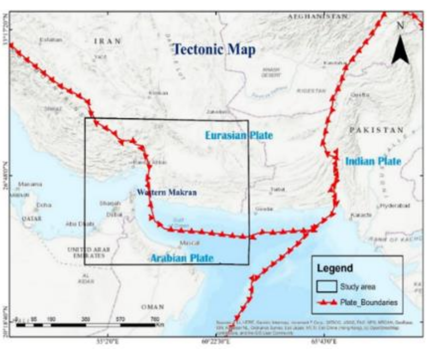

Figure 3: Regional Tectonic map, with area selected to be study for seismicity of Western Makran.

A group researchers used satellite imagery, from Interferometric Synthetic Aperture Radar (InSAR) for investigation of active time series of convergence between slip on the megathrust and internal deformation (Lin, 2015; Lin et al., 2015). He inferred that elastic strain is accumulating in the region which can trigger a high magnitude earthquake as in the past.

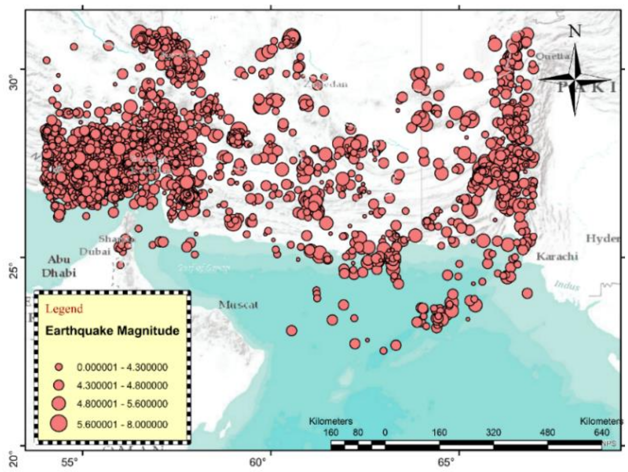

Figure 4: Earthquake events (1990-2019) recorded in the Makran region.

3. Extension

Makran accretionary wedge (Eastern and Western Makran) extends almost 1000 km between the Zendan/Minab dextral fault at WM in Iran and the Chaman sinistral strike-slip fault system in Pakistan (Figure 3). This wedge trending N-S and is originally a transform fault with Left lateral movement (Byrne et al., 1992; Kopp et al., 2000; Siddiqui and Jadoon, 2012; Khan et al., 1991). The 3D models of the density variation and the magnetic susceptibility along a few cross segments opposite to the EW strike of the MSZ demonstrate that the Arabian oceanic plate is subducting with a very trivial plunge slant beneath the Eurasian plate (Abedi and Bahroudi, 2016). From a thorough examination of seafloor spreading in offshore Makran, the pattern of oceanic ridges has been observed (Okal and Synolakis, 2008). And by fault mechanism studies, these tectonic plates reported to be have convergence rates ranging from 35.50 to 36.50 mm/a towards WM and 40 to 42 mm/a towards the Eastern Makran (Haghipour et al., 2012; Burg, 2018). However, stated that the convergence rate ranges between 19.5–27 mm/a through his GPS employed work (Reilinger et al., 2006; Vernant, 2014; Vernant et al., 2004). Moho depth beneath the Oman Trench is around 20-25 km observed with variation in acoustic impedance in high-resolution maps (Abdetedal et al., 2014).

Observation of the Morphotectonics of the MSZ by the aid of Swath Mapping and Parasound echo sounding of 3.5 kHz, exhibits approximately 7 km of sediment deposited in the Oman trench and the main rivers are bringing a large number of sediments to the offshore area in the east (Kukowski et al., 2001). The growth of such a large Accretionary wedge/prism is believed to be because of the deposition and deformation of the marine flysch deposit (Burg, 2011). A thick sediment accumulation accreted during the Cenozoic (Farhoudi and Karig, 1977). Based on Tectono-stratigraphy, Makran has been subdivided into four parts from North to South, 600 km from offshore Oman trench to Volcanic arc, and ophiolites (Kopp et al., 2000). These parts are known as Northern Makran and are mainly surrounded by the Quaternary deposits (Glennie et al., 1990; Burg et al., 2013). Next to North Makran, is Inner Makran, which is mainly composed of marine deposits and is followed by Outer Makran which lies between Ghasr Ghand Thrust GGT and Chah Khan thrust CKT having Marls, Calcareous sandstones, shales and deep marine turbiditic sequence (McCall and Eftekhar-Nezad, 1993; Harms et al., 1982; Dolati, 2010). And at the end is Coastal Makran where transitional facies, marl, calcareous sandstones are dominated for several kilometers, which is bounded by Oman Trench (Haghipour et al., 2015; Mohammadi et al., 2016).

4. Microplates

Recent research work using the latest technology for plate tectonics can give clues about the microplates in this region where the Arabian oceanic plate is undergoing beneath the Eurasian continental plate. The Lut block is at North of the Jiroft fault, near Zagros ranges in SW of Iran. It covers around 900 KMs in NS direction from 28^0 to 35^0 North latitude and along EW direction 200 KMs wide from 57^0 to 61^0 East longitude (Figure 1) (Stocklin, 1968; Stöcklin et al., 1972a; Hussain et al., 2002; Saadat et al., 2010). High seismicity can be observed only adjacent to the junction of the Lut block, where the flysch zone in the East is prominent (Stöcklin et al., 1972b).

Afghan/Helmand Block is located towards the northern boundary of PIMM, in Afghanistan. Ormara Microplate (OM) was separated from the eastern segment of the Arabian oceanic plate along with SPF and possessing separate attributes (Pang et al., 2014; Penney et al., 2017). The Northeast edge of the Arabian plate is an isolated block and seismicity can be visible around OM as resulting due to SPF and its splays. PIMM bounded from all sides by Faults, already described above (Kukowski et al., 2000; Siddiqui and Jadoon, 2012).

5. Focal Mechanism Solution

Earthquake mechanism or commonly known as Focal Mechanism Solution (FMS) tells us how an earthquake originated or the behavior of a particular event of an earthquake. Events related to fault's FMS has been integrated as a fault plane solution. Seismologists plot FMS as Beach ball diagrams so that it will be easier for Geologists to interpret. Its famous method nowadays because of its significance in the evaluation of seafloor spreading, plate motions, fault behaviors. The seismological waves encode information among them, that decoding seismic waves unlock secrets about many processes including source rupture, Subduction zones, plate tectonics, etc (Banghar and Sykes, 1969; Shimizu et al., 2019).

A study performed by Penney et al., 2017, for FMS of MSZ on limited data, showed us subsurface attributes of this area. Earthquake events used for that research were between 1945 and 2013 with a magnitude of 4 or greater, have been selected for FMS study for MZS. Recently a study performed geophysical research on Iranian Makran and its vicinity by using virtual Seismograms data acquired by local stations equipped by the Iranian Seismological Center (Shirzad, 2019; Shirzad et al., 2019). Around 630 Earthquake events recorded from January 2006 till May 2019, with a magnitude of 4 or greater, were processed to generate precise Tomographic Maps. Along C-OFS deep focus events recorded in past, beyond crustal thickness, suggesting that the Eastern edge of PIMM is cutting beyond crustal thickness at some points. Generally, events are above 50Km depth but some deep events recorded along Normal fault, pinched crustal wedge and 80Km is maximum depth recorded in MSZ.

6. Conclusion

Despite previous research work related to MSZ, critics arise on PIMM. Although FMS data is available for this region, a proper study is missing that deals with microplates inferred for this region. Our recommendation is to plot Focal depths and Mechanism Solutions for MZS, by drawing cross-sections along MZS to see the crustal thickness in this area and depth of hypocentres. *(Figure 5),* map for Earthquake events initially taken for FMS study showing data cluster of Earthquake events in this region. *(Figure),* has been plotted by using Generic Mapping Tool (GMT), where FMS plotted, after filtering out noisy data The numbers mentioned above Beach Balls are Earthquake Event number as used in the processing of data.

It is suggested to take the velocity model with 5-6 subsurface layers. That can give us a better view of PIMM, as we will easily see either the faults surrounding PIMM are of the crustal thickness or not. That will also let us visualize the shallow angle of the subduction, which is a unique attribute of MSZ.

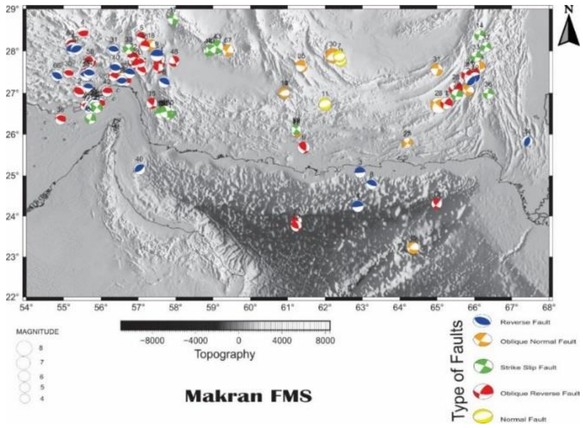

Figure 5: FMS of Makran derived from filtered data of events that occurred from 1990 to 2019

References

Abdetedal, M., Shomali, Z.H., Gheitanchi, M.R., 2014. Crust and upper mantle structures of the Makran subduction zone in south-east Iran by seismic ambient noise tomography: Solid Earth Discussions, 6, Pp. 1–34.

Abedi, M., Bahroudi, A., 2016. A geophysical potential field study to image the Makran subduction zone in SE of Iran: Tectonophysics, 688, Pp. 119–134.

Ahmed, S.S., 1969, Tertiary geology of part of south Makran, Baluchistan, West Pakistan: AAPG Bulletin, 53, Pp. 1480–1499.

Avouac, J.P., Ayoub, F., Wei, S., Ampuero, J.P., Meng, L., Leprince, S., Jolivet, R., Duputel, Z., Helmberger, D., 2014, The 2013, Mw 7.7 Balochistan earthquake, energetic strike-slip reactivation of a thrust fault: Earth and Planetary Science Letters, 391, Pp. 128–134.

Banghar, A.R., Sykes, L.R., 1969, Focal mechanisms of earthquakes in the Indian Ocean and adjacent regions: Journal of Geophysical Research, 74, Pp. 632–649, doi:10.1029/jb074i002p00632.

Burg, J.P., 2011. The Asia–Kohistan–India collision: review and discussion, in Arc-continent collision, Springer, Pp. 279–309.

Burg, J.P., 2018. Geology of the onshore Makran accretionary wedge: Synthesis and tectonic interpretation: Earth-Science Reviews,.

Burg, J.P., Dolati, A., Bernoulli, D., and Smit, J., 2013, Structural style of the Makran Tertiary accretionary complex in SE-Iran, in Lithosphere dynamics and sedimentary basins: The Arabian Plate and analogues, Springer, Pp. 239–259.

Byrne, D.E., Sykes, L.R., and Davis, D.M., 1992, Great thrust earthquakes and aseismic slip along the plate boundary of the Makran subduction zone: Journal of Geophysical Research: Solid Earth, 97, Pp. 449–478.

Curray, J.R., Emmel, F.J., Moore, D.G., and Raitt, R.W., 1982, The Ocean Basins and Margins: Structure, tectonics, and geological history of the northeastern Indian Ocean AEM Nairn, FG Stehli, Plenum, New York.

Dolati, A., 2010, Stratigraphy, structural geology and low-temperature thermochronology across the Makran accretionary wedge in Iran:

Ellouz-Zimmermann, N., Deville, E., Müller, C., Lallemant, S., Subhani, A.B., and Tabreez, A.R., 2007. Impact of sedimentation on convergent margin tectonics: Example of the Makran accretionary prism (Pakistan), in Thrust Belts and Foreland Basins, Springer, Pp. 327–350.

Farhoudi, G., Karig, D.E., 1977, Makran of Iran and Pakistan as an active arc system: Geology, 5, Pp. 664–668.

Glennie, K.W., Clarke, M.W.H., Boeuf, M.G.A., Pilaar, W.F.H., and Reinhardt, B.M., 1990. Inter-relationship of Makran-Oman Mountains belts of convergence: Geological Society, London, Special Publications, 49, Pp.

773–786.

Haghipour, N., Burg, J.P., Ivy-Ochs, S., Hajdas, I., Kubik, P., Christl, M., 2015. Correlation of fluvial terraces and temporal steady-state incision on the onshore Makran accretionary wedge in southeastern Iran: Insight from channel profiles and 10Be exposure dating of strath terraces: Bulletin, 127, Pp. 560–583.

Haghipour, N., Burg, J.P., Kober, F., Zeilinger, G., Ivy-Ochs, S., Kubik, P.W., Faridi, M., 2012. Rate of crustal shortening and non-Coulomb behaviour of an active accretionary wedge: The folded fluvial terraces in Makran (SE, Iran): Earth and Planetary Science Letters, 355, Pp. 187–198.

Harms, J.C., Cappel, H.N., and Francis, D.C., 1984. The Makran coast of Pakistan: its stratigraphy and hydrocarbon potential: Marine geology and oceanography of Arabian Sea and coastal Pakistan, 3, Pp. 27.

Harms, J.C., Cappel, H.N., Francis, D.C., 1982, Geology and petroleum potential of the Makran Coast, Pakistan: Society of Petroleum Engineers.

Heidarzadeh, M., Pirooz, M.D., Zaker, N.H., Yalciner, A.C., Mokhtari, M., and Esmaeily, A., 2008. Historical tsunami in the Makran Subduction Zone off the southern coasts of Iran and Pakistan and results of numerical modeling: Ocean Engineering, 35, Pp. 774–786.

Hussain, J., Butt, A., Pervaiz, K., 2002. Makran Coast: A potential seismic risk belt: Geological Bulletin Univ. Peshawar, 35, Pp. 43–56.

Jacob, K.H., Quittmeyer, R.L., 1979. Geodynamics of Pakistan: Geological Survey of Pakistan, Pp. 305–317.

Jenkins, J., Turner, B., Turner, R., Hayes, G.P., Davies, S., Dart, R.L., Tarr, A.C., Villaseñor, A., and Benz, H.M., 2013. Seismicity of the Earth 1900–2010 Middle East and vicinity: US Geological Survey.

Kashfi, M.S., 1976, Plate tectonics and structural evolution of the Zagros geosyncline, southwestern Iran: Geological Society of America Bulletin, 87, Pp. 1486–1490.

Khan, M.A., Raza, H.A., and Alam, S., 1991. Petroleum geology of the Makran region: implications for hydrocarbon occurrence in cool basins: Journal of Petroleum Geology, 14, Pp. 5–18.

Kopp, C., Fruehn, J., Flueh, E.R., Reichert, C., Kukowski, N., Bialas, J., and Klaeschen, D., 2000. Structure of the Makran subduction zone from wide-angle and reflection seismic data: Tectonophysics, 329, Pp. 171–191.

Kukowski, N., Schillhorn, T., Flueh, E.R., and Huhn, K., 2000. Newly identified strike-slip plate boundary in the northeastern Arabian Sea: Geology, 28, Pp. 355–358.

Kukowski, N., Schillhorn, T., Huhn, K., von Rad, U., Husen, S., and Flueh, E.R., 2001. Morphotectonics and mechanics of the central Makran accretionary wedge off Pakistan: Marine Geology, 173, Pp. 1–19.

Lin, Y.N., Jolivet, R., Simons, M., Agram, P.S., Martens, H.R., Li, Z., and Lodi, S.H., 2015. High interseismic coupling in the Eastern Makran (Pakistan) subduction zone: Earth and Planetary Science Letters, 420, Pp. 116–126.

Maggi, A., Jackson, J.A., Priestley, K., and Baker, C., 2000. A re-assessment of focal depth distributions in southern Iran, the Tien Shan and northern India: Do earthquakes really occur in the continental mantle? Geophysical Journal International, 143, Pp. 629–661.

Masson, F., Chéry, J., Hatzfeld, D., Martinod, J., Vernant, P., Tavakoli, F., and Ghafory-Ashtiani, M., 2005, Seismic versus aseismic deformation in Iran inferred from earthquakes and geodetic data: Geophysical Journal International, 160, Pp. 217–226.

McCall, G.J.H., 2002. A summary of the geology of the Iranian Makran: Geological Society, London, Special Publications, 195, Pp. 147–204.

McCall, G.J.H., and Eftekhar-Nezad, J., 1993. Explanatory Text of the Nikhshahr Quadrangle Map, 1: 250 000, L14: Geological Survey of Iran, Tehran.

McCall, G.J.H., and Kidd, R.G.W., 1982. The Makran, Southeastern Iran: the anatomy of a convergent plate margin active from Cretaceous to Present: Geological Society, London, Special Publications, 10, Pp. 387–397.

McCall, G.J.H., Kidd, R.G.W., and Leggett, J.K., 1982. Trench-Forearc Geology: Sedimentation and Tectonics on Modern and Ancient Active Plate Margins.

Minshull, T.A., White, R.S., Barton, P.J., and Collier, J.S., 1992. Deformation at plate boundaries around the Gulf of Oman: Marine Geology, 104, Pp. 265–277.

Mohammadi, A., Burg, J.P., Winkler, W., Ruh, J., and von Quadt, A., 2016. Detrital zircon and provenance analysis of Late Cretaceous–Miocene onshore Iranian Makran strata: Implications for the tectonic setting: Bulletin, 128, Pp. 1481–1499.

Mokhtari, M., Amjadi, A.A., Mahshadnia, L., and Rafizadeh, M., 2019. A review of the seismotectonics of the Makran Subduction Zone as a baseline for Tsunami Hazard Assessments: Geoscience Letters, 6, Pp. 1–9.

Mokhtari, M., Fard, I.A., and Hessami, K., 2008, Structural elements of the Makran region, Oman sea and their potential relevance to tsunamigenisis: Natural hazards, 47, Pp. 185–199.

Musson, R.M.W., 2009. Subduction in the Western Makran: the historian's contribution: Journal of the Geological Society, 166, Pp. 387–391.

Normand, R., Simpson, G., and Bahroudi, A., 2019. Extension at the coast of the Makran subduction zone (Iran): Terra Nova, 31, Pp. 503–510.

Okal, E.A., and Synolakis, C.E., 2008. Far-field tsunami hazard from mega-thrust earthquakes in the Indian Ocean. Geophysical journal international, 172, Pp. 995–1015.

Pang, K., Chung, S., Zarrinkoub, M.H., Chiu, H., and Li, X., 2014. On the magmatic record of the Makran arc, southeastern Iran: Insights from zircon U-Pb geochronology and bulk-rock geochemistry. Geochemistry, Geophysics, Geosystems, 15, Pp. 2151–2169.

Paul, A., Kaviani, A., Hatzfeld, D., Vergne, J., and Mokhtari, M., 2006. Seismological evidence for crustal-scale thrusting in the Zagros mountain belt (Iran). Geophysical Journal International, 166, Pp. 227–237.

Penney, C., Tavakoli, F., Saadat, A., Nankali, H.R., Sedighi, M., Khorrami, F., Sobouti, F., Rafi, Z., Copley, A., and Jackson, J., 2017. Megathrust and accretionary wedge properties and behaviour in the Makran subduction zone. Geophysical Journal International, 209, Pp. 1800–1830.

Rajendran, C.P., Rajendran, K., Shah-Hosseini, M., Beni, A.N., Nautiyal, C.M., and Andrews, R., 2013. The hazard potential of the western segment of the Makran subduction zone, northern Arabian Sea: Natural hazards, 65, Pp. 219–239.

Reilinger, R., McClusky, S., Vernant, P., Lawrence, S., Ergintav, S., Cakmak, R., Ozener, H., Kadirov, F., Guliev, I., and Stepanyan, R., 2006. GPS constraints on continental deformation in the Africa-Arabia-Eurasia continental collision zone and implications for the dynamics of plate interactions: Journal of Geophysical Research: Solid Earth, 111.

Saadat, S., Karimpour, M.H., and Stern, C., 2010, Petrochemical characteristics of Neogene and Quaternary alkali olivine basalts from the Western Margin of the Lut Block, Eastern Iran: Iranian Journal of Earth Sciences, 2, Pp. 87–106.

Schlüter, H.U., Prexl, A., Gaedicke, C., Roeser, H., Reichert, C., Meyer, H., and Von Daniels, C., 2002. The Makran accretionary wedge: sediment thicknesses and ages and the origin of mud volcanoes: Marine Geology, 185, Pp. 219–232.

Shimizu, K., Yagi, Y., Okuwaki, R., Fukahata, Y., 2019. Development of an inversion method to extract information on fault geometry from teleseismic data.

Shirzad, T., Riahi, M.A., and Assumpção, M.S., 2019. Crustal structure of the Collision-subduction Zone in south of Iran Using Virtual seismometers. Scientific reports, 9, Pp. 1–11.

Siddiqui, N.K., and Jadoon, I.A.K., 2012. Indo-Eurasian Plate collision and the evolution of Pak-Iran Makran Microplate, Pishin-Katawaz Fault Block and the Porali Trough, in Search and Discovery Article# 30265 (2013), PAPG/SPE Annual Technical Conference, Pp. 3–5.

Smith, G., McNeill, L., Henstock, T.J., and Bull, J., 2012. The structure and fault activity of the Makran accretionary prism: Journal of Geophysical Research: Solid Earth, 117.

Stocklin, J., 1968. Structural history and tectonics of Iran: a review: AAPG bulletin, 52, Pp. 1229–1258.

Stöcklin, J., Eftekhar-Nezhad, J., and Hushmand-Zadeh, A., 1972a, Central Lut reconnaissance, East Iran: Geological Survey of Iran.

Stöcklin, J., Eftekharnezhad, J., and Hushmandzadeh, A., 1972b. Central Lut reconnaissance East Iran, Geological Survey of Iran: Report.

Vernant, P., Nilforoushan, F., Hatzfeld, D., Abbassi, M.R., Vigny, C., Masson, F., Nankali, H., Martinod, J., Ashtiani, A., and Bayer, R., 2004. Present-day crustal deformation and plate kinematics in the Middle East constrained by GPS measurements in Iran and northern Oman. Geophysical Journal International, 157, Pp. 381–398.