31-1 - A SEISMOTECTONIC REVIEW OF THE IMPACT OF THE MAKRAN SUBDUCTION ZONE ON THE HELMAND-SISTAN BLOCK -- AFGHANISTAN, IRAN, AND PAKISTAN*

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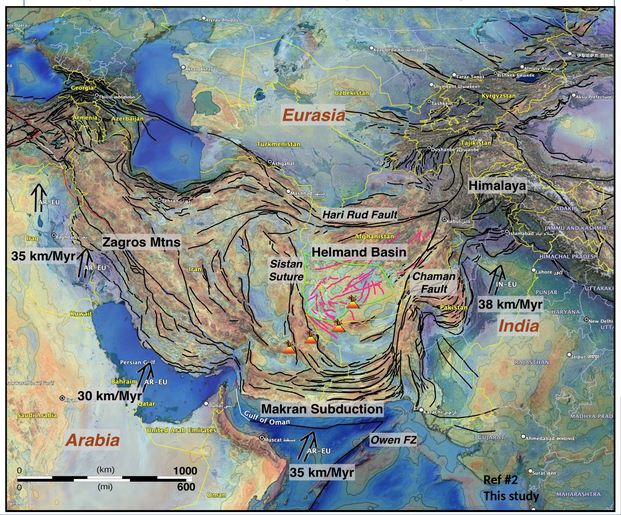
SEISMOTECTONIC DETAILS

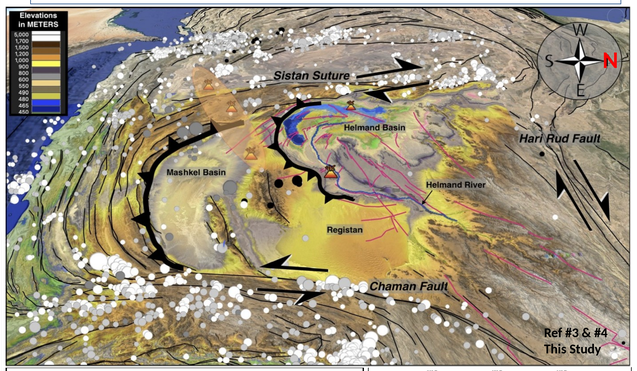
The Makran subduction zone (MSZ) located along the coasts of eastern Iran and western Pakistan is approximately 900 km in length and accommodates ~30 to 40 km/Myr of convergence between the subducting Arabian and overriding Eurasian plates. Subduction of the Arabian oceanic slab has formed an elaborate accretionary prism. The MSZ seismicity and tomography indicate a tear in the Arabian oceanic slab that divides it into a shallower western and a steeper eastern section. The slab has a shallow dip beneath the accretionary prism (~3° to 5°), the downgoing trench is beneath the prism, far south of the volcanic arc, and it bends downward into a near vertical slab that is foundering beneath the Helmand-Sistan (H-S) continental Block in Afghanistan. The chemistries and effusion rates of the 4 volcanoes in the arc reflect the expiration of volcanism as one moves eastward along the Makran arc.

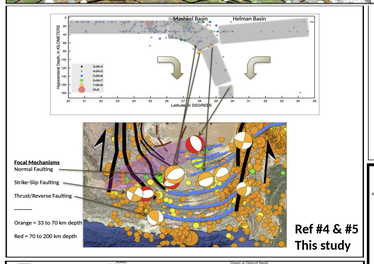
To the west, the MSZ connects with the right-lateral Minab fault system that bounds the eastern Zagros fold and thrust belt as well as with the right-lateral Sistan Suture that merges into the Makran's accretionary prism. To the east, the MSZ is bounded by the transpressional left-lateral strike-slip Ornach-Nal and Chaman fault zones, which forms an unstable triple junction with relative plate convergence of India with Eurasia and the Himalayan orogeny. The plate boundary faults and MSZ volcanic arc play a significant and complicated role in the seismotectonics within and around the Helmand-Sistan (H-S) Basin. We propose that the MSZ is expiring and has possibly jumped or is rolling back southward, allowing the slab to tear and founder, which encourages the H-S Basin to subside while being deformed by regional crustal faults.

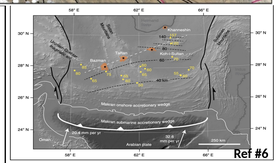


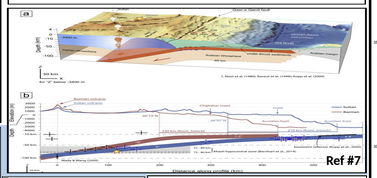
PROPOSED SEISMOTECTONIC MODEL

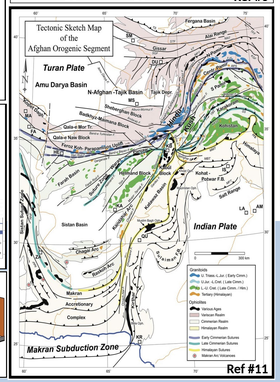
We propose a trap-door-style seismotectonic model of the H-S Block, given that it is bounded by the left-lateral Chaman Fault and the right-lateral Sistan Suture system, and the volcanic back arc. The MSZ is retreating slowly (~2 km/Myr) southward between these two subparallel, strike-slip plate boundary faults. The Makran slab is foundering ~150 to 200 km beneath the H-S Block and encourages subsidence of the Block in the S and SW corner of the H-S Basin. The Zabol Fault acts to push the hamuns into the NW corner of the basin. Regional tilt and subsidence are evidenced by the Sheila River overflow located along the W-SW side of the basin. We infer that the circuitous path of Helmand River is created by active faults and arc subsidence.

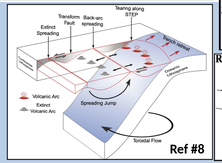


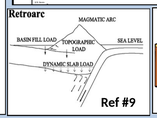


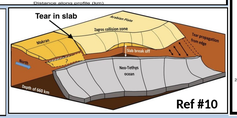






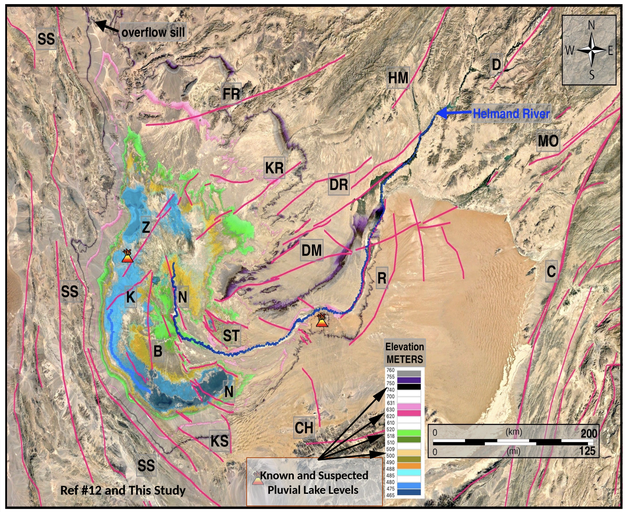






TECTONIC GEOMORPHOLOGY

The H-S Basin is endorheic with an overflow sill 300 m above the basin floor. It contains mostly fluvial-lacustrine sedimentary rocks; sandstones, mudstones, siltstones, and evaporites deposited during the Neogene and Quaternary periods as a result of the basin's subsidence and pluvial lakes. Using satellite images and DEMs, we mapped several fault and fracture zones, and numerous dolines and dayas in the basin related to these faults and fracture zones. The youngest ~100-km-long Holocene fault zone named the Zabol Fault is located ~15 km west of Zabol, Iran, the NW-side up fault serves to tilt the Helman Hamuns to the NW. Another prominent fault named the Nimruz Fault offsets Quat?-Pliocene basin fill and has caused repeated captures and avulsions of the Helmand River. Very limited data exists on the ages of the basin fill. The scattered, poorly-preserved pluvial shorelines and abandoned river terraces are inferred on the basis of elevation and preservation to range in age from Holocene to Pliocene(?). We infer that most of the basin geomorphology is from active tectonics.



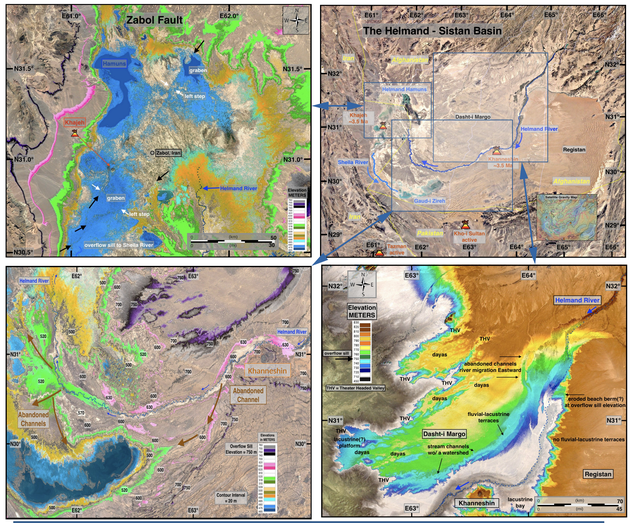
B = Biyaban (Buried) Fault
C = Chagai Hills Faults
CH = Chagai Hills Fault
D = Darafshan Fault
DM = Dasht-i Margo Zone
DR = Dor Rud Fault

FR = Farah Rud Fault
HM = Helmand Fault
K = Khajeh Fault
KR = Khash Rud Fault
KS = Koh-i Sultan Faults
MO = Mokur Fault

N = Nimruz Fault
R = Registan Faults
SS = Sistan Suture
ST = Sar-o-Tar Faults
Z = Zabol Fault

UNCERTAINTIES

Previous workers have inferred the H-S Block is not internally deforming, an uncertainty we did not accept after scrutiny. Our geomorphologic mapping is limited by the resolution of satellite imagery and DEM data. Field confirmation is not possible. Fault slip rates and slip styles and down-dip fault geometries vary along the Chaman Fault and across the Sistan Suture faults. The wide Makran accretionary prism is being accreted to the southern edge of the Eurasian Plate, apparently as a result of subduction zone jump or roll back, opening a trap-door. This model is complicated by regional transpression and slab tearing and foundering as the volcanic arc is cross-faulted, folded and expiring, cut off to the East by India collision. Thus the local fault kinematics are uncertain. We cannot explain why pluvial shorelines and river terraces on the Dasht-i Margo easterner foot slopes are not preserved on the East side of the Helmand River canyon or the lack of shorelines along the West, Southwest, and South margins of the basin, other than to infer active faulting and regional subsidence.



CONCLUSIONS

Mapping has identified structures within the H-S Basin that appear to be tectonically active. The circuitous path and numerous abandoned channels of the Helmand River are a result of active tectonics, stream captures, avulsions, and entrenchments. The locations of the Helmand Hamuns and certain groundwater paths are fault-controlled.

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