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Provenance analysis and detrital zircon geochronology on the onshore Makran accretionary wedge, SE Iran: implication for the geodynamic setting

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The Makran, located in Southeast Iran and South Pakistan, is one of the largest accretionary wedges on Earth. In Iran it comprises turbiditic sediments ranging in age from Late Cretaceous to Holocene. We present a provenance analysis on sandstones, which is aimed at reconstructing the assemblages of source rocks and the tectonic setting from which the clastic material was derived. Sandstone samples collected from different units span the regional stratigraphy from Late Cretaceous to Miocene.
Laser ablation ICP-MS resulted in ca 2800 new U-Pb ages of individual detrital zircons from 18 samples collected in onshore Makran. 101 detrital zircons from a Late Cretaceous fine grained sandstone range from 180 to 160 Ma (Middle Jurassic). 478 detrital zircons from mid- to late Eocene sandstones allow differentiating a NE and NW sector of the Makran Basin. Zircon grains in the NE basin belong to two populations peaking at 180 to 160 Ma (late Early to Middle Jurassic) and 50 to 40 Ma (Mid-Eocene), with the noticeable absence of Cretaceous grains. In the NW basin, detrital zircons are 120 to 40 Ma (late Early Cretaceous to Lutetian, Eocene). 587 detrital zircon grains from fine to medium grained Oligocene sandstones collected over the whole area also range from 120 to 40 Ma (late Early Cretaceous to Eocene, Lutetian). 1611 detrital zircons from early Miocene sandstones show again distinctly different ages in the eastern and western parts of the basin. They range from 120 to 40 Ma (late Early Cretaceous to Eocene) in the eastern and from 80 to 40 Ma (Late Cretaceous to Eocene) in the western basin.
Hf isotopes analyses were performed on 120 zircon grains from 6 samples. Negative values (-2 to -15) in Middle Jurassic and late Early Cretaceous zircons indicate minor or no influence of mantle reservoirs which implies a rifting setting during crystallization of the zircons. Low negative to positive (-5 to +10) values in Late Cretaceous and Eocene zircons indicate mixed crustal and juvenile magma sources, which are common in continental arc environments.
Point counts of 32 sandstone thin sections were performed following the Gazzi-Dikinson method. 300-400 points were counted in each thin section. The sandstones are feldspathic litharenites and litharenites. Feldspar is dominantly plagioclase (> 90%) with minor amounts of K-feldspar. Most of the quartz grains (75%) are mono-crystalline but poly-crystalline ones (maximum 25%) also occur. Rock fragments are represented by sedimentary, volcanic and metamorphic grains. Volcanic rock-fragments mostly are andesites and volcanic chert. Sedimentary lithic grains comprise mostly sandstone, siltstone, limestone and dolomite. Metamorphic lithic grains generally are low-grade schists and phyllites. In various compositional ternary diagrams, the sources of the sandstones plot in the transitional to dissected arc and recycled orogenic fields.
We selected 26 samples for heavy mineral study. 200-300 grain were identified and counted in each sample. Heavy mineral suites show a highly variable composition including (1) a group of ultra-stable minerals (zircon, monazite, tourmaline, rutile, brookite, anatase and sphene) derived from a granitic continental crust sources, (2) metastable minerals delivered from variable metamorphic-grade source rocks (epidote group, garnet, staurolite, chloritoid, kyanite, andalusite, glaucophane), (3) chromian spinel from ultrabasic rocks, (4) common hornblende either supplied from metamorphic or basic igneous series, and (5) a local pyroxene-rich source in the pyroclastic sandstone formation overlying pillow lavas. Glaucophane (5-20%) occurs in several samples, which indicates high-pressure/low-temperature metamorphic rocks in the detrital source areas for Eocene and Miocene sandstones. Earlier work in the Pakistani Makran suggested that pre-Miocene sediments were supplied from the Himalaya, whereas Miocene to Recent deposits were reworked older sediments of the accretionary wedge. Our data do not support this conclusion. Instead, we identified rifting-related detrital sources from Middle Jurassic to late Early Cretaceous (175 - 100 Ma) and the establishment of a continental volcanic arc from Late Cretaceous to Eocene (80 to 40 Ma). In addition, paleocurrent directions in Makran sandstone show general sediment transport from North to South; Cr-spinel as well as high-P/low-T heavy minerals most likely have been derived from the blueschist-bearing Makran ophiolitic and igneous belt to the North.