Seismic and Hydroacoustic Studies of Surficial Sediment Tectonics along the northern Red Sea Rift and the Dead Sea Transform Fault

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Abstract

This work presents multichannel seismic and hydroacoustic data of four survey areas along the Red Sea Rift and the Dead Sea Transform Fault. Sedimentary Basins that developed due to the rifting of the Red Sea and the strike-slip displacement of the Dead Sea Transform Fault were investigated and models for their evolution were derived.

The Red Sea Rift and the Dead Sea Transform Fault are the main tectonic features in the Middle East. The rifting process of the Red Sea that initiated in the late Oligocene and early Miocene separated the African Plate from the Arabian Plate. In the Middle Miocene, the extension was compensated in the northern part of the Red Sea with the initiation of the left lateral Dead Sea Transform Fault. Along the Red Sea, different stages of evolution can be observed. Whereas the southern part comprises already seafloor spreading, the northern part is assumed to be in the late stage of continental rifting. Because of huge evaporitic sediment layers within the entire Red Sea, direct basement observations are sparse. Surficial features like ocean deeps along the axis of the Red Sea are interpreted as first seafloor spreading cells in the transition process between seafloor spreading and continental rifting.
Along the Dead Sea Transform Fault, 105 km of left lateral displacement are observed within the last 20 Ma. The displacement is most likely not continuous since its onset. The Dead Sea Transform Fault may have experienced a break in its history before 5 Ma. This event could be resolved within the sediments of the Gulf of Aqaba, the southern extension of the Dead Sea Transform Fault.

Three Red Sea Deeps were investigated in the northern Red Sea, the Conrad-, Shaban- and Kebrit Deeps. All Deeps are accompanied with hypersaline brine layers that developed because of hydrothermal circulation. Magnetic anomalies point to

magmatic activity at the Conrad- and Shaban Deeps, whereas the Kebrit Deep shows no magmatic affinity. The development of the Conrad- and Shaban Deeps can be correlated with the emplacement of magmatic intrusions into the evaporate layers. The hot magmatic material lowered the viscosity of the surrounding evaporates locally. These low-viscosity zones reacted faster to the Red Sea extension do that locally limited deeps developed. In contrast, the Kebrit Deep is most likely a collapse structure because of subrosion of evaporates due to hydrothermal circulation. The mapped sedimentary pattern and fault system point to a collapse mechanism.

The Gulf of Aqaba is composed out of several en-echelon distributed sedimentary basins that are interpreted as pull-apart basins. The Elat Deep is located in the northernmost part of the Gulf. It builds the link to the onland part of the Dead Sea Transform Fault. The northern part of the Elat Deep and the transition zone to the Arava Valley (onland) were investigated with a dense grid of multichannel seismic and hydrocaoustic measurements. For the first time, the step over of the Dead Sea Transform Fault was mapped that shows a more smooth trace than previously suggested. Within the sediments a major unconformity supports the theory that the displacement along the Dead Sea Transform Fault experienced a break and was reactivated about 5 Ma ago. The sedimentary pattern and the fault system in the northern Gulf do not agree with the interpretation of the Elat Deep as a classical pull-apart basin. The new data point to a decoupling of the sediments from the basement, most likely because of a salt layer. This approach explains the Elat Deep and the onland Arava Valley as conjugate basins that developed because of a crystalline pull-apart basin below the transition zone between the Elat Deep and Arava Valley.