

Three-dimensional P-Wave Velocity Structure in the Northern Red Sea Area, Deduced from Local Earthquake Data Inversion

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The northern Red Sea area including the Gulf of Suez and the Gulf of Aqaba plays an important role in the great east African rift system, and exhibits a very high seismic activity. The Hurghada seismic network has been installed in the northern Red Sea area and on both sides of the southern Gulf of Suez since August 1994 to investigate the seismicity and tectonics around the triple junction of the African plate, the Arabian plate, and Sinai subplate. The three-dimensional velocity structure in the northern Red Sea area was estimated by using the arrival time data from local earthquakes.

We estimated the one-dimensional P-wave velocity structure and station corrections by using 1538 P-arrivals from 216 well-located earthquakes recorded by the Hurghada seismic network from August 1994 to January 1999. Earthquakes used in the present study were located in depths less than 28 km so that the upper 20 km of the 1-D velocity model was well constrained. The resulting P-velocity model indicated velocities from 5.0 to 6.0 km/sec down to a depth of 10 km, and velocities from 6.0 to 6.8 km/sec with a nearly constant gradient in a depth range from 10 to 20 km. This 1-D velocity model reduced the RMS residual by 47% from 0.21 to 0.11 sec and improved routine earthquake locations, which clearly indicated clusters of hypocenters in the southern tip of the Sinai Peninsula and the entrance of the Gulf of Suez. The resulting station corrections suggested irregular surface geology in the area. Negative and positive station corrections were obtained; the minimum value (-0.35) was observed at the station MAZR, while the maximum value (0.24) at SHRM.

We obtained the three-dimensional (3-D) P-wave velocity structure, based on the seismic tomographic by inversion of local earthquake arrival time data. We used 2431 P-wave arrival times from 350 earthquakes. The present results showed a clear evidence for the laterally inhomogeneous crustal velocity structure in the Sinai triple-junction area and a significant variation of the velocity structure on the southern side of 27.5N, where the Red Sea trough axis ends. The inhomogeneity of the velocity structure corresponds to; (1) the high geothermal activity in the northern part of the Red Sea; (2) the presence of evaporated layers along the Gulf of Suez; (3) the presence of many local faults with different trends; (4) different regional tectonic settings in the area. Concerning the top layer, there is a high velocity (6.3 km/s) zone with a thickness of about 8 km directly beneath Shadwan Island, which extends northwest about 22 km. There also exists a low velocity zone with a thickness of 13 km around the southern tip of Sinai Peninsula extending in the south direction. We could find that the variation of the velocity structure was closely associated with a high seismic activity in the study area.