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Crustal Structure of the Middle East from Regional Seismic Studies

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We present results of crustal studies obtained with seismic data from the Northern Iraq Seismic Network (NISN). NISN has operated ten broadband stations in north-eastern Iraq since late 2005. This network was supplemented by the five-element broadband Iraq Seismic Array (KSIRS) in 2007. More recently, the former Iraq Seismic Network (ISN), destroyed during the war with Iran, was reestablished with the deployment of six broadband stations throughout Iraq. The aim of the present study is to derive models of the local and regional crustal structure of the Middle East, including Eastern Turkey, Iraq and Iran. To achieve this goal, we derive crustal velocity models using receiver function, surface wave and body wave analyses. These refined velocity models will eventually be used to obtain accurate hypocenter locations and event focal mechanisms. Our analysis of preliminary hypocenter locations produced a clearer picture of the seismicity associated with the tectonics of the region. The largest seismicity rate is confined to the active northern section of the Zagros thrust zone, while it decreases towards the southern end, before the intensity increases in the Bandar Abbas region again. Additionally, the rift zones in the Red Sea and the Gulf of Aden are clearly demarked by high seismicity rates. Surface wave velocity analysis resulted in a clear demarcation of the tectonic features in the region. The Arabian shield, Zagros thrust zone and the Red Sea are apparent through distinct velocity distributions separating them from each other. Furthermore, the shear wave velocity of the crust in North Iraq appears to be 10% higher than that of the Iranian plateau. The velocity anomaly of the Zagros mountains appears to be present into the upper mantle beyond the resolving limit of our model. Analysis of waveform data for obstructed pathways indicates clear propagation paths from the west or south-west across the Arabian shield as well as from the north and east into NISN. Phases including Pn, Pg, Sn, Lg, as well as LR are clearly observed on these seismograms. In contrast, blockage or attenuation of Pg and Sg-wave energy is observed for propagation paths across the Zagros-Makran zone from the south, while Pn and Sn phases are not affected. These findings are in support of earlier tectonic models that suggested the existence of multiple parallel listric faults splitting off the main Zagros fault zone in westerly direction. These faults appear to attenuate the crustal phases while the refracted phases, propagating across the mantle lid, remain unaffected. Azimuthal phase count and velocity analyses of body waves support the findings of blockage by the Zagros-Makran zone as well as higher shear wave velocities for the crust in Northern Iraq. In combination with receiver function and refraction studies, our first structural model of the crust beneath north-eastern Iraq indicates crustal depth of 40-45 km for the foothills, which increases to 45-50 km below the core of the Zagros-Bitlis zone.