SEISMICITY AND CRUSTAL STRUCTURE OF THE ZAGROS FOLD-AND-THRUST-BELT

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A long-standing debate about the nature of continental deformation, seismicity, and seismic hazard in the Zagros Fold-and-Thrust Belt revolves around the question of whether the frequent earthquakes occur solely in the thick sedimentary package or extend into the crystalline basement. If seismicity is limited to the ~10+ km thick sedimentary package and does not involve the basement, large-magnitude events are unlikely and shortening of the basement is accommodated by aseismic means. A possible detachment layer in this scenario is the Hormuz salt. If seismicity extends into the basement, large magnitude events are possible and some of the continental shortening is accommodated in the basement. Either case has implications for the fundamental behaviour of continental deformation during collision (e.g. Sherkati and Letouzey, 2004; McQuarrie, 2004; Oveisi et al., 2009; Nissen et al., 2011). The difficulty in answering this question arises from uncertainties in determining the depth of earthquakes and of interfaces within the crust. Even in situations with ideal seismic station coverage, depth determination in both cases is subject to a strong trade-off with velocity structure; uncertainty in the crustal velocity structure leads to large uncertainties in the depth of located seismicity and of imaged crustal seismic velocity contrasts.

We attempted to minimize the depth uncertainty by simultaneous analysis of hypocentre depths and intracrustal interfaces from receiver functions. Receiver functions used teleseismic P-to-S conversions arising at velocity contrasts under a seismic station. The depth of the converting interface is mapped by the difference in travel time from the converting interface to the station of the direct P wave compared to the converted S wave. This S-P delay time can be directly compared to delay times between local event S and P picks to determine whether those events occurred above or below a converting crustal interface. The approach requires selection of events with ray paths to the station that are of comparable steepness to those of teleseismic rays. Our starting point is thus an accurate epicentre determination. We use a technique for multiple event relocation that has been developed especially for the determination of calibrated locations, i.e. locations that are minimally biased by unknown Earth structure. This method has been used in a number of studies in Iran (e.g., Ghods et al., 2012; Aziz Zanjani et al., 2013; Walker et al., 2013). We use arrival time data from the permanent Iranian seismograph networks, the national network of strong-motion instruments, and from temporary networks, as well as readings from seismograph stations at regional and teleseismic distances. For receiver functions, we analyse data from permanent and temporary three-component short period and broadband stations. While this combined approach alleviates the problem of accurate depth determination, the determination of whether seismicity is limited to above the basement or not still requires accurate identification of converters seen in the receiver functions with interfaces within the crust. Possible converters, aside from a basement-sediment interface, are interfaces within the sediment as well as a proposed thick evaporite layer (Hormuz salt) near the bottom of the sedimentary package. This and shallower evaporite layers may act as décollement surfaces along which crustal shortening is decoupled between layers.

The sediment-only shortening model (McQuarrie, 2004) invokes a Hormuz salt layer thickened to several km. Numerical modelling shows that such a layer should result in a clear contrast in receiver functions. Detection of a thick Hormuz salt layer, or the absence thereof, therefore aids in making the distinction between basement-involved shortening and other models. The folds lead to significant azimuthal dependence of radial and transverse component receiver functions. We use both components when identifying crustal interfaces (Schulte-Pelkum and Mahan, 2014). Reverberations from shallower interfaces must be separated from possibly time-coincident conversions from deeper interfaces and we use a stripping technique (Yeck et al., 2013) to make this distinction. We present relocated event clusters including the Qir aftershock sequence and clusters near the northern and central Zagros French temporary networks with corresponding S and P picks and receiver functions. A prominent negative amplitude conversion that may represent the top of a thick Hormuz salt layer is seen at many Zagros stations. Preliminary comparisons to regional S-P picks suggest that most of the seismicity occurs above this interface.

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