A New Seismic Model for Kachchh Rift Basin, Gujarat and Its Implications for Crustal Dynamics

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Occurrences of several infrequent earthquakes due to existence of hidden and unmapped faults on the surface have become one of the key issues for geo-scientific research, which need to be addressed for evolving plausible earthquake hazard mitigation model for a region. Several pieces of studies on the 26th January 2001 Bhuj earthquake (Mw 7.6) revealed that the mainshock was triggered on the hidden unmapped fault in the western part of Indian stable continental region that caused a huge loss in the entire Kuchchh rift basin (KRB) of Gujarat, India. In order to get deep insight into the crustal dynamics of the KRB we have assimilated new 3-D seismic velocity (Vp, Vs) and Poisson' ratio (σ) models using a new dataset consisting of 576-local earthquakes recorded between November 2006 and April 2009 by a seismic network consisting of 18numbers of three-component broadband digital seismograph stations of Institute of Seismological Research (ISR), Gandhinagar, Gujarat, India. In this study a total of 5143 arrival times of P-wave (2575) and S-wave (2568) recorded by at least 4-seismograph stations for individual events were inverted to assimilate 3-D seismic models for achieving reliable interpretation of the imaged structural heterogeneities and their bearing on crustal dynamics of the region. Our new models showed that the 2001 Bhuj mainshock hypocenter is located in a distinctive zone characterized by high-Vp, low-Vs and high- σ ratio in the depth range of 20-30 km and extending 20 to 40 km laterally, which vindicates the findings of the earlier studies made by previous researchers using old data set. The high Vp and low Vs may be due to a fluid-filled, fractured rock matrix, which might have contributed to the initiation of the 2001 Bhuj earthquake. The high Vp body may be due to dehydration of hydroxyl bearing rocks of the crustal and sub-crustal layers, presence of olivine rich mafic magma and mafic intrusive with structural uplifts. The mafic intrusive may be related to the Deccan trap activity at 65 ma or the older activity related to the geological settings of the KRB. We also infer that use of detailed 3-D seismic tomography may offer potential information on hidden and unmapped faults beneath the plate interior to unravel what and how the genesis of such big damaging earthquakes caused. This study may help in evolving a comprehensive earthquake risk mitigation model for regions of analogous geo-tectonic settings, elsewhere in the world.

Keyword: Kuchh Rift Basin; Crustal dynamics; New Seismic model; New Data set; Fluid filled rock matrix; Earthquakes; Dehydration