Improved earthquake locations in a reservoir-triggered seismic zone: insights from the Koyna borehole seismic network

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The Koyna-Warna region, located in the Deccan Volcanic Province on the west coast of India, is the world's most prominent example of reservoir-triggered seismicity. The region experienced its largest earthquake, magnitude 6.3, on 10 December 1967, and seismicity continues to occur to this day. The Council of Scientific and Industrial Research-National Geophysical Research Institute, Hyderabad, has established a first-of-its-kind deep-borehole seismic network in the region to precisely monitor and locate earthquakes. In the present study, we analyse data recorded from surface broadband and borehole networks for the period 2015–2024, which indicate a substantial improvement in earthquake detection, achieving epicentral errors of the order of ~200 m and a magnitude completeness (M_c) of 0.1 for microearthquakes. Further, these earthquake arrival times are utilised for local earthquake tomography, which reveals prominent velocity variations in *P*-wave velocity (V_P) structure up to seismogenic depths, indicating subsurface signatures of the Donachiwada fault.

Keywords: Borehole, earthquake, fault, Koyna, reservoir, reservoir-triggered seismicity.

The Koyna-Warna seismic region is situated in the vicinity of the Western Ghats escarpment within the Deccan Volcanic Province, which is about 65 Ma old. The entire region is covered by a thick pile of Deccan basalts, which overlies the basement. These basaltic rocks cause attenuation of seismic wave arrivals at recording stations; hence, errors in earthquake location estimates using surface seismic records have been significant. To overcome this problem, a unique deep-borehole seismic network is established, with boreholes penetrating through the Deccan Traps and reaching the basement (Figure 1). Under an exploratory study, eight deep boreholes are drilled, providing good azimuthal coverage of the seismic zone and reaching maximum depths of 1522.5 m on the Deccan Plateau in the east and 981 m on the Konkan Plains in the west. These boreholes penetrated the Deccan Traps, which have an average thickness of 1100 m in the east and 500 m in the west, and sampled the granitic basement in the region for the first time. The primary objective of this network is to reduce noise from the overlying basalt flows and to record high-quality seismograms, thereby improving the detection and location accuracy of earthquakes[5]. In the present study, we report a distinct improvement in the detection and location of earthquakes that occurred during 2015–2024. Furthermore, the improved arrival-time data enabled delineation of the subsurface velocity structure of the Donachiwada Fault (DF) zone in the Koyna region, which is the main causative