

Scientific drilling in Koyna region, Maharashtra

Spudding of the first 3000 m deep borehole KFD-1 in the Koyna region, on 20 December 2016 marked the beginning of the Pilot Phase of the Koyna Scientific Drilling Project. The scientific drilling and associated investigations are being carried out by the Borehole Geophysics Research Laboratory (BGRL), Ministry of Earth Sciences, New Delhi, to comprehend the genesis of artificial water-reservoir triggered earthquakes in the Koyna intraplate seismic zone. The region has experienced continued seismicity during the past five decades, since the impoundment of the Koyna and the nearby Warna reservoirs. The borehole site was carefully chosen after a detailed preparatory phase of investigations carried out by the CSIR-National Geophysical Research Institute, Hyderabad. KFD-1 is located within the active seismic cluster in Gothane village near Koyna, as brought out from the analysis of seismological data obtained from a dense network of surface broadband stations operating in the Koyna region during the past decade and a set of borehole seismometers installed within the granitic basement up to 1522 m depth in the vicinity of the seismogenic zone. The site is located in close proximity of the seismically active Donichawadi fissure zone, the surface manifestation of the 1967 *M* 6.3 Koyna earthquake. The borehole design was optimized on the basis of subsurface geology and structure obtained from drilling and borehole measurements up to 1522 m depth at nine sites

and land as well as airborne geophysical studies covering the seismogenic zone.

The pilot phase is a fore-runner to the main phase in which it is proposed to establish a deep fault zone observatory at depth of ~5 km depth. The borehole KFD-1 has reached a depth of 2900 m passing through the entire thickness of Deccan basalt (~1247 m) and ~1653 m in the underlying granitic basement. After completion, it will be utilized to make measurements of physico-mechanical properties, temperature and stress regime up to a depth of 3000 m for the first time in the region. These data are critical to the design of the fault zone observatory. Periodic measurements over the next few years may shed new light on potential temporal changes in rock properties, stress regime and hydrological properties due to ongoing seismic activity in the region. Besides *in situ* measurements, laboratory studies of cuttings throughout the borehole column and cores from select depths between 1500 and 3000 m depth will bring out a wealth of geological information regarding deformation of rocks within an active seismogenic zone. Core samples will be tested under varying confining pressure, temperature and pore pressure conditions to study rock strength, as well as nucleation and propagation phases of fault in host rocks. Additionally, frictional parameters will be measured under varying rate and state conditions to constrain fault dynamics. Deep drilling through Deccan basalts into the continental bedrock provides

unprecedented opportunity to examine the microbial life and the processes that they may catalyse deep underground. This interdisciplinary research aims to unravel subsurface microbial diversity and aids the global quest to know limits of life, mechanisms of microbial interaction with inorganic environment and their adaptation. A companion borehole, planned to be drilled adjacent to KFD-1, will house a permanently installed seismometer–piezometer array that will complement the existing network of about 20 broadband seismometers and 6 borehole seismometers in the region. The improvement in hypocentre locations from such a network will help delineate the active fault zone(s) and guide the trajectory of the main borehole for establishment of a fault zone observatory.

One of the foremost challenges was to mobilize the large drill rig and associated equipment to the remote site in a hilly terrain immediately after the monsoon season last year. A temporary drill-site camp houses about 70 drilling crew, support staff, engineers from various service providers, besides BGRL scientific and technical staff. Utmost attention is given to ensure the safety of man and machine in executing the project. The complete suite of drilling operations, including drilling, mud logging, mud services, casing and cementation, coring, geological sampling, downhole geophysical logging and on-site laboratory studies are being carried out round the clock under BGRL supervision. Successful completion of the project will lead to indigenous capacity building both in terms of trained manpower and infrastructure to address challenging and societally relevant geosciences problems through scientific drilling investigations in other parts of the country.

ACKNOWLEDGEMENT. Publication of this note is authorized by the Secretary, Ministry of Earth Sciences, New Delhi.



KFD-1 drill site.

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