Swami Ramanand Teerth Marathwada University

Center of Excellence in Seismological Studies (CESS)

at

School of Earth Sciences

Center of Excellence in Seismological Studies (CESS)

Initiation

Based on the scientific and societal contributions made by the Seismic Observatory of the School of Earth Sciences under the Coordinator-ship of Dr. T. Vijay Kumar, the RUSA, Govt. of Maharashtra has funded the establishment of **Center of Excellence in Seismological Studies (CESS)** in the SRTM University, Nanded and sanctioned a grant of One Crore Eighty lakhs. The **School of Earth Sciences, Swami Ramanand Teerth Marathwada University**, Nanded has established **Center of Excellence in Seismological Studies (CESS)** in collaboration with **Council of Scientific and Industrial Research – National Geophysical Research Institute (CSIR-NGRI)**, Hyderabad and **Indian Institute of Science Education and Research (IISER)**, Kolkata.

The **Center of Excellence in Seismological Studies (CESS)** is aimed at carrying out regional scale Geoscientific studies in the South Eastern Deccan Volcanic Province and to understand the Crustal and Upper Mantle fabric of the region. The center will be instrumental in carrying out 1) sustained and focused research in the region using a 11 station digital broad band seismic network (120 x 160 km) and 2) for a period of 3 years over a fixed region surrounding the Latur intraplate earthquake source region spanning an area of ~19000 Km^2 with a station spacing of 60-80 Km. The orientation of the grid is tentative and will change depending on the results of the gravity and magnetic surveys of the region to delineate faults in the region. The stations after a period of 3 years will be shifted to other parts of Deccan Trap region based on the need and importance of the region. The data obtained from this network will be used to carry out the following studies.

The geoscientific investigations will be pursued by SRTM University in collaboration with NGRI, Hyderabad and IISER Kolkata, especially focusing on seismological studies which would help in understanding the evolution of Deccan Volcanic Province (DVP) including 1) possible thermal anomaly beneath the DVP, 2) sub-surface basement topography beneath the exposed traps, 3) infrastructure of Precambrian basement and possible sub-surface sedimentary basins with possible hydrocarbon resources, 4) lithospheric thickness, 5) delineating faults and lineaments and 6) seismicity of the region. These deeper level investigations will be useful in understanding the magmatic processes and assessing the seismo-tectonic scenario of the area.

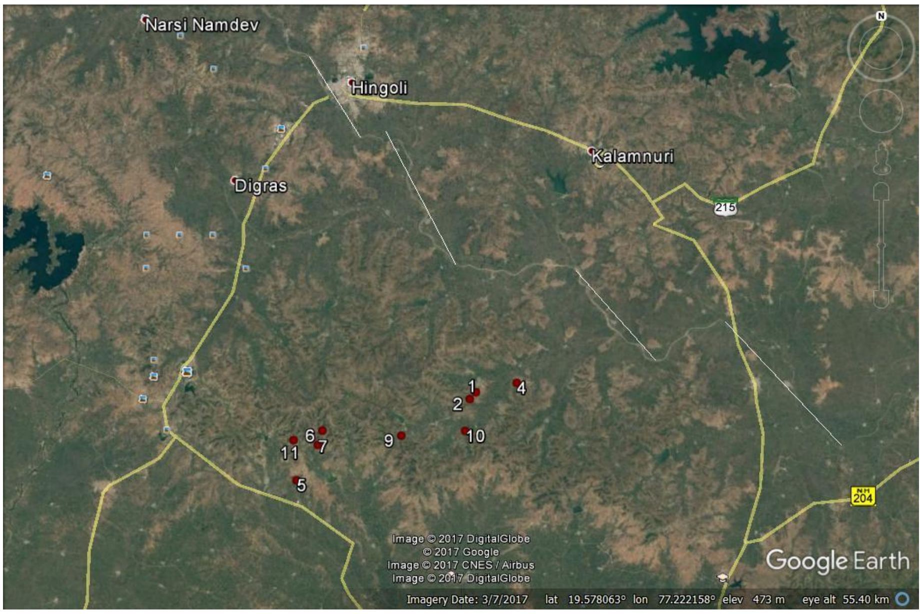

Image depicting the river flow and white lines represent linear flows with abnormal turns, red dots represents the recent seismic activity (Hingoli district) of 2017 located using single station unpublished.

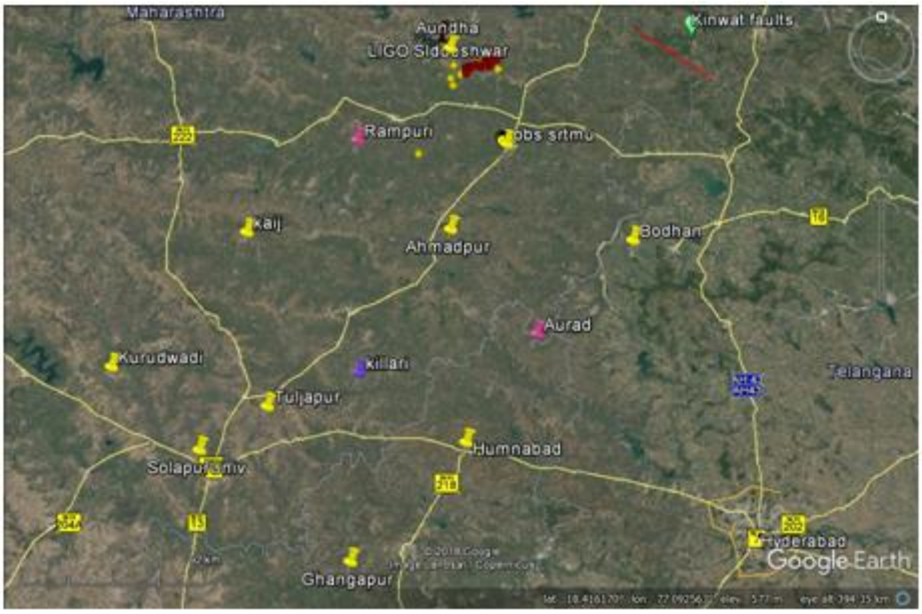

Image displaying 11 station grid around the intraplate earthquake source region Latur

Research Priorities of the CESS

Deccan Volcanic Province (DVP) is one of the largest Igneous Province in the World spreading over an area of 500 000 km^2 and possibly thought of originally to be even greater area of 1.5 x 10^6 km^2 (Krishnan 1960, Raja Rao et al 1978) as many outliers are observer far away from the main body of flows. The DVP is thought to be rested on Archean basement. The present Deccan flows probably represents now an eroded remnant of once molten lavas (Klootwijk 1979). The Deccan Basalts are seen up to a thickness of more than 2 km near the Western Ghats. Its maximum exposed vertical thickness is about 1700 m near Igatpuri (Mahoney 1984, Beane et al 1986). At Mahabaleshwar nearly 200 km farther south of Bombay about 1200 m of flows are exposed (Deshmukh et al 1977, Najafi et al 1981). In Cambay further North drill-holes have encountered large bodies of buried Deccan traps over 1000 m in some places lying beneath 4-6 km of later sediments (West 1958, Raju et al 1972, Ramanathan 1981). The Deccan Trap thickness is thinnest toward the East of around 196 m in Nanded and further East, Archean Granites are exposed Near Kinwat region of Maharashtra. To generate such huge amounts of basaltic melt generally a huge thermal anomaly is required and mantle plume models are invoked (White and McKenzie 1989, Campbell and Griffiths 1990, Duncan and Richards 1991). There are two possible theories regarding how a plume interacts with the Continental Lithosphere, one is the active mantle hypothesis of Morgan (1971, 1981) wherein it is considered that Mantle plumes drive plates and initiates continental breakup by doming and cracking the continents and pushing the continents apart. The other is a passive model where plume does not result in breaking up continent except for the fact that it results in rapid out-pouring huge amounts of flood basaltic magma. It is speculated that the Reunion Hot spot was the source of thermal energy in generating huge volumes of flood basalts when Indian plate passed over it during Cretaceous-Tertiary times (Morgan, 1981; Richards et al., 1989; Campbell & Griffiths, 1990). The mantle plume model however is challenged by (Sheth 1999, Sheth et al 2003) describing that the Continental Flood basalts have formed due to rifting based on geochemistry and geochronology and Petrology and does not necessarily need a plume model to support the generation of Deccan Basalts. The geomorphology of the Western India shows that it is elevated and all the river system of peninsular India flows from west to east following the natural slope of the region; however, on close observations from some of our own studies published and unpublished (Srinagesh et al, 2012, Kaplay et al, 2017a, Kaplay et al 2017b) we have found that rivers follow linear trends and also show abnormal turns indicating that they are also controlled by subsurface structures. Due to the Deccan basalt flow the subsurface structure of Archean rocks are covered and needs to be studied to understand the seismicity of the region experienced in Latur, Nanded, Kinwat and Hingoli. The focus is therefore to understand the deep velocity structure of Intraplate earthquake source region.

Extensive geophysical studies have been carried out in understanding the subsurface structure and stress concentration mechanism in Intraplate earthquake regions like New Madrid Seismic zone (Johnston 1996, Johnston and Schweig 1996), Swabian Jura, Southwest Germany (Turnovsky and Schneider 1982), Ghana (Talwani and Rajendran, 1991), Australia (Langston, 1987; Bowman, 1991,1992), Miramichi-Canada (Hasegawa, 1991; Talwani and Rajendran, 1991). The New Madrid Seismic zone (NMSZ) and the Australian cratons are exhaustively studied using the Tomography and Receiver function technique. The NMSZ is associated with a local NE-SW trending low velocity anomaly in the lower crust and the upper mantle. The Lithospheric weak zone has been identified as transferring stress to the upper crust leading to repeated shallow earthquakes (Qie Zhang et. al. 2009). The receiver function analysis has revealed a variation in crustal thickness from 25 Km to 43 Km (Moidaki et al 2010). Initial velocity model have suggested a fault of 30 Km length in the region (Zoback et al 1980) and an anomalously mafic lower crust. In most of the intraplate scenario it is identified that the localized stress concentrations occur at old rifts, intersection of faults or in the periphery of plutons (Gangopadhyay and Talwani 2003).

In India intraplate earthquakes are observed in Kutch, Gujarat in 1819 –7.8 Mw (Johnston et. al. 1994), Bhuj 2001 –Mw 7.5 (Kayal et. al 2002), Narmada Son region 1938 –6.3 Mb (Rajendran and Rajendran 1998), Jabalpur 1997 –6.0 Mb (Kayal 2000), Latur 1993 –6.3 Mw (Rajendran et. al. 1996, Kayal et. al. 1996, Kayal and Mukhopadhyay 2002). In Narmada Son region it has been established that the hypocenter of the earthquake was deep (Singh et. al. 1999) and had a stress drop of 300 bars (Singh et. al. 2003). The seismic structure through deep seismic sounding revealed that the crust is ~40 Km (Kaila et. al. 1987). The receiver function analysis by Rai et al. 2005 has revealed that the crust is thickened to 56 Km with a mafic lower crust beneath the Narmada Son Lineament to gravitationally induce stress in the lower crust. In a previous study using MT soundings in the Latur region the trap thickness has been inferred around 300-400 m (Sharma et. al. 1994). They also found an anomalously shallow upper crustal conductor in the hypocentral zone intruded in otherwise resistive upper crust at a depth of 6-10 Km (Sharma et. al. 1994). The conductor is oriented in WNW-ESE direction. The foreshock and aftershock studies (Baumbach et. al. 1994) have proposed a fault plane mechanism as thrust fault for the main shock of the region. Which implies the region is under compressional regime. The subsequent studies by Kayal and Mukhopadhyay (2002) have revealed the fact that the earthquake has occurred in the vicinity of the contact of high velocity and low velocity zone around the depth of 6 Km. A point measurement of the crustal shear wave velocity structure by Rai et. al. (2003) revealed that the crust is 37±2 Km near the main shock region. In addition to these studies if we get an insight into the lower crustal structure and character and the upper mantle structure and character it would help us in understanding the seismotectonics of the region.

It is therefore necessary to conduct geoscientific surveys in a focused manner in regional scale to understand the Crustal and deeper Upper Mantle 3D velocity structure to understand the evolution of the Deccan Traps and to look at how the thermal anomaly has modified the deeper Lithospheric structure and derive the seismo-tectonic character of the region.

Significance of the CESS

This geoscientific work would be an initiative in preparing a disaster plan for the South Eastern Deccan Province and would help in up-scaling and preparing a detailed structure for other parts of Maharashtra state. The Seismic network of this scale is needed to understand the Deep Earth structure in the Deccan Volcanic Province crucial for many geoscientific studies including finding sedimentary layers beneath traps. Hitherto, these kind of studies were not been carried out so far in this part of India.

Aims, background and vision of the CESS

- The aim of this center is be a nodal Center for seismological studies in Deccan Traps to understand the evolutionary aspects of it.
- Understanding the structure of intraplate earthquake source region
- Mapping the Lithospheric thickness of the region.
- Gravity and magnetic prospecting for fault delineation.
- 3D Velocity structure from Receiver Function, Teleseismic Tomography and Noise Tomography.
- Determination of Source parameter of local earthquakes in the region.
- Mapping the local seismicity of the region

Expected Outcomes from the CESS

- 3D Modelling of Velocity structure near intraplate earthquake source region
- Upper Mantle Anisotropy
- Noise tomography using the array of proposed stations
- Attenuation Tomography using local Coda Q
- Locating hypocenters and mapping Seismicity
- Fault delineation from gravity and magnetic surveys and fault characterisation (geometry and slip) based on waveform inversion
- The project will also provide training and manpower development in operating, handling and managing the broadband seismological stations and seismological data analysis.
- Outreach activities to raise awareness about earthquakes and seismic hazard

Advancement of Science and Innovation through the CESS

The present geophysical work would enable us to understand the effect of Thermal anomaly on the upper mantle and crust in this region and the lithospheric thickness can be evaluated which would form the basis for other geoscientific studies in the region and further enhance our understanding regarding the mechanism of intraplate earthquakes.

Detailed deep Earth structure beneath traps a region of non rift related intraplate setting is not known today and need to be evaluated to form a base for further geoscientific studies useful for risk evaluation and also understanding the basic deep earth processes in this region

The **SRTMU Center of Excellence in Seismological Studies (CESS)** is first of its kind in State Universities of Maharashtra catering to varied seismological studies in the region of Deccan basalts. Establishing a closely spaced (40km) network of 20 broadband digital stations in a 4x5 grid to study the Crustal and Upper Mantle structure of ~19000 sq.km in the vicinity of the epicentral region of 1993 intraplate Latur earthquake is itself first of its kind effort in understanding the deeper structure of the region. This data will be utilized in Teleseismic tomography, Receiver function and Surface wave analysis to map the deeper velocity structure. In addition to this the network a detailed gravity-magnetic mapping will be carried out in the region with a station spacing of 1-5 km. The velocity structure deduced from the seismological studies will be integrated with Gravity-Magnetic results to obtain a crisp model of the subsurface structure to be correlated with geological model. Seismological studies will provide the basic structure beneath the region and forms a basic knowledge base for further scientific work.

The **CESS** has already initiated new and novel methods of studying signal processing by collaborating with Researchers with Engineering and Computational background. Application of AI and ML in processing the seismic data will be carried out in near future. In this regard, the **CESS** is offering **Post-Doctoral Visiting Fellowship (PDVF)** under the aegis of **Centre for Research Outcome and Promotion (CROP)** policy of the SRTM University.

Key Socio-Economic Objectives of the CESS

- Development of Algorithms for seismological data handling and modeling and generation of seismic hazardous maps.
- Scientific understanding of the Earth processes beneath Traps and identification of Earthquake prone zones for Disaster risk evaluation

Social benefits

The outcome of seismological and gravity magnetic studies will enable us to delineate hidden faults in the region and mapping the seismic activity will enable us to identify the active faults. This will enable us to evaluate the risk due to earthquakes in the region and would provide a base to prepare disaster management plan for the state.

Disaster Management plan can be prepared on the basis of the outcomes of this Geophysical studies for the entire South Eastern Deccan Volcanic region, what is beneath traps can be found in a regional scale.

Benefits to State/National Economy

The outcome will enable us to understand the tectonics of a non-rift related intraplate seismicity only of its kind so far in India. Disaster Management plan can be prepared on the basis of the outcomes of this Geophysical studies for the entire South Eastern Deccan Volcanic region, what is beneath traps can be found in a regional scale, could be useful for further determining useful natural resources in future, ground for young researchers and an advanced training facility for faculty and scholars from the region.

Project Management Committee (PMC) for the CESS

<u>Host</u> **School of Earth Sciences** **SRTM University** **Nanded**	**<u>Collaborator 1</u>** **CSIR-NGRI** **Hyderabad**	**<u>Collaborator 2</u>** **IISER** **Kolkata**
Dr. T. Vijay Kumar ***(Seismology)***	**Dr. Sandeep Gupta** ***(Seismology)***	**Prof. Supryio Mitra** ***(Seismology)***
Dr. S.K.G. Krishnamacharyulu ***(Gravity and Magnetic)***		

Advisory Committee Members for the CESS

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