550.347.62 : 551.508.826

STRUCTURAL FRAMEWORK OF THE REGION IN AND AROUND HYDERABAD AS INFERRED FROM SATELLITE IMAGE ANALYSIS : IMPLICATIONS FOR SEISMIC ACTIVITY

It is known that most of the earthquake epicenters over the earth's surface are confined to narrow zones of inter-plate seismic activity. The intra-plate regions such as the Indian peninsular shield, account for only about 1% of global seismicity (Lowrie, 1997). However, in view of the occurrence of major earthquakes *viz*., Koyna (1967), Latur (1993) and more recently, Bhuj (2001) in the shield area, the stability of the Indian peninsular shield is debatable. It has been opined that the shield is tectonically and structurally divisible into a number of faulted fragments, which have been differentially moving relative to each other from Tertiary to Recent times (Ravi Shanker, 1995).

Further, within the seismic/aseismic zones with varying intensities of recorded/expected seismicities, urban areas are more vulnerable to the threat posed by seismic activity as the density of population as well as that of built up structures is far higher as compared to other inhabited areas. As urban concentrations grow around places with locational, strategic, or economic advantage rather than structural soundness, it is useful to examine such regions and identify structurally weak zones for follow up hazard management.

In this context the city of Hyderabad and the region to the north of it (Latitude 17° 20′ to 18° North and Longitude 78° 10′ to 78° 45′ East) was selected for analysis of the correlation between the structural framework of the region (in terms of the location and disposition of tectonic elements such as faults, fractures and lineaments) and the seismicity. The general geology of this area consists of members of the peninsular shield – the Archaean granites and gneisses.

The analysis of lineaments mapped from remote sensing data is a common reconnaissance tool for structural evaluation and follow-up geophysical studies. Geologic/geomorphologic elements associated with lineaments include fault zones, fractures (joint zones), fault axes, linear igneous intrusions, apart from major features such as fronts of mountain ranges, straight

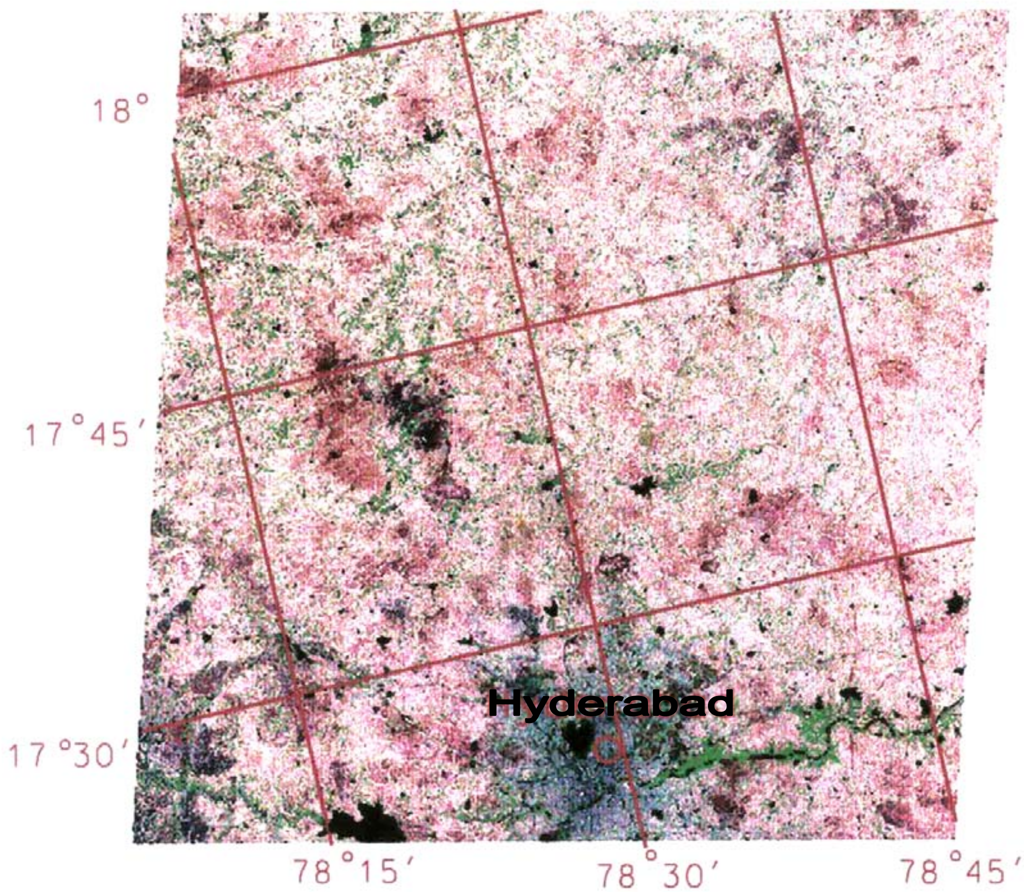

Fig. 1. IRS-ID LISS-III image of parts of Hyderabad and surrounding areas

coastlines or lines of volcanoes. Preliminary regional structural inferences were drawn from analysis of an IRS-ID LISS-III satellite image (Fig. 1) acquired from the National Remote Sensing Agency (NRSA), Hyderabad. Fig. 2 shows the lineament map of the study area inferred from Fig. 1. Broadly, two kinds of linear features – dykes and lineaments - have been delineated. The latter have been numbered 1 through 20 (Fig. 2). Lineaments with observed relative displacement of geologic/ geomorphologic features on either side have been identified as faults. Thus lineaments 2, 9 and 19 represent faults. It is evident that most of the lineaments in the study area are oriented along two major directions – NW-SE and SW-NE.

The seismic zoning map of India is an index of seismic hazard in a given region. It is pertinent to note that taking into consideration observed seismic activity of the 'stable' peninsular shield, various revisions to seismic zonation maps of India have been characterized by a progressive shift towards assigning of greater seismic susceptibilities to the hitherto seismically inactive or minimally active regions. Broadly, the earlier maps classified the country into a total of five seismic zones in increasing order of susceptibility to seismic events. While the seismic zoning maps of India of 1962 and 1970 (Jai Krishna, 1992) indicate the region in and around Hyderabad under zone 0 and zone I respectively (both zones of least likelihood of seismic hazard, with the

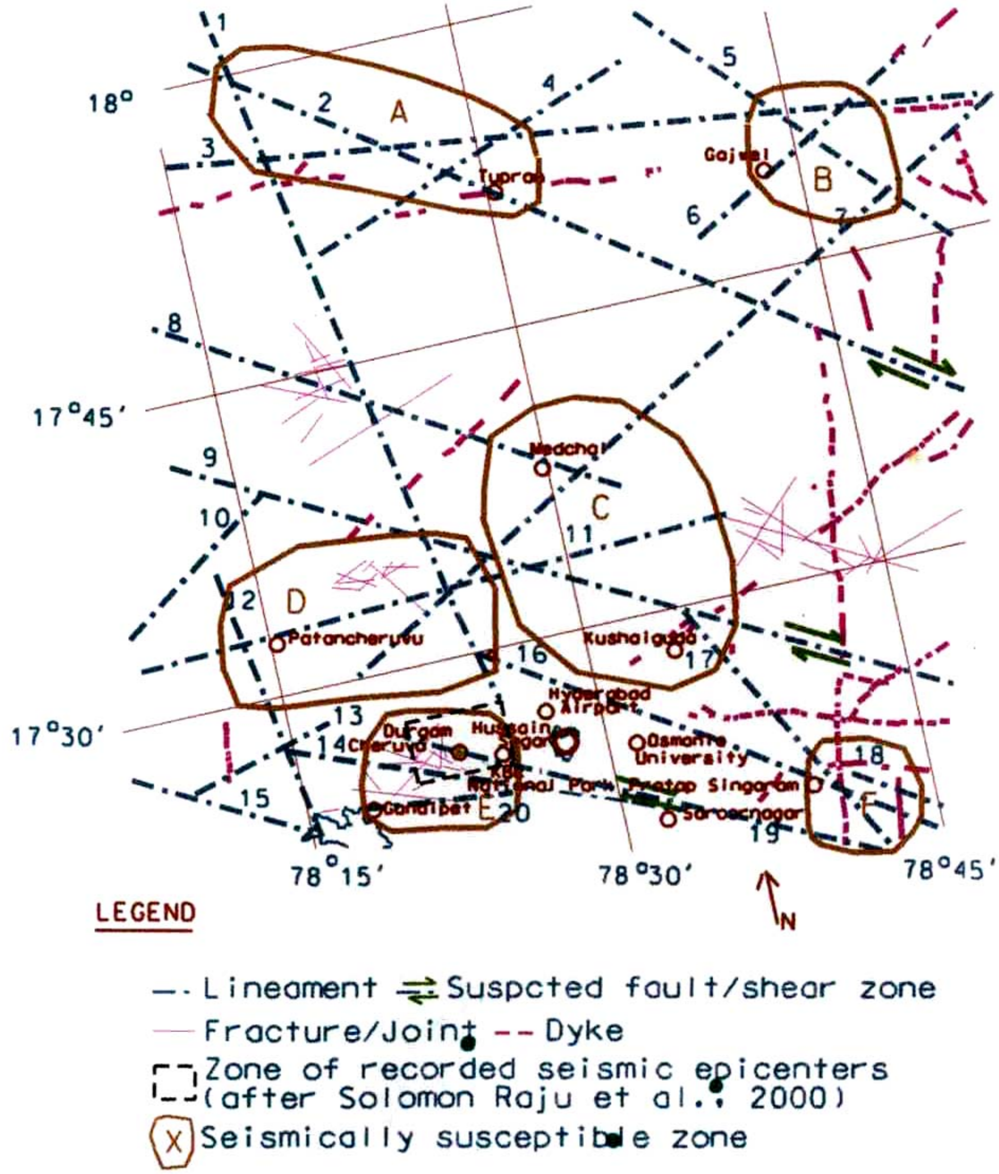

Fig. 2. Lineament map of the area in and around Hyderabad as inferred from IRS-ID LISS-III satellite image

change in order taking into consideration that no zone is absolutely safe from earthquake activity), in the most recent fifth revision of the Bureau of Indian Standards (IS 1893, Part-1:2002), it has been placed in zone II. This change has come about with the merging of the earlier zone I with the zone II. As a result, there are now only four zones – II, III, IV and V - of seismic hazard. These zones correspond to an earthquake shaking of maximum intensity of VI or less for zone II, VII and VIII for zones III and IV respectively, and IX & above for zone V. A change in the order of seismic zone implies a corresponding change in the seismic zone factor that is computed from effective peak ground acceleration based on MCE (maximum considered earthquake) and service life of built structure in each seismic zone. The zone factor for the Hyderabad region is 0.1 (BIS, 2002).

The tectonic significance of many lineaments arises from associated seismic activity. Active faults and intersecting faults form tectonically unstable regions that represent regions of possible seismic displacement. The shield area has recorded micro-seismic events over the past several decades (Ramakrishna Rao, 1989). The basic approach here is to firstly, examine the seismotectonics of the region in and around Hyderabad in terms of the correlation between linear structural elements (lineaments) and recorded earthquake epicenters and secondly, to delineate areas potentially susceptible to seismic activity on the basis of the structural and tectonic configuration of the region.

From Fig. 2 it is evident that available earthquake epicenter information is confined to the region around Durgam Cheruvu. However, from identified faults and intersecting lineaments in the study area six areas prone to seismic activity – A (lineaments 1, 2, 3 and 4), B (lineaments 3, 5, 6 and 7), C (lineaments 7, 8, 9 and 11), D (lineaments 1, 7, 9, 11, 12 and 16), E (lineaments 14, 19 and 20) and F (lineaments 16, 17, 18 and 19) near Tupran, Gajwel, Medchal, Patancheruvu, Gandipet and Pratap Singaram respectively, are identified. Of these, regions C and D are supported by reported evidences of seismicity. In zone C, a seismic event of magnitude 4 was recorded near Medchal in 1983 (Rastogi and Chadha, 1985). Significantly, this region is marked by the intersection of lineaments 8 and 7. In zone D, which has been experiencing micro-tremors occasionally, seismic events of magnitude 3.5 in the Gandipet area in 1982 (Rastogi *et al*., 1986) and of maximum magnitude 2 in 1994 and magnitude 1.7 in 1998 in the Jubilee Hills area, were observed. While Ramakrishna Rao and Solomon Raju (1996) opined that residual stresses generated due to the northward movement of the Indian Plate coupled with skin effects were probably responsible for the observed microseismic activity, Solomon Raju *et al*. (2000) suggested that the WNW-ESE trending shear zone extending from Banjara Lake through Kasu Brahmananda Reddy National Park and going up to Durgam Cheruvu (lineament 19) was causally related to observed seismicity in the region (Fig. 2). Significantly, in 1984, three tremors - the largest 2.2 in magnitude - were felt in Saroornagar, which, as can be seen from Fig. 2, lies along the southeastward extension of the above-mentioned shear.

No supporting seismic evidence is available for regions A, B, E and F have. Nevertheless, from their tectonic situation their susceptibility to seismic activity cannot be ruled out.

It is to be noted that generally the correspondence between lineaments as inferred from satellite imagery studies and faults mapped from geophysical investigations in not very high (O'Leary and Simpson, 1997). Even so, it is interesting to note that most of the recorded earthquake epicenters correspond with one or the other of the major lineaments marked in the region as for example, the epicenter of the Kushaiguda tremor (magnitude 1.6) recorded in 1984 lies very close to lineament 17.

To conclude, it is evident that although not all the blocks of lineaments mapped represent active seismic regions, they nevertheless serve as probabilistic guides to locations of seismic occurrences.

Acknowledgements

The authors are extremely grateful to the DST and CSIR for the financial support extended by them.

References

Bureau of India Standards (BIS), 2002, "Indian Standards : Criteria for Earthquake Resistant Design of Structures", Part – I – General Provisions and Buildings (fifth revision).

Jai Krishna, 1992, "Seismic Zoning Maps of India", *Current Science*, **62**, 1 & 2, 17-23.

Lowrie, William, 1997, "Fundamentals of Geophysics", Cambridge University Press, United Kingdom, 112-113.

O'Leary and Simpson, 1997, "Remote Sensor Applications to Tectonism and Seismicity in the Northern Part of the Mississippi Embayment Geophysics", **42**, 3, 542-548.

Ramakrishna Rao, C. V., 1989, "Seismotectonics of Southern Peninsula of India", Ph.D Thesis, Indian School of Mines, Dhanbad.

Rao, Ramakrishna C. V. and Solomon Raju, P., 1996, "A note on micro-tremor activity in Jubilee Hills area of Hyderabad during 1994 and 1995", *Jour. Geol. Soc. India*, **48**, 467-469.

Rastogi, B. K. and Chadha, R. K., 1985, "Study of Medchal, Andhra Pradesh, earthquake of 30 June 1983 of magnitude 4.0 close to Hyderabad", NGRI Technical Report, p56.

Rastogi, B. K., Ramakrishna Rao, C. V., Chadha, R. K. and Gupta, H. K., 1986, "Micro-earthquakes near Osman sagar reservoir", Hyderabad, India, *Phy. of Earth and Planet. Inte*., **44**, 134-141.

Ravi Shanker, 1995, "Fragmented Indian Shield and Recent Earthquakes", Spl. Pub. No. 27, Geological Survey of India, 41-48.

Solomon Raju, P., Srinivasan, A., Raghavan, R. V. and Kousalya, M., 2000, "Micro-tremor activity in Jubilee Hills area of Hyderabad", Andhra Pradesh., *Jour. Geol. Soc. India*, **55**, 443-446.

D. HIMABINDU
G. RAMADASS

Deptt. of Geophysics, Osmania University, Hyderabad, India
(*30 July 2002, Modified 18 June 2003*)