EARTH TREMORS IN THE COASTAL BELT OF TAMIL NADU AND PONDICHERRY IN SEPTEMBER, 2001 – A GEOLOGICAL ANALYSIS

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The earth tremors experienced in Tamil Nadu and Pondicherry on the 26th September 2001, is discussed on the basis of the evolution of the geological and structural setup in the coastal region, consequent on the separation of Antarctica from India in the geological past. Subsurface data obtained by drilling in the Cauvery basin bear out the definition of a number of NE-SW to NNE-SSW fault bounded ridges and depressions extending from land into the offshore area. The stupendous thickness of sediments in the structures is suggestive of the sagging of the Precambrian crystalline basement and the release of strain in the process is ostensibly manifested as earth tremors. The reported occurrence of volcanic activity off the coast and the occurrence of thermal water in deep boreholes drilled in the coastal region, both falling within the NE-SW to NNE-SSE fault system, suggest that the weak fault planes in the crust provided channel ways for the eruption of magma and dissipation of subsurface heat.

Introduction

Peninsular India, though traditionally considered to be more stable than the Extra-Peninsula, is known to have experienced several earthquakes with a magnitude of more than 5 in historical times (Bansal and Gupta, 1998). In most cases, the causative factor for seismicity has been attributed to reactivation of ancient crustal faults. The epicentre of the earthquake that was experienced in Tamil Nadu and Pondicherry on the 26th September 2001, was reported in the press to be located in the Bay of Bengal, about 50 km off the Pondicherry coast; and the magnitude of the earthquake on the Richter Scale was given as 5.6. The authors felt the tremors in Chennai in two pulses, each lasting for a few seconds and separated by an interval of a few seconds, at around 8.25 p.m. The tremors were sensed as a gentle movement of the seat in a south-north direction.

People gathered on streets and discussed their experiences till late in the night. Though in general people were not panicky, this brought to their mind the havoc caused by the horrendous earthquake that struck Gujarat on the 26th January 2001 and left behind a trail of death, destruction and human misery. Following the Tamil Nadu-Pondicherry earthquake, there were press reports on the development of cracks in walls, caving in of thatched roofs, slumping of mud walls and so on in Chennai and around. There was no report on the generation of giant sea waves, similar to tsunamis in the Bay of Bengal, possibly because of the shallow depth of water in the epicentral region close to the coast.

Geological and Structural Setup

The epicentre of the earthquake falls well within intracratonic terrain, away from the Indian plate boundary and so a link between the earthquake and the plate boundary does not seem to hold good. What is of interest is the analysis of the geological and the structural set up of the coastal tract of Tamil Nadu and Pondicherry and the adjoining continental shelf area. Geological mapping, aerial photo interpretation and subsurface data culled out from drilling carried out in the Cauvery basin during exploration for oil, are relevant to the analysis.

Tamil Nadu is by and large covered by Precambrian crystalline rocks and patches of Gondwana, Late Jurassic, Cretaceous, Tertiary and Quaternary sediments are traced along the east coast, extending from south of Chennai, through Pondicherry to near the southern tip of the Peninsula (Subramanian and Selvan, 2001). To the west of the east coast, a well-defined NE-SW trending fault demarcates the boundary between the basement Precambrian crystalline rocks and the coastal Phanerozoic sediments (Grady, 1971). According to Gopalakrishnan (1996), this fault appears to have been affected by E-W faults, giving rise to sinistral strike-slip movements (Fig.1). Apart from these, a number of faults in NNE-SSW, NE-SW, E-W and N-S directions, covering entire Tamil Nadu and Pondicherry were identified by Vemban et al. (1971). The significance of the east coast faults in the formation of sedimentary basins in the coastal tract and the adjoining offshore area to the east has been amply brought out on the basis of subsurface data provided by deep drilling for oil in the Cauvery basin (ONGC, 1993).

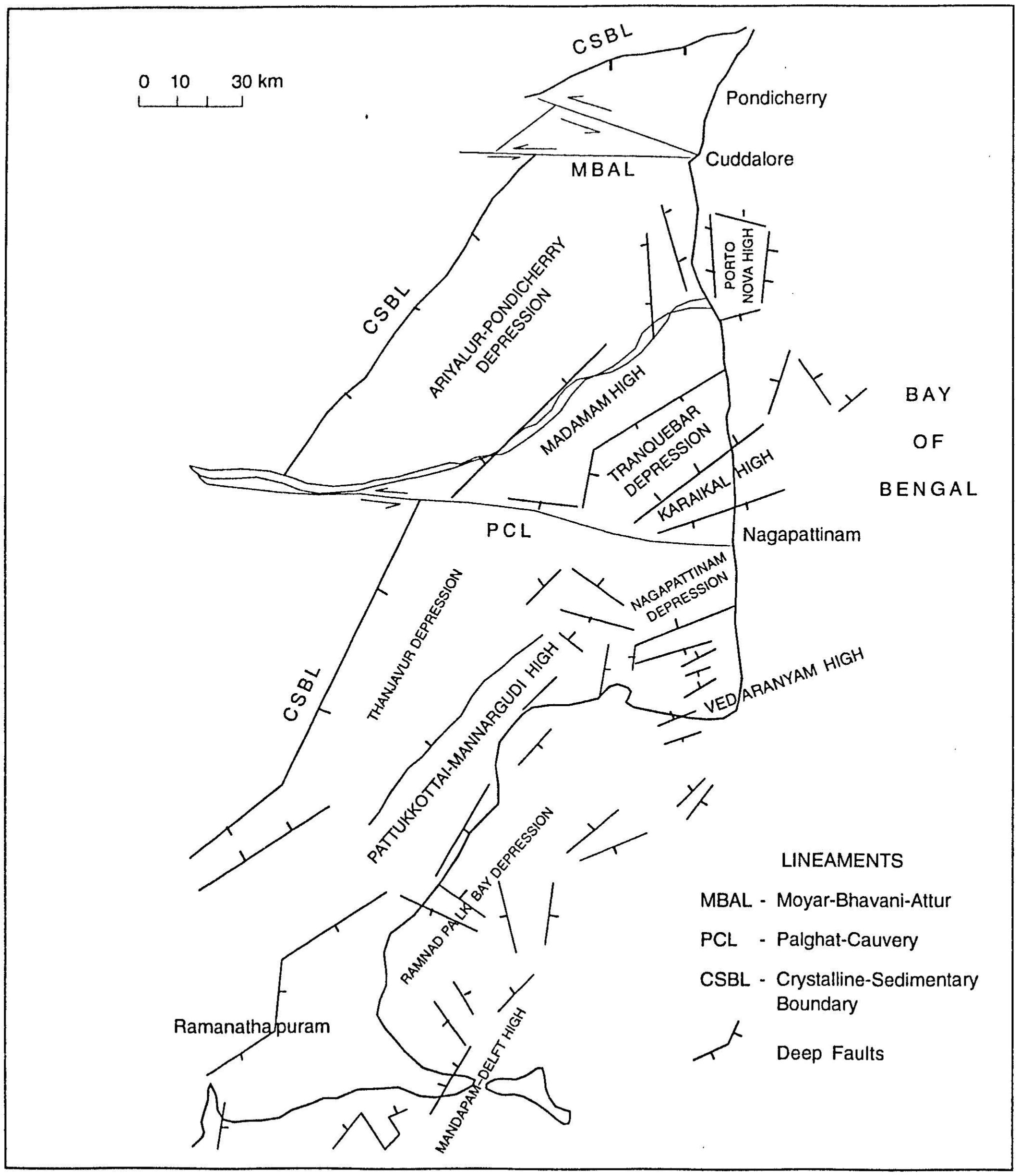

Fig.1. Fault systems of parts of coastal sedimentary belt, Tamil Nadu (*after* ONGC, 1993).

Subsurface data point to the definition of a number of depressions and ridges in a NE-SW to NNE-SSW direction, separated by faults and filled with sediments, ranging in age from Jurassic to Quaternary. Generally, the thickness of sediments is more in the depressions than in the ridges and the thickest pile of sediments of Cretaceous-Tertiary age, totalling to 5000-5500 m occurs in the Ariyalur-Pondicherry depression (Govindan and Ravindran, 1996). Biswas et al. (1993) opined that the pericratonic type of basins along the east coast, extending into the offshore area, evolved as a consequence of separation of Antarctica in Neocomian, when ancient faults in the Precambrian crystalline basement were reactivated, leading to extensive strike-slip faulting. Thus, it is evident that the faults in the coastal region owe their origin to global tectonic processes related to the rifting and fragmentation of Gondwanaland.

Discussion

The stupendous tectonic processes involved in the separation of Antarctica from India are no longer active, but they have left behind their imprint in the form of fault-bounded ridges and depressions. Reasonably, the accumulation of a heavy burden of sediments in the ridges and depressions over the course of millions of years has inevitably led to crustal instability, resulting in vertical movement along faults. Such movement accounting for neotectonic activity in the coastal region may well be the root cause for the earth tremors of September 2001. The

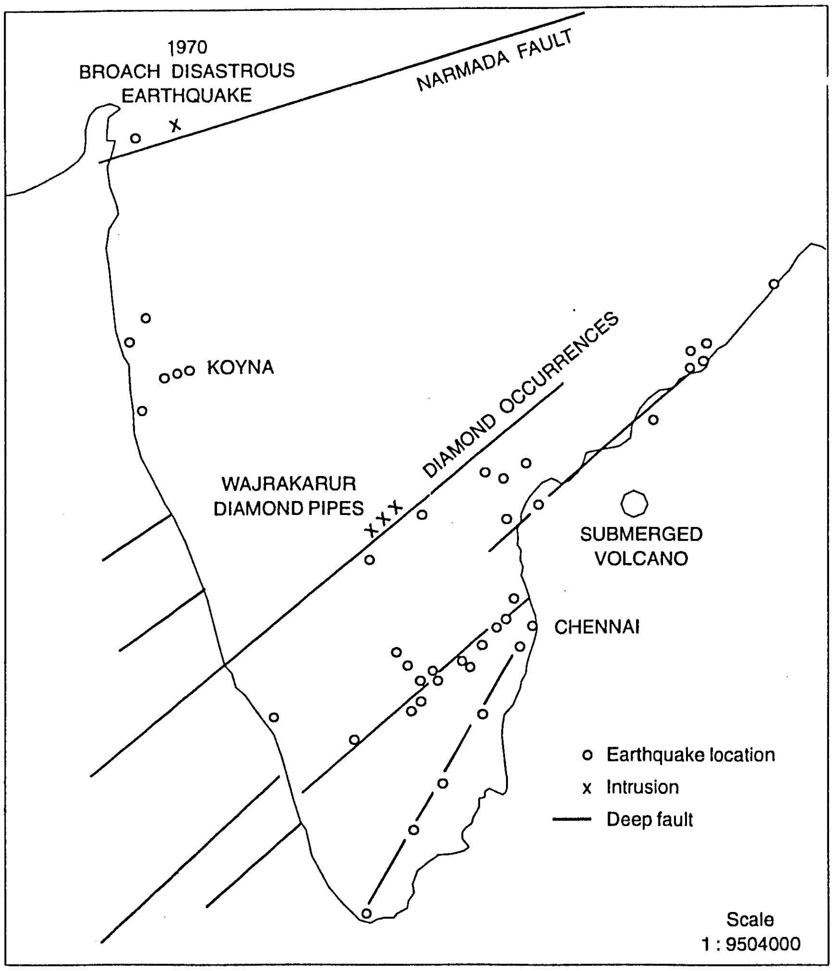

Fig.2. Earthquake locations in Peninsular India 1800 to 1970 (Grady, 1971).

other historically recorded earthquakes in the coastal region may also be the outcome of periodical release of strain by fault movement.

Grady (1971) has mentioned the location of a submerged volcano off the coast of Andhra Pradesh and has suggested that the volcano may be located on the NE-SW trending fault system along the coastal region of Tamil Nadu (Fig.2). He has also touched on the recording of volcanic activity in 1756 off the coast of Pondicherry. Though he has expressed doubt on the exact location of the volcanic activity with reference to the present day Pondicherry town, such activity in the coastal region may be related to the NE-SW fault system like the one off the Andhra Pradesh coast

In the context of the reported volcanic activity in the past, it is interesting to note that the heat flow map of India (Ravi Shanker, 1988) shows a zone of higher than normal to moderately high heat flow along a NNE-SSW zone parallel to the Tamil Nadu-Pondicherry coast and two other E-W zones, one along the Cauvery valley and another in the path Bay offshore region.

Gopalakrishnan and Varadan (1996) opined that the source of heat may be partly attributed to frictional heat generated by crustal movements along faults and to a larger extent to the definition of mantle plumes or deep level igneous bodies. In recent years, deep boreholes drilled for groundwater in parts of the coastal terrain were reported to yield thermal water with a temperature of 30° to 62°C (Gopalakrishnan and Varadan, 1996), confirming anomalous heat flow. The reported past volcanic activity off the coast was possibly facilitated by the ascent of magma from the lower crust or upper mantle, along the weak fault zones in the structural set up. Though no volcanic activity is defined presently, the tapping of geothermal water from several borewells suggests that the fault zones are channel ways for the emanation of subsurface heat.

From the geophysical point of view, a couple of points are of interest. Subrahmanyam et al. (1995) observed that analysis of bathymetric data from a part of the shelf and slope region of the Cauvery basin points to a mosaic of a deep-seated graben blocks, flanked by rift-related intrusives over the shelf region. The Bouguer anomaly map of Tamil Nadu-Pondicherry coast shows a number of highs and lows trending in a NE-SW and NNE-SSW direction and they coincide with ridge and depression structures aligned in the same direction (Gopalakrishnan and Varadan, 1996).

Conclusions

The east coast of India is now considered as a passive margin but at the time of the separation of Antarctica, it must have been an active margin, subjected to global tectonic processes attendant on the disruption of Gondwanaland. Slices of the crust at the continental edge of India bounded by NE-SW to NNE-SSW faults came into being. Vertical movement along the faults was imposed by stupendous sedimentation, giving rise to ridges and depressions. The faults continue to be active, accounting for earth tremors and the definition of a thermal signature along the coast.

There is a view that if the epicentre of the earthquake of 2001 had been located on land and not in the offshore area, there would have been greater damage to structures. This is of mere academic interest and should not form the basis for creating panic in society. Earthquakes are no longer considered as 'Acts of God or sports of devils', but despite tremendous progress achieved in the field of seismology, forecasting the area and timing of earthquake occurrence is still an elusive, though a highly desirable goal (Gupta et al. 2001).

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