

Evidence of fault reactivation off Pondicherry coast from marine geophysical data

The Indian subcontinent, in particular the South Indian shield, is sandwiched between two regions of high seismic activity, the extra peninsular region, mainly the Himalayan belt, and the equatorial region of the Central Indian Ocean, an area of intense intraplate crustal deformation¹. Both these regions are currently under intense compressional stress due to the northward pushing of the Indian plate and the

resistance at its contact with the Asian plate.

However in recent times, the South Indian shield, hitherto considered as a stable continental region, has become an area of slight seismicity. This may be due to the long recurrence interval associated with stable shield regions like South India. During the last 50 years, eight earthquakes of moderate magnitude have occurred in this region, majority of

them spatially coincident with palaeo rifts and clustered around the pre-existing structural features². High-magnitude intraplate earthquakes of Killari (M_w 6.2, 1993), Jabalpur (M_w 5.8, 1997) and Bhuj (M_w 7.7, 2001) have claimed a lot of human lives, and moderate earthquakes in Kerala (M 5.0, 2000), Karnataka (M 4.3, 2001) and Tamil Nadu (M 5.5, 2001) in the southern peninsular India have created enough concern to understand

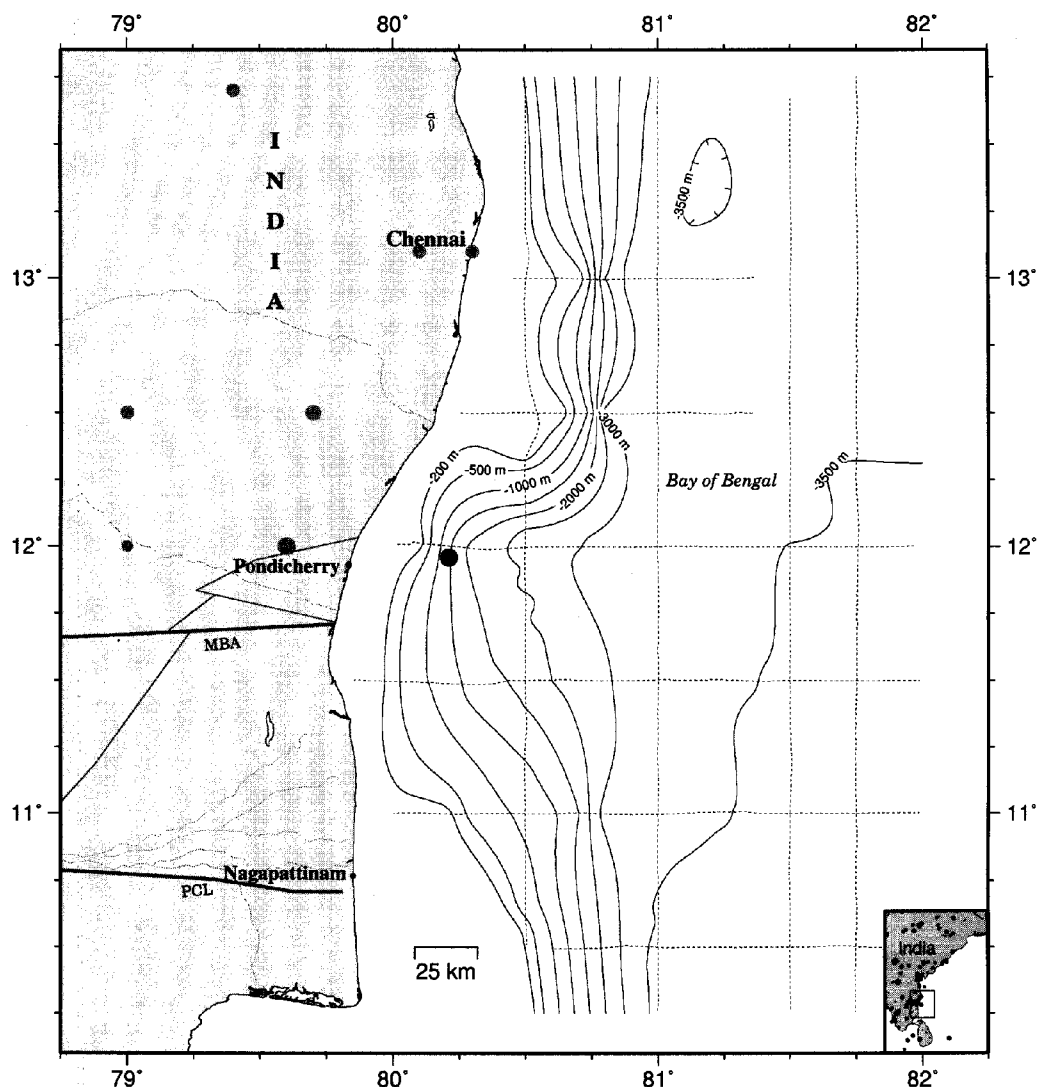


Figure 1. Location map of the study area showing bathymetry, earthquake epicentres and major onshore structural elements. Dashed lines indicate ship tracks along which bathymetry and gravity data were acquired. Black dot indicates the location of Pondicherry earthquake (M_w 5.5) of 25 September 2001. (Inset) Seismicity map of India along with the location of study area on the ECMI. MBA, Moyar-Bhavani-Attur lineament; PCL, Palghat-Cauvery Lineament.

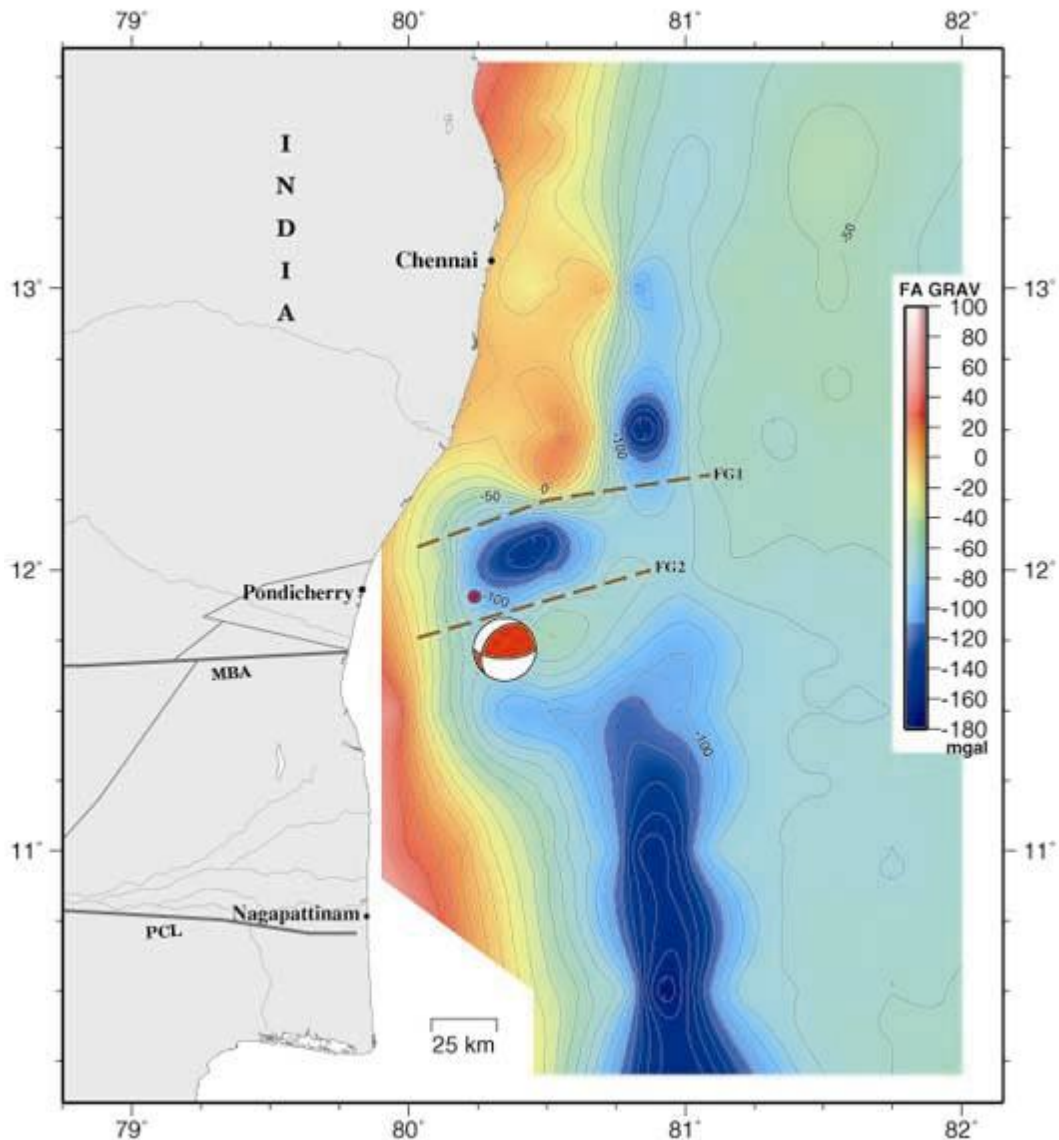


Figure 2. Free-air gravity anomaly map (contour interval 10 mGal). FG1 and FG2 are the inferred faults. Location and focal mechanism of the Pondicherry earthquake are shown.

the temporal and spatial behaviour of seismically-active faults and the nature of recurrence. The recent seismicity has been related to the rejuvenation of activity along some of the zones of weakness³. In light of this, it is essential to carry out geological and geophysical studies to map the faults/fractures and other tectonic lineaments and to correlate them to historical seismicity to understand the factors responsible for the seismic activity. Recent earthquakes in coastal regions of Tamil Nadu and Kerala have invoked interest among the earth scientists to study the coastal seismicity in relation to morphological and

tectonic lineaments associated with coastal and near-shore regions of the eastern continental shelf. As a first step, geophysical data acquired through magnetic and gravity methods were analysed to demarcate the tectonic lineaments over the shelf regions of Eastern Continental Margin of India (ECMI).

Magnetic, gravity and high-resolution shallow seismic data of the eastern continental shelf, along with some reported locations of the epicentres of recent tremors, suggest reactivation of some tectonic lineaments extending from the coast to the continental shelf⁴. The study areas include Visakhapatnam and Vizianagaram, off

Andhra coast and Palar and Cauvery basins of Tamil Nadu shelf.

The present study mainly focuses on the northern part of the Cauvery offshore basin, between latitudes 10° and 14°N, and longitudes 80° and 82°E (Figure 1), over which the bathymetry, gravity and magnetic data are collected. The bathymetry map in general shows a linear N-S trend, except between latitudes 10°45'N and 12°15'N, where the contours trend coastward indicating a major fault zone. Similar trend is also evidenced by the geophysical anomalies. The free-air gravity anomaly map (Figure 2) is characterized by a significant north-south

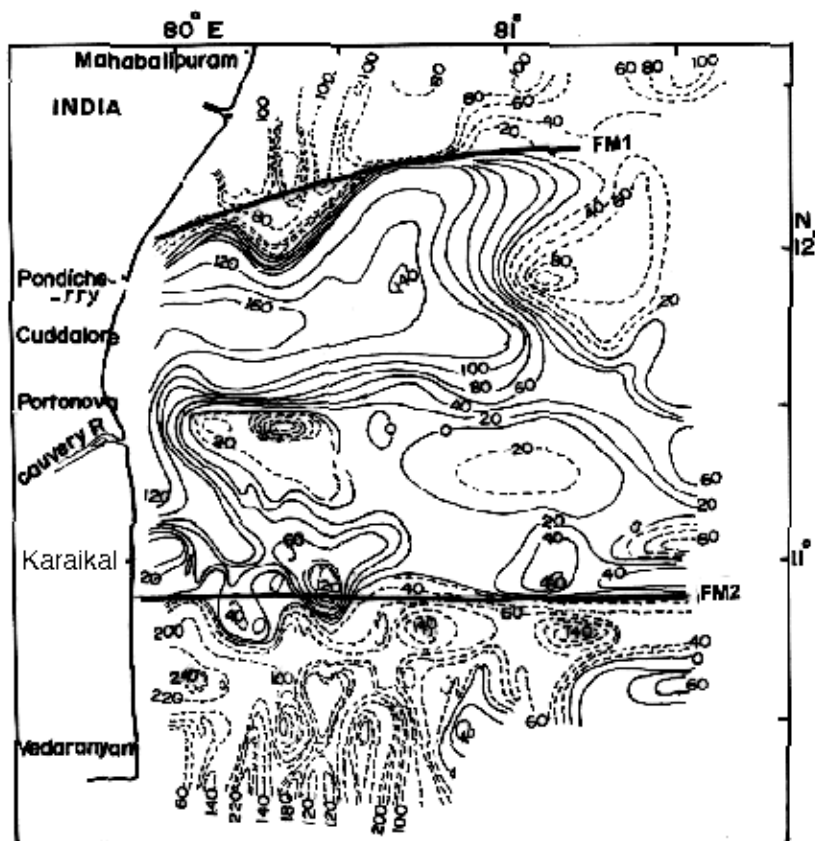


Figure 3. Total field magnetic anomaly map (modified from Subrahmanyam *et al.*⁵). Contour interval is 20 nT. FM1 and FM2 are the faults inferred.

trending linear gravity low with major discontinuities, FG1 and FG2, along 12°15'N and 11°45'N respectively, indicating major fault zones. Total field magnetic anomaly map⁵ (Figure 3) also shows two major discontinuities, FM1 and FM2, along 12°15'N (off Pondicherry), and 10°45'N (south of Karaikal) respectively.

The discontinuity observed in the gravity data (FG1) correlates well with the major discontinuity observed in the magnetic data (FM1). Similar trend has also been evidenced from the bathymetry, which may indicate a major structural trend. FM1, trending ENE–WSW, was interpreted earlier as an offshore extension of NE–SW trending Kumbum–Pondicherry lineament on land⁶. The E–W trending lineation FM2, which correlates well with the landward Palghat–Cauvery Lineament (PCL) can be considered as its offshore extension. The PCL has been termed as a shear zone by Drury *et al.*⁷.

Another major discontinuity having ENE–WSW trend (FG2), as observed in

the gravity data, may be spatially correlated to the E–W trending Moyar–Bhavani–Attur (MBA) lineament on land. This lineament was interpreted as a shear zone⁸ and has also been suggested as a suture zone⁹ and a steeply-dipping thrust fault¹⁰. It can be suggested that FG2 may be the offshore extension of the MBA lineament.

An earthquake of magnitude M 5.5, which occurred on 25 September 2001 off Pondicherry, can be considered as a fairly larger event for the South Indian shield so far. Located at 11.95°N and 80.23°E, the epicentre falls over the continental slope, about 40 km off Pondicherry at 1900 m water depth with a focal depth of 10 km. The epicentre of the earthquake falls over the reported fault zone FG2, which has been interpreted as an offshore extension of the MBA lineament. The focal mechanism solution of the earthquake (Figure 2) suggests thrust faulting¹¹ and indicates small strike-slip component with left lateral motion along a northeast striking nodal plane. The other nodal plane in the

solution strikes in the east-west direction and is preferred to be the fault plane on the basis of the seismicity trend in this region along 12°N latitude.

Chandra³ has reviewed the seismicity of peninsular India and obtained the focal mechanism solutions for some of the prominent earthquakes, including the Bhadrachalam (M 5.7, 1969) and Ongole (M 5.4, 1967) earthquakes. Some similarities can be drawn between these earthquakes and the Pondicherry earthquake, as they all fall in the vicinity of the 80°E longitude, along which the coastline trends nearly N–S in the South Indian shield. The fault-plane solutions suggest that they are of thrust type. Interestingly, the Ongole earthquake also suggests faulting along an E–W trending fault, which is similar to the Pondicherry earthquake.

Based on the qualitative analysis of geophysical data, it is conjectured that the Pondicherry earthquake might have occurred due to the release of compressional stresses along the fault zone FG2, which may be the offshore extension of E–W trending MBA lineament. This further indicates the recent reactivation of the Precambrian shear zones in the offshore regions of Tamil Nadu, particularly the MBA lineament.

Detailed studies to locate the coastal and offshore lineaments, coupled with information on recent seismicity, may throw more light on the neo-tectonic activity within the South Indian shield. The frequent tremors in this region stress the need to carry out systematic studies over the eastern continental shelf to establish a possible link between land–ocean tectonic lineaments and their reactivation under the compressional stress regime.

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