A GEOPHYSICAL INSIGHT OF EARTHQUAKE OCCURRED ON 21ST MAY 2014 OFF PARADIP, BAY OF BENGAL

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Abstract

An earthquake of 6.0 magnitude on the Richter scale occurred around 21:52 hrs on 21 May 2014, nearly 275 km south-east of Paradip off Odisha coast. The epicentre of the earthquake was in the Bay of Bengal (18.201°N, 88.019°E) at a depth of around 40 km. The tremors were experienced all along the east coast of India. Magnetic (T.F.) along with Bathymetric data collected during the cruise SM-232 (December 2013) of Marine & Coastal Survey Division, Geological Survey of India was analysed to study the neo-tectonic activity within the area off Paradip, Odisha coast where the above mentioned earthquake occurred. Detailed examination of the Magnetic (T.F.) anomaly data revealed the presence of major lineaments along NW-SE and NE-SW directions in the study area and the stress release activities from these lineaments may be responsible for this seismic event. The movements along the growth faults at the margins of large Bengal channels due to huge sediment loads could also play a significant role to developed seismicity across these margins.

Keywords: *Magnetic, Bathymetry, Lineaments, Earthquake, Bengal Fan*

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1. INTRODUCTION

Southern Indian Craton, bounded by passive margins, is earlier considered stable being an intraplate zone. The occurrences of higher magnitude earthquakes in Latur (Maharastra), Jabalpur (Madhya Pradesh) and Kutch (Gujrat) belied this view. Earthquakes of 5-6 magnitue on Richter scale along the East Coast of India in last few decades and the above mentioned recent one indicates the existence of neo-tectonic activity in this region.

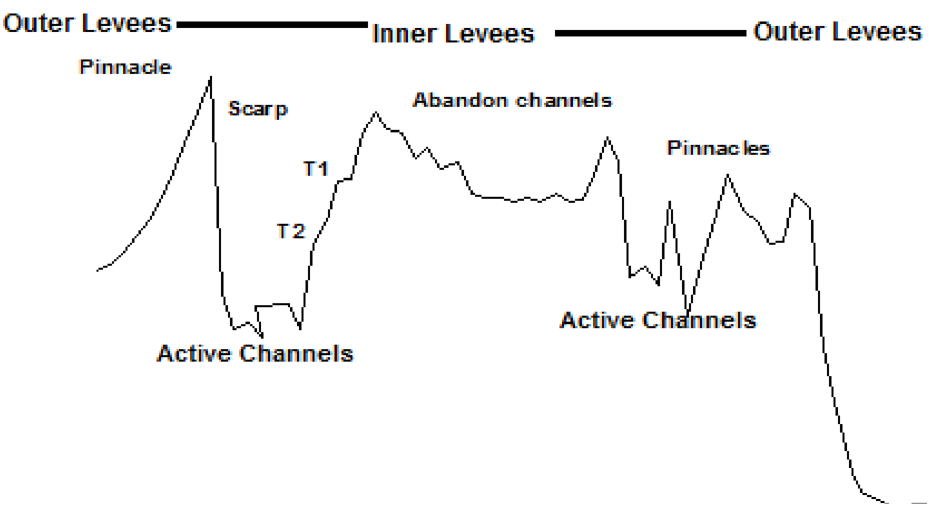
The Eastern Continental Margin of India (ECMI) is believed to have evolved due to the Gondwanaland breakup by Late Cretaceous and its subsequent collision with the Asian plate around the Eocene period. This cratonic margin is circumscribed by rifted grabens and sags near to shelf besides deep/ultra deep water basins in offshore areas (Bhowmick, P. K., ONGC). Recent crustal seismic and other geophysical studies indicate that ECMI is a divergent type of margin. Geological and geophysical studies of the similar type of continental margins provide information on the basic processes of crustal rifting and tectonics in different stages of their evolution. Some seismic activity is evidenced for this divergent margin where the seismic zones orient NE-SW (Chandra, 1977). Aeromagnetic data over parts of the Mahanadi basin and its offshore extension (Babu Rao et al., 1982) bring out more details for the NE-SW subsurface ridges and depressions on the basement surface which is down faulted seaward below the ECMI where the steep magnetic gradient is observed.

2. DATA ACQUISITION AND PROCESSING

Marine & Coastal Survey Division of Geological Survey of India conducted Magnetic and Bathymetric survey off Puri-Balasore, Odisha Coast onboard RV Samudra Manthan during cruise SM-232 during the period 10-12-13 to 31-12-13. The survey area is bounded by latitudes 17.58º N to 20.86º N and longitudes 86.00º E to 89.67º E. A total of 3030 lkm of magnetic and bathymetric data have been collected along 10 coast perpendicular transects (ML-1 to ML-10) aligned in NW-SE direction (Fig. 1). Cesium vapor magnetometer (G-880) has been deployed for carrying out magnetic survey during the cruise. MagLog software interfaced with the magnetometer, GPS and the Bathy-2000 (for bathymetry) used for digital recording of data. As per the Cesium Sensor Active Zones (CSAZ) program, the sensor's rotation and tilt have been adjusted for NW-SE traverses perpendicular to the coast. The magnetometer is lowered taking all precautions and 300m of towing cable paid out to avoid magnetic noise of ship & equipments. Total field magnetic values recorded during the survey ranges from 43542 nT to 44870 nT, whereas bathymetry values ranges from 100 m to 2420 m. The offshore total field intensity magnetic anomalies were computed after correcting for the International Geomagnetic Reference Field (IGRF, 2015). Magnetic anomaly profiles, bathymetry profiles, magnetic anomaly map, reduced to pole map, upward continuation (4 km & 8 km) map, free air gravity anomaly map & bathymetry contour map were prepared and interpreted for the present study.

3. RESULTS AND DISCUSSION

In view of the recently occurred earthquake in Bay of Bengal, magnetic and bathymetric profiles (Fig. 2) of all the survey lines have been studied in detail around the location of the earthquake. The location of earthquake is falling near the end of survey line, Line-3. Bathymetric profiles of all the lines from Line -3 to Line -10 are marked with sea floor rise in the form of rugged topography towards the region of earthquake location. Sudden rise and fall of bathymetry over this region vary from 100 m to 400 m within the distance of 5-10 kms along all the lines. These complicated patterns are identified at the cross-sections of channels of Bengal fan levee system, which is the largest elongated submarine fan in the world. The Bengal fan has covered approximately an area of 3 x 10^6 km^2 (Curray and Moore, 1971,1974; Curray et al., 1982) in the Bay Of Bengal & Indian Ocean and it is extended from approximately 20^0 N to 9^0S, with a length of more than 3000 km and a maximum width of about 1400 km. The observed Bengal channel-leeve system in the survey area is considered as a part of middle fan. The width of the channels along different survey lines varies from 30 km to 40 km. At the outer leeve they are marked with several growth faults, whereas in the inner leeve they consists of various vertical segments. The internal segments are characterized by steep borders and complicated patterns. The tops of the several segments form pinnacles on the seafloor and the inner flanks generally dip more than the outer flanks. Sharp and deep V-shaped sub-channels are believed as active channels, whereas shallow concave-shaped sub-channels are considered as abandoned/inactive channels. These Bengal fan channels are clearly observed in the Bathymetry contour map (Fig. 3)



A CROSS-SECTION OF BENGAL CHANNEL ALONG LINE-7

The existence of growth faults at the margins of channels draw attention during the neo-tectonic study in adjacent area. The short wavelength and high amplitude negative anomalies in the magnetic profiles at the margins of channels also indicate the presence of deep seated basement faults/lineaments. The huge overlying sediment load on the basement may have triggered the movements/dislocations along the faults which can be linked with the seismicity of moderate magnitude earthquake and contributing to the channel-levee system on the sea floor.

The magnetic anomaly contour (Fig. 4) map were prepared taking the data sets of earlier cruises SM-17 and SM-73 along with present cruise SM-232 brings out prominent NW-SE lineaments (perpendicular to coast) divide the offshore basins into three domains viz. Bengal basin, Mahanadi basin and Chilka basin. The Reduced to pole map (Fig. 5), Upward (4 km) continuation map (Fig. 6) & Upward (8 km) continuation map (Fig. 7) with high magnetic value contours in the central part of the area trending in the NW-SE direction depicts the existence of major lineament with basic intrusive bodies. These intrusive bodies are cutting across by several NE-SW intrusives, which shows the presence of several lineaments in the NE-SW direction. Incidentally the present earthquake location falls near the cross over point of NW-SE and NE-SW lineaments. These intersected lineaments which might be the result of the rifting episodes during Late Cretaceous are appeared to be the cause for this seismic event . A sharp contrast in the free air gravity values (Fig. 8 Data downloaded from http://topex.ucsd.edu/) demarcated on both the sides of Bengal fan channel also confirm the existence of NE-SW lineaments. The tectonic map (Fig. 9) prepared by Directorate of Hydrocarbon(DGH) marked this zone as NE-SW growth faults zone also confirm the presence of shear zones in this area. Several other earthquakes occurred earlier along the east coast might be controlled by these NE-SW tectonic trends.

CONCLUSIONS:

In the light of geophysical findings by this study, following conclusions may be drawn:

1. Existence of major offshore NW-SE and NE-SW lineaments which are interpreted in all the magnetic maps could be activated to trigger the seismictiy at the margins.
2. Moderate magnitude of the recent and the earlier earthquakes suggest that movements along the growth faults at the margins of large Bengal channels due to huge sediment loads could also play a significant role in the occurrence of this seismic event.
3. Such moderate earthquakes are likely to occur in future also along these week zones of the ECMI but the probability of destruction due to earthquake are less. Even though disaster monitoring and management agencies with the coordination with scientific organisation should be prepare for these inevitable events.
4. Extensive geological and geophysical studies are required to establish the link between onland and offshore tectonic lineaments which would help to understand the factors responsible for the tectonic activities along the ECMI.

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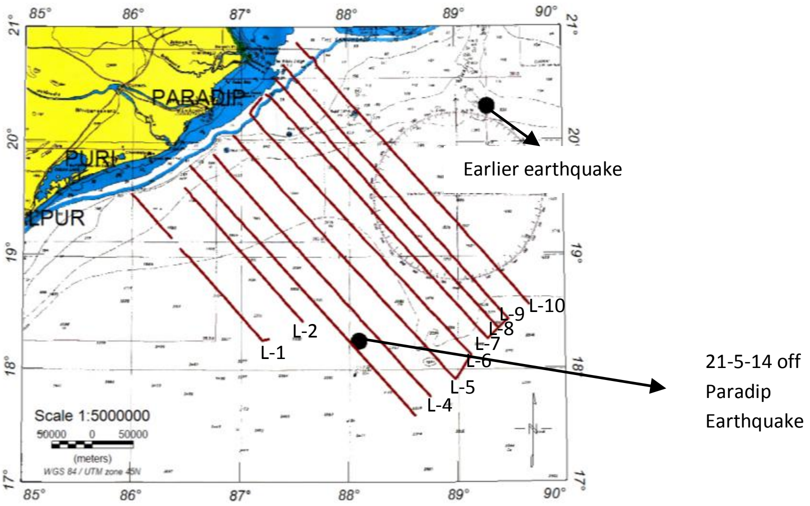

FIG.1 CRUISE TRACK MAP

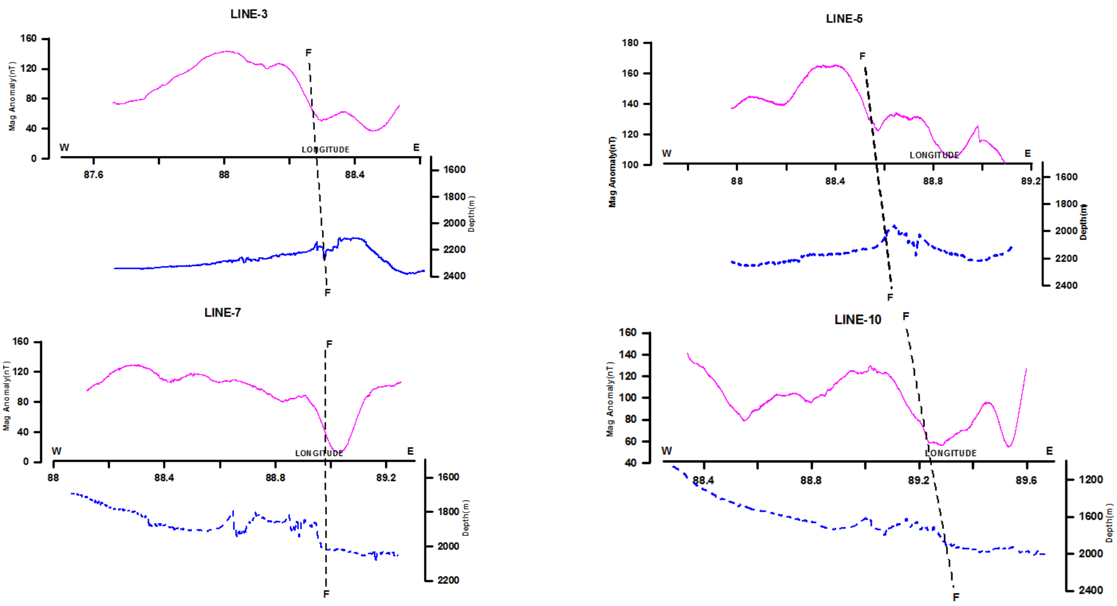

FIG.2 MAGNETIC & BATHYMETRIC PROFILES

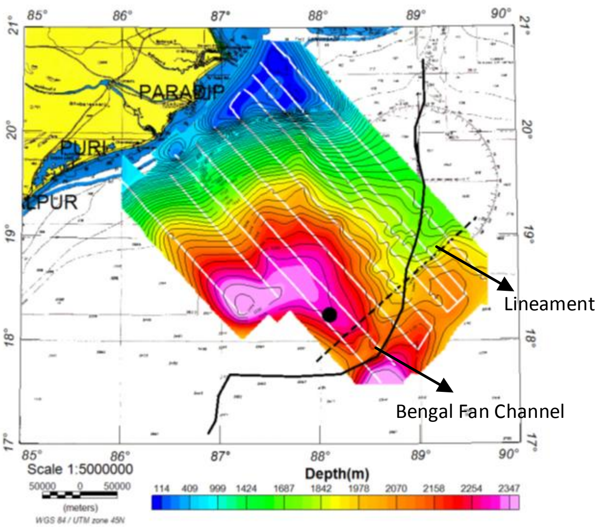

FIG.3 BATHYMETRY MAP

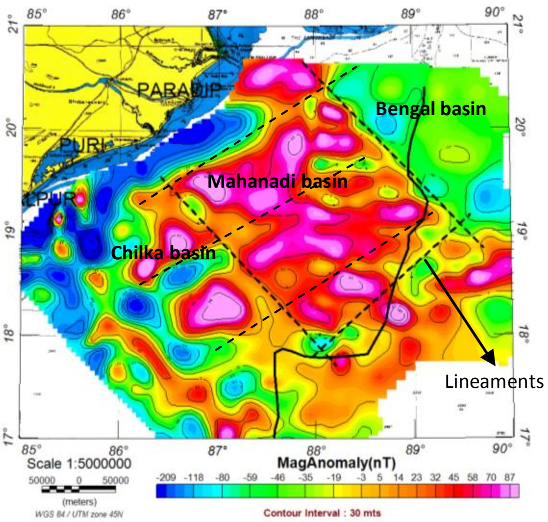

FIG.4 MAGNETIC ANOMALY MAP

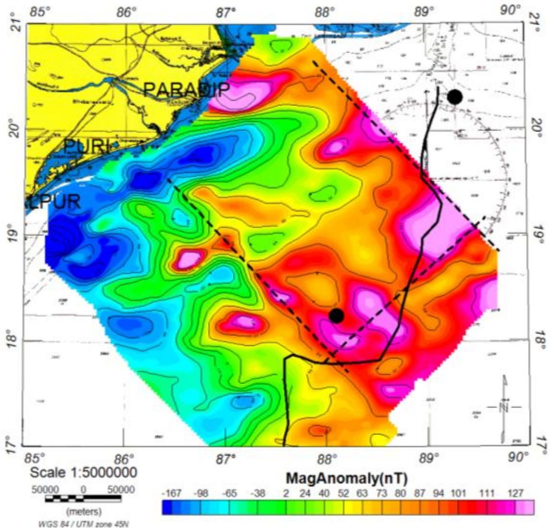

FIG.5 REDUCED TO POLE MAP

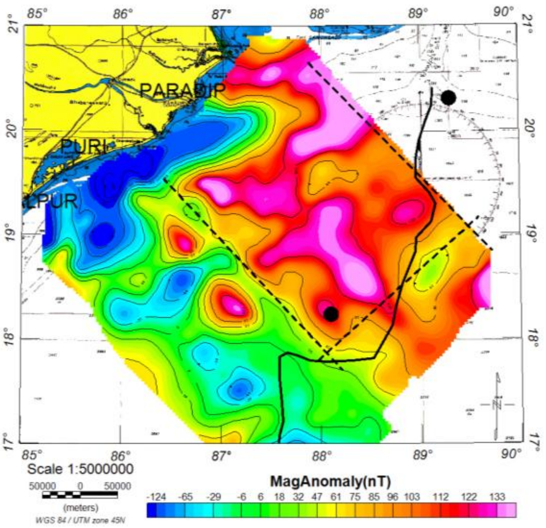

FIG.6 4KM UPWARD CONTINUATION MAP

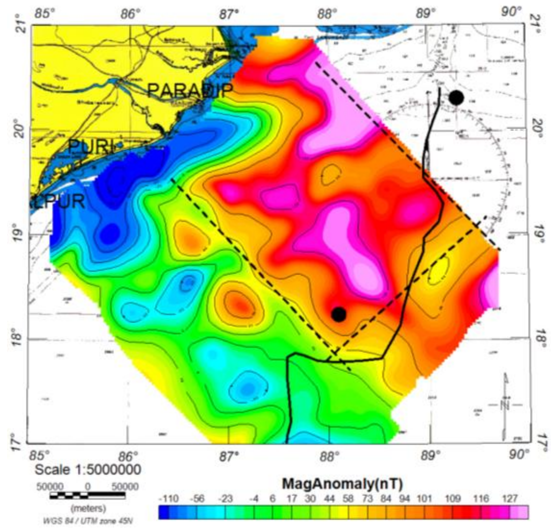

FIG.7 8KM UPWARD CONTINUATION MAP

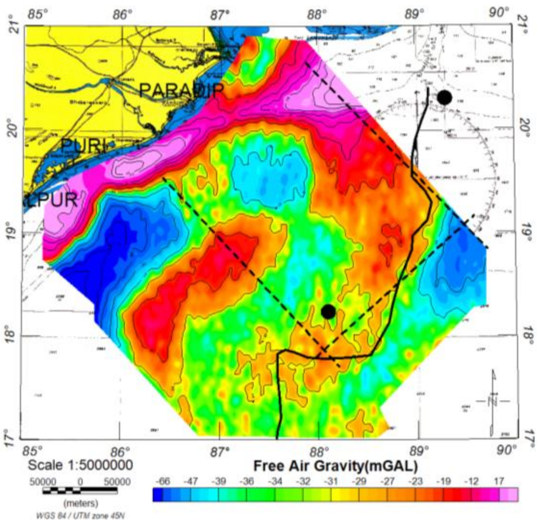

FIG.8 GRAVITY ANOMALY MAP
(COURTESY: http://topex.ucsd.edu)

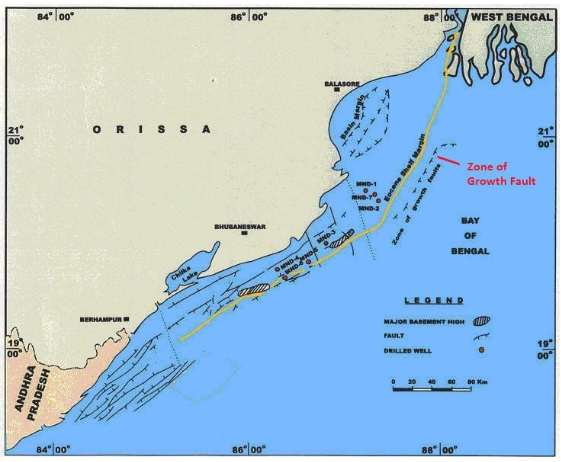

FIG.9 TECTONICS OF MAHANADI BASIN
(COURTESY: DIRECTORATE OF HYDROCARBON)