

## Earthyroid Storms: Brewing Cyclones, Megaquakes and Tsunamis? K. R. Y. Simha, Indian Institute of Science, Bengaluru (*E: simha@iisc.ac.in*)

*Earthights* published previously in GSI Journal (v.96, pp.528) discussed constraints preventing mega continental earthquakes (M9). This concluding segment Earthyroid Storms explains why M9s prefer oceans and how rapid body heating, sweating and palpitation symptomatic of a thyroid storm applies to earth too! Sudden local heating of land, sea and air triggers cyclones, earthquakes and tsunamis. Ocean trenches along the 40,000 km ring of fire (RoF) present perennial hazard; but, a trench linked to an estuarine bay like Bay of Bengal (BoB) becomes deadly for tsunamis as witnessed on December 26, 2004. Damage to life and property inflicted by attacks of war, terror, cyclones, pandemics and megaquakes ushering in the proposed anthropocene era is terrifying. The tumultuous 2020 witnessed BoB bred Amphan, Gati, Nisarga and Nivar devastating life and habitat for a billion people. In this megaquake quest, this article explores underwater seismic scenarios.

Clambering down south of Shillong takes us to the famous BoB vying with Himalayas challenging earth scientists and technology. While BoB and Gulf of Mexico (GoM) breed cyclones, colder Chesapeake and Hudson bays or the Gulf of Alaska (GoA) do not. Dotted with islands, these estuarine bays and gulfs ensconced by coastlines spanning several states are replenished by myriad rivers like Brahmaputra, Cauvery, Godavari, Potomac, Mississippi etc. Both BoB and GoM whistle out cyclones after cyclones like gigantic pressure cookers. The RoF branch proximity in the tsunami-susceptible Indian Ocean renders BoB a symbol for peril pinnacle. GoM that bred Katrina and Rita in 2005 pales when compared to BoB. Being warmer and a kilometer deeper with 30% larger area BoB is the busiest cyclone launch pad on earth. Integrating seismology-meteorology-oceanography-geology (SMOG) becomes inevitably crucial for characterizing BoB dynamics.

Oldham's 1897 Shillong earthquake memoir inspired the naturalist Newell probe Andaman and Nicobar (A&N) islands. Nobelist Raman communicated an elegant 1957 La Fond's summary of century-old campaigns into BoB at Andhra University tracking the annual temperature-salinity (TS) cycle. Bullard, a protégé of Rutherford, exploring sea floor spreading underlying plume and plate tectonics (PPT) stimulated authors like Holton writing on atmospheric and Apel popularizing ocean physics with the latter quoting a 1985 pop album lyric erroneously! The phenomenal rise of meteorology and oceanography in the new millennium surpassed geology and astronomy heroically acquired across millennia from field workers. Robots, technologies and numerical models propel relentless radar and satellite data assimilation dictating global climate narratives today. Paradoxically, nucleation, propagation and annihilation (NPA) of cyclones remain tragically elusive. More alarmingly for BoB, recent papers linking storms, quakes and tsunamis (google storm quake) warrant greater R&D on allied topics like reservoir triggered seismicity (RTS). Aptly, a special 2018 BSSM issue celebrated 50 years of RTS research at Koyna pioneered by GSI President Gupta, who has also examined BoB tsunami genesis. Singapore set up an observatory laudably directed by Sieh for mitigating tsunami damage deploying early warning Argos and sensors.

Observation, imagination and chronology as key elements of geology require blending litho-hydro-tropospheres influencing BoB. Kanyakumari-Leh (KL) meridian passing through Bangalore and Bhopal (B) suggests Kanyakumari-Bhopal-Shillong triangle as

hinterland to 3140 km Kanyakumari-Kolkata (KK) coastline. The 2000 km chord KK aids estimating BoB water mass. Taking Kanyakumari origin, a 2000 km arc drawn from Kolkata intersects 5°N latitude near Indra Point of A&N (cyclogenesis is impossible within 555 km from equator). Twice the area under this arc yielding about 80% of BoB estimates its thermogenesis potential of heat stored in the top 60 meters with sea surface temperature (SST) above 26.5 Celsius. Complementing these initial conditions, thermal boundary conditions for cyclogenesis are set 110 km in the thermosphere beyond tropo-strato-mesospheres where SST is regained. The humongous cyclone NPA energy budget is readily drawn from abundant solar radiation (> 1 KW/sqm) permeating all space. Surprisingly, minuscule terrestrial heating by conduction (0.1 W/sqm) manifests volcanoes, hot springs and geysers! While radiation and conduction modes are largely predictable, heat transfer by convection in air and water renders great complexity to cyclone dynamics. Intuitive and observational skills acquired in school and college geology immensely aid avoiding attractive but misleading numerical and theoretical data correlations hampering seismology, meteorology and oceanography for predicting earthquakes, cyclones and tsunamis. Theoretical and numerical models become unreliable for predicting the destructive power gauged by depression (50-500 mm), rainfall(1-10 mm/hr), translation vector (3-10 m/s NSEW) and duration (20-200 hrs).

Gigantic cyclones pounding BoB cause considerable turbulent pressure fluctuations destabilizing ocean floor dynamics by churning clay and terrigenous sediments donated generously by flooding Deccan and Himalayan rivers across millennia (Japan 2011 megaquake attributed to clay layer). The Shillong-Leh arc which bears the brunt of continental Himalayan tectonics has attracted tremendous R&D support. Despite unfathomable losses year after year from floods, winter rains and cyclones, the ecologically and economically vulnerable KK coast has received less attention. A dedicated Coastal Observatory for Seismology, Meteorology, Oceanography and Geology (COSMOG) promoting intuitive and observational skills of field scientists, volunteers and entrepreneurs can reverse this trend.

Concluding this quest for M9 megaquakes lurking in the Indian Ocean, the arc from Kolkata traversing along A&N chain finally leads us to the treacherous 2004 tsunami source site – Sunda trench. Sunda is a potent member of the notorious league of RoF trenches girdling the mighty Pacific Plate (PP). These deep trenches conspiring with volcanoes and hot spots turn into explosive M9 sea mines launching vicious tsunamis into bays and gulfs of satellite plates jostling PP activating seaquakes. The M9 Chile tsunami blasted distant Hawaii in 1960. Quickly followed the second M9 tsunami decimating GoA in 1964! This double assault repeated 40 years later 10,000 km away in Asia. The first 2004 Sumatra M9 tsunami blew up BoB tearing up eastern and peninsular coastline. The pernicious M9 quick return mechanism destroyed Japan in 2011 like an ominous anthropocene apocalypse precursor. These horror videos and Keeling plot warning global warming have spurred public activism for regulating ostensible technologies polluting air, water and land. A comprehensive fortification strategy for protecting pristine but fragile coastal ecology around BoB will go a long way in restoring glorious R&D heritage of this enigmatic estuarine cyclone breeding tsunami attracting bay extraordinaire!