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GENERAL ARTICLE

A NEW PLATE BOUNDARY NEAR SRI LANKA: IMPLICATIONS FOR FUTURE GEOHAZARDS

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On the 26th of December 2004, an earthquake measuring 9.0 in the Richter scale, which caused an extremely energetic Tsunami, devastated much of the coastline of Sri Lanka, with considerable damage to the east and south coasts. Amidst the frantic efforts made to cope up with the disaster, the general public who were completely taken unawares, became deeply interested in the scientific aspects of earthquakes and Tsunamis. Among the questions most frequently asked was whether there is a likelihood of another Tsunami affecting the country and how vulnerable we are to earthquakes. While the geologists, engineers, geophysicists and oceanographers responded to the public request with a series of newspaper articles and television programmes, one geological aspect hitherto not mentioned by those who frequently comment on geohazards, attracted the attention of the scientific community and the interested laymen. This is the existence of a new plate boundary approximately 400-500 km south of Sri Lanka in the central Indian ocean. It is the purpose of this article to elaborate on the nature of the new plate boundary and its possible effects on future geohazards in Sri Lanka, notably earthquakes, minor tremors and Tsunamis.

There are about 13 major plates in the outer shell of the earth and it is the boundaries of these plates that are geologically active. The collision of the plates at their margins, most notably in subduction zones (deep trenches in the sea) , where an oceanic lithosphere sinks under another plate, causes earthquakes generally classified as shallow, intermediate and deep. Earthquakes also take place at other plate margins such as the mid-oceanic ridges. An important point to note however, is that even though 95% of the world's earthquakes occur at or near plate margins, there are other locations where earthquakes occur within plates (termed 'intraplate' by geologists), at distances significantly far from the conventional plate boundaries. The New Madrid earthquake of Missouri, U.S.A in 1811 which had an intensity of 8.0 in the Richter scale is a good example of an 'intraplate" earthquake. The building up of stress within the plate is considered as a cause of these intraplate earthquakes.

Sri Lanka lies in the Indo-Australian plate, seemingly far away from any of the plate boundaries. Geological, geophysical and oceanographic studies within the last 3 decades however, have revealed some very interesting information that brought about a whole new dimension to the plate tectonic scenario of Sri Lanka.

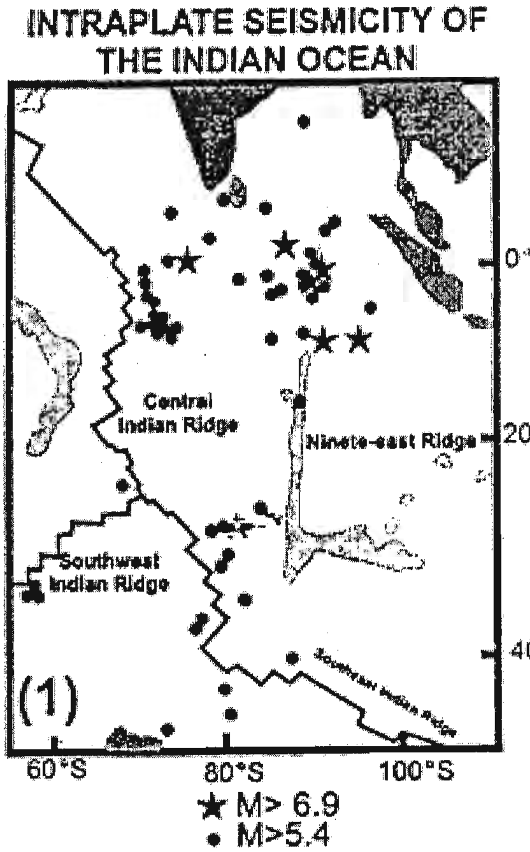

Figure 1: Locations of unusually strong earthquakes south of Sri Lanka (After Wiens, 1986).

In 1980, Weissel *et al.*,[1] noted abnormally high heat flow characteristics in the Indo-Australian plate and suggested that the deformation within the plate appeared to be connected to the Himalayan Mountain building stage of the collision between India and Asia.

Wiens,[2] who studied the historical seismicity near Chagos, in the equatorial Indian Ocean (Figure 1), brought to light, a seismicity rate disproportionate to its supposed intraplate location. His study indicated a broad zone of deformation stretching across the equatorial Indian Ocean from the Chagos bank to the Ninety East Ridge and beyond. This zone contained all known magnitude 7.0 intraplate earthquakes not associated with subduction zones or continental margins. This study of Wiens[2], proposed that a slow, diffuse plate boundary extends east from the Central Indian Ridge to the Ninety East Ridge and north of the Sumatra Trench. A plate motion study confirmed the new boundary and it was suggested that it splits the Indo-Australian plate.

Several other scientists[3-8], made further contributions towards the understanding of this unusual plate tectonic process.

In a landmark paper Orman *et al.*[9], presented convincing evidence to confirm the existence of a new plate boundary in the central Indian Ocean. They analyzed a single-channel seismic (SCS) reflection profile that completely crossed the zone of deformed oceanic lithosphere in the central Indian Ocean and concluded that approximately 11 km of crustal shortening had occurred during the last 7.5 million years. This estimate together with 27 kms of shortening previously estimated from a Multichannel Seismic profile (MCS) provided direct evidence for the existence of a new plate boundary (Figure 2) separating the Indo-Australian plate into the Indian Plate and the Australian Plate. James Cochran of the Lamont-Doherty Earth Observatory of Columbia University, U.S.A, who led this research team together with some French scientists, made a truly significant contribution to the understanding of new plate boundary formation.

The break zone (Indo-Australian split) of the Indo-Australian Plate, where the new plate boundary is forming, is centered on a point roughly 600 miles south of the tip of India. The Australian plate which has now separated from the Indian plate is pivoting counter clockwise around the point while the Indian plate moves towards northeast. Interestingly, this new plate boundary has a unique feature. Its western part shows divergence while there is convergence of the two new plates in the eastern sector (Figure 2).The Indo-Australian split had occurred approximately 8 million years ago, the likely cause of which the stress undergone by the large plate as it is slammed into the Eurasian plate and which pushed up the Himalayas and the Tibet plateau. It is also worthy of note that the location of the new plate zone is the shortest horizontal distance between the east and west margins of the previous Indo-Australian plate - an obvious zone of weakness.

NEW PLATE BOUNDARY IN
THE INDIAN OCEAN

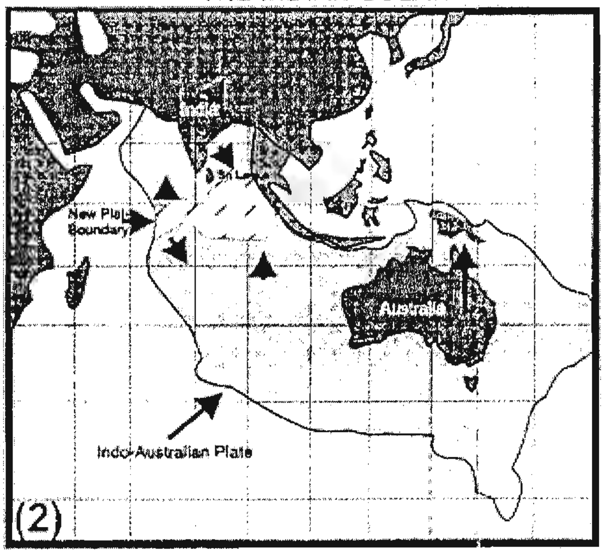

Figure 2: Formation of the new plate boundary south of Sri Lanka.

This new plate tectonic scenario has some very important implications for Sri Lanka as a land. Bearing in mind that the plate boundaries are the well known loci for earthquakes and due to the fact that the new plate boundary is only 400-500 km from its southern shores, Sri Lanka perhaps now needs to be classified as a " moderate earthquake prone area" (Figure 3).

Further, the new plate boundary meets the infamous subduction zone of the Java-Sumatra Trench at a triple junction (rather close to the December 26th 2004, 9.0 earthquake epicentre). The plate boundary at the Sumatra Trench is one of the world's best known earthquake regions and it is reasonable to assume that the hyperactivity at the Sumatra plate margin will have a significant impact on the new plate boundary close to Sri Lanka. Interestingly, scientists from Melbourne University led by Professor Michael Sandiford have discovered that the Indo-Australian plate (now split) is now under considerable stress from its neighbouring plates in Indonesia and Asia. They noted that the energy generated from the connection points between plates at Sumatra and Java are transferring back into the Indo-Australian plate causing immense tectonic stress. This kind of stress is known to produce earthquakes up to 7.0 in the Richter scale every 30 years. Sri Lanka's vulnerability to earthquakes is therefore a matter of serious concern based on these findings. Even Tsunamis, considered hitherto a rarity in the Indian Ocean, now need to be monitored much more closely.

On the northern side, a team of researchers from Colorado University, U.S.A and Indian Institute of Astrophysics, Bangalore, India, in a recent paper in the prestigious journal 'Science' , have forecast an "inevitable massive earthquake" (between Ms 8.1 and 8.3) due to strike the Himalayan mountain region anytime with over a million people at risk[10].They discovered a slip zone – an area where plates of the earth's crust slide against each other, at about 12 km underground along the Himalayas.

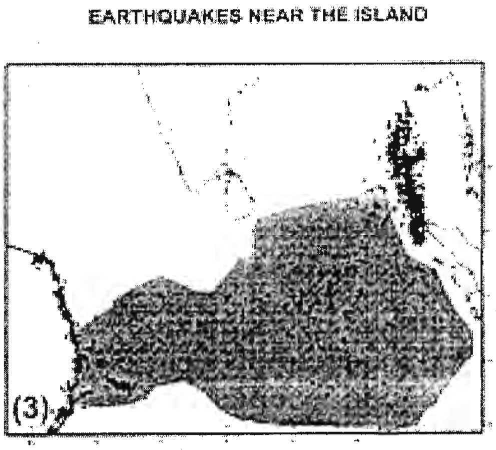

Figure 3: Scatter of earthquake locations in the new plate zone.

The possible effects of such plate tectonic phenomena on Sri Lanka will have to be studied carefully.

The Highlands of Sri Lanka are abounding with faults, lineaments and other geologically weak zones. Earthquakes occurring in the vicinity of the Island, notably in the new

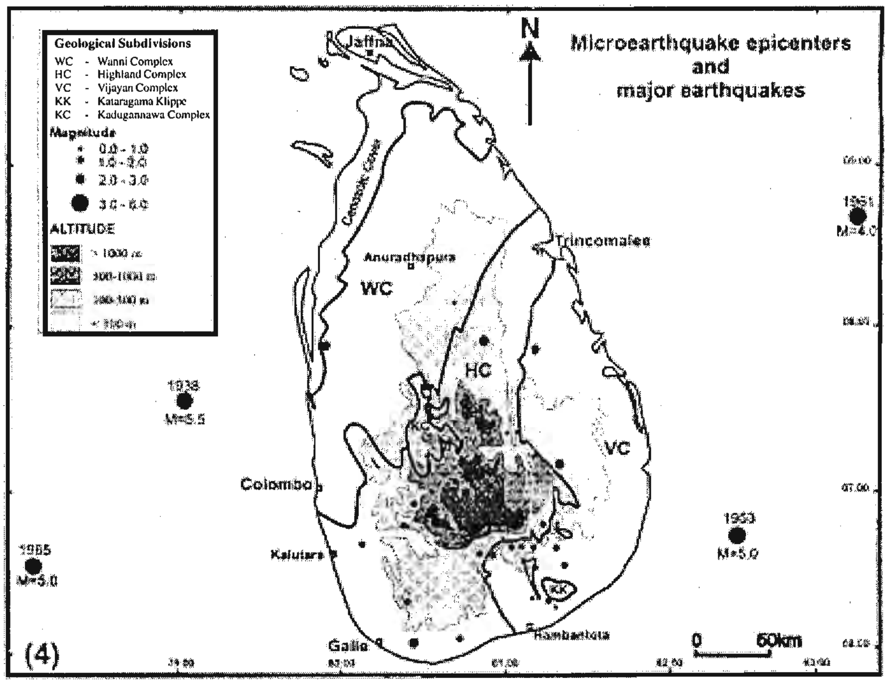

Figure 4 : Microseismicity in Sri Lanka.

plate zone may have an impact on these weak zones. Minor to moderate tremors may occur and the large reservoirs located in such geologically weak zones will have to be monitored through a series of seismometers installed at the dams. The minor earth tremors felt in Sri Lanka (Figure 4), may turn out to be important forewarnings of a later disastrous event. It should be mentioned that the Late Professor P.W.Vitanage, a doyen of Sri Lankan geology, had several decades back, cautioned the authorities to take stringent measures for the safety of dams of the large reservoirs.

These new geological phenomena occurring in the Indian Ocean and in the Indian sub continent will provide a strong challenge to both local and foreign geoscientists, in their efforts to understand Sri Lanka's vulnerability to future geohazards.

Reference

1. Weissel J. K., Anderson R.N.& Geller C.A. (1980). Deformation of the Indo-Australian plate. *Nature* **287**:284-291.

2. Weins D.A. (1986). Historical seismicity near Chagos : a complex deformation zone in the equatorial Indian Ocean. *Earth and Planetary Science Letters* **76**:350-360.

3. Zuber M.T. (1987). Compression of oceanic lithosphere: an analysis of intraplate deformation in the central Indian basin. *Journal of Geophysical Research* **92**: 4817-4825.

4. DeMets C., Gordon R.G. & Argus D.F (1988). Intraplate deformation and closure of the Australia-Antarctica-Africa plate circuit. *Journal of Geophysical Research* **93**: 11,877-11,897.

5. Curray J.R. & Munasinghe T. (1989). Timing of intraplate deformation, north-eastern Indian Ocean. *Earth and Planetary Science Letters* **94**: 71-77.

6. Gordon R.G., DeMets C. & Argus D.F. (1990). Kinematic constraints on distributed lithospheric deformation in the equatorial Indian ocean from present motion between the Australian and Indian plates. *Tectonics* **9**: 409-422

7. Bull J.M.& Scrutton A. (1990). Fault reactivation in the central Indian ocean and the rheology of oceanic lithosphere. *Nature* **344**: 855-858.

8. Chamot-Rooke N., Jestin F., de Voogd B. & Phedre Working Group (1993). Intraplate shortening in the central Indian Ocean determined from a 2100-km long north-south deep seismic reflection profile. *Geology* **21**: 1043-1046.

9. Van Orman J., Cochran J., Weissel J.K. & Jestin F. (1995). Distribution of shortening between the Indian and Australian plates in the central Indian Ocean. *Earth and Planetary* Science *Letters* **133**: 35-46.

10. Bilham R., Gaur V.K. & Molnar P. (2001). Himalayan Seismic Hazard. *Science* **293**:1442-1444.