J. Ind. Geophys. Union (2003)
Vol.7, No.2, pp.115-116

Passive and active deep seismic studies to understand the linkage between Madagascar, India and Sri Lanka, segments of East Gondwana super-continent

P.R.Reddy

National Geophysical Research Institute, Hyderabad – 500 007

ABSTRACT

Various East Gondwana super-continental models show linkage between Madagascar, India and Sri Lanka, before the break up. However, absence of continuity of structural elements from one continent to the other through the intervening oceans and presence of varied metamorphic events in different segments of the super-continent suggest detailed imaging of sub-surface structures through passive and active deep seismic studies to provide meaningful inputs to bridge some gaps in our understanding the structure and evolution of East Gondwana super-continent.

INTRODUCTION

Studies on deep continental crust assume great significance in terms of continental lithospheric dynamics primarily because much of the upper crust has developed in processes that involve the deep crust. These studies have gained global significance and are fundamental to the formulation of geodynamic models on the evolutionary history of the Earth, in understanding the juxtaposition of the continents in the geologic past as well as continental dynamics. So, one has to have deeper structural images to firm up geological models.

However, till to-date, this aspect has not caught the attention needed and while building up evolutionary models of super-continent researchers have tried to visualize the assembly, disruption and reassembly of super-continental configuration using mostly geological, geochemical and geochronological data. These models introduce an amount of subjectivity in invoking the role of lithospheric dynamics wherever the geophysical data support is missing, as the geophysical signatures help in having structural details that are vital for building up evolutionary models. To support such a theory a detailed and logically coherent picture is shown in the next couple of paragraphs involving Madagascar, India and Sri Lanka.

STUDY AND DISCUSSION

It is widely believed that the East African Orogen (EAO) (Stern 1994) stretches from the Middle East southward through Arabia, Egypt, Eritrea, Ethiopia, East Africa, and Madagascar into Southern India, Sri Lanka and Eastern Antarctica (Collins & Windley 2002). Prior to the break up of Gondwana, Madagascar was located adjacent to East Africa with the Seychelles to the northeast, India and Sri Lanka to the east and Mozambique to the south (Lawver, Gahagan & Coffin 1992; Lawver, Gahagan & Dalziel 1998).

When any evolutionary model is being developed one has to make use of the intricate tectonic setting involving both the oceans and continents, as different continental segments of East Gondwana super-continent are linked with one oceanic segment or the other. However, it has long been a problem how to accurately match up the Proterozoic structures across the intervening oceans (Kroener et al. 2000). Collins & Windley (2002) tried to provide answers to this by summarizing the available geochronology and tectonic history of the regions of Gondwana that surrounded Madagascar, using a number of different features to correlate the remnants of Gondwana distributed around the Western Indian ocean. These include (a) shear zones, (b) thermal fronts, (c) Provenance domains and (d) suture zones. According to them the Betsimisarka stuture zone of Madagascar being a provenance and thermal boundary, interpreted as an oceanic suture zone, has similar features as the Palghat-Cauvery shear zone system of South India and can be linked with each other. This apart the Ranotsara shear zone seems to be associated with the Karur-Kambam-Painavu-Cauvery shear zone (KKPT) and the Achankovil shear zone with the Tranomaro shear zone of Madagascar. In spite of such a supporting evidence one finds it difficult to categorically provide a deeper structural linkage model as much of the evidence along the proposed/conjectured suture zone has been destroyed by some combinations of tectonic over printing, isotopic resetting, burial beneath younger sediments and covering by mega thrusts.

As per Braun, Krisegsman & Cenki (2003) a linkage model between Sri Lanka and India through lithology, structural style, age and degree of metamorphism could be established as the lower crustal terrains of the Southern Granulite Terrain (SGT) can be correlated with the high-grade complexes of Sri Lanka.

They also suggest a link between Achankovil unit with southwestern position of Sri Lanka.

The above findings fairly support a linkage between Madagascar, India and Sri Lanka. However, absence of Neoproterozoic ages (820-640) in the SGT (Kroener et al. 2000), which are wide spread in Central Madagascar introduces an amount of objection to the linkage theory. Similarly presence of large volumes of ~880, ~1000 Ma calc alkaline granitoid rocks in the Wanni and Vijayan crustal provinces of Sri Lanka, unlike in SGT suggest that the basement rocks of Sri Lanka do not correlate with crustal domains in Southern India or in East Africa (Kroener, Kehelpannala & Hegner 2003). These opposing schools of thought have thrown open number of oft asked questions regarding linkage of different segments of East Gondwana super-continent.

SUGGESTED FOLLOW UP

When such a scenario is present what one has to do to resolve (if not fully) this problem is correlating deeper structural images through deep seismic reflection/refraction profiling supported by passive broad band based seismic receiver function studies, as they alone can bring out more explicitly subsurface extensions of surface features viz. shear zones, sutures etc.

These experiments need to be planned and executed in such a way that one can get a comprehensive subsurface crustal structural images of adjoining continents and intervening oceans along with continent-ocean transition zones. They in turn could be synthesized with the geological models to arrive at a more realistic structural and evolutionary model of super-continent.

ACKNOWLEDGEMENTS

This work has been carried out as an Emeritus Scientist (CSIR). Shri VYN Sarma has helped in preparation of the manuscript.

REFERENCES

Braun, I., Krisegsman, L.M. & Cenki, B., 2003. What happened to India and Sri Lanka during the Proterozoic? Proc. of the IGCP-440 and LEGENDS Int. Sym. & Workshop, Sri Lanka, March-April 2003, 13-17.

Collins, A. & Windley, B.F., 2002. The tectonic evolution of Central and Northern Madagascar and its place in the final assembly of Gondwana, The J. Geol., 110, 325-339.

Kroener, A., Hegner, E., Collins, A.S., Windley, B.F., Brewer, T.S., Razakamanana, T. & Pidgeon, R.T., 2000. Age and magmatic history of the Anatananrio block, Central Madagascar as derived from Zircon geochronology and Nd isotope systematics, Am. J. Sci., 300, 251-288.

Kroener, A., Kehelpannala, KV.W. & Hegner, E., 2003. 880-1000 Ma magmatic event(s) in the Wanni complext of Sri Lanka and speculations on their relevance for Rodinia and Gondwana super-continent formation, Proc. of the IGCP-440 and LEGENDS Int. Sym. & Workshop, Sri Lanka, March-April 2003, 32,

Lawver, L.A., Gahagan, L.M. & Coffin, M.F., 1992. The development of palaeoseaways around Antarctica. In Kennet, J.P., and Warnke, D.A., eds;. The Antarctic paleoenvironment: perspective on global change , Pt. 1. Vol.56, Antarctic Research Series, Washington, D.C., American Geophysical Union, 7-30.

Lawver, L.A., Gahagan, L.M. & Dalziel, I.W.D., 1998. A tight-fit early Mesozoic Gondwana: a plate reconstruction perspect5ive, Mem. Natl. Inst. Polar Res., Tokyo, 53, 214-229.

Stern, R.J., 1994. Arc assembly and continental collision in the Neoproterozoic East African Orogeny—implications for the consolidation of Gondwana, Annu. Rev. Earth Planet. Sci., 22, 319-351.