Where do we go from here?

Having been a part of the activities carried out in and around Mangalore, I sincerely feel that there should be a concerted, sustained and co-ordinated effort of Geoscience Departments, Geological Society of India, Geological Survey of India, Department of Education of State Governments, Service Organisations and the Industry to ensure that geoscience promotional activities are carried out on a larger scale and in a more effective and efficient manner. I urge fellow geoscientists to take the initiative and carry out some activities to promote Geoscience Education at the school level, kindle interest in young minds and enhance the common man's knowledge and appreciation of the importance of geosciences in our day-to-day lives.

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TECTONO-GEOLOGICAL MAP OF NORTHEASTERN INDIA AND ADJOINING REGION (Scale 1:4,000,000)

A Tectono-Geological Map of Northeastern Indian and Adjoining Region has been compiled and printed under the DST Project No. HR/UR/35/95 by D.R. Nandy ("Shefalika", GC-78, Salt Lake City, Calcutta - 700091). No brochure accompanies this map.

Nandy has long personal experience in working in different parts of Northeast India, from where he also hails. He had been compiling geological map of Northeast India and the adjoining regions of Bangladesh, Myanmar and Tibet (China) over a long time. He is one of the active workers on geology and tectonics of Northeast India and Adjoining Region, as well as, on the seismotectonic activity of the region.

Nandy has compiled this map from "published and own sources". A list of 13 sources has been included. Apart from references to geological maps of some countries included in the area and other than his own publications, other sources cited are of 1983 and earlier. A very similar Geological and Tectonic Map prepared by Nandy-1979 was published (in black and white) in the Geology of Nagaland Ophiolite (Anon, 1986). Neither this work nor later publications on geology and tectonics of NE India and the adjoining regions by other workers are cited. There had been an information explosion on geology of China, written in English, particularly during the 30th International Geological Congress, held at Beijing in 1996. A few publications have come out recently on the Eastern Himalayan syntaxis involving the Siang and Namche-Barwa domes (Berg et al. 1997; Acharyya and Sengupta, 1998). Much of these published data has not been incorporated in the present tectono-geological map. This may have been partly caused by logistic problem faced by the emeritus scientist. Redrafting and updating of such complex map is not easy and is time consuming in the conventional mode. The present-day mode of digital cartography amenable to easy editing and updating is not likely to be available to Nandy.

The map has been titled tectono-geological map, but tectonic domains and settings have not been identified. The author has relied on geographic domains and geological time units. The area has been subdivided into following domains in the inset map and legend: Meghalaya platform, Surma and Bengal basin, Assam-Burma basin including Assam valley, Axial zone, Central Burma basin,

Himalayan basin, Trans-Himalayan basin and Transverse mountains. From tectonic point of view, basins, shelf, rift setting in them, fold belts, sutures, arc complex, continental and oceanic domains, etc., need to be differentiated (cf. Acharyya, 1999). Units of diverse tectonic setting have been put together conversely domains with similar tectonic setting have been separated by Nandy (1999). For example, Assam valley is extension of Meghalaya massif with Tertiary shelf cover beneath the alluvial cover. The Surma 'basin' with its folded molassic Neogene sediments differs in its tectonic setting and stability to that of the Bengal basin. The Mesozoic-Tertiary shelf, in the western part of the latter, resembles more the shelf to the south of Meghalaya or Assam. Eastern part of Bengal basin might be floored by oceanic crust, and it is subducting beneath the Tertiary fold belt located further east. Parts of Assam-Burma 'basin' have significant similarity to the Surma 'basin'. What is the nature of crust beneath these areas? Traditionally it was thought to be oceanic but others contend it to be continental (Acharyya et al. 1990; Acharyya, 1997, 1998). Tectonic units of diverse settings are clubbed in the axial zone. It includes olistosromal trench sediments, the so-called exotics, and dismembered ophiolites corresponding to oceanic domain, and continental basement rocks and cover from the overriding Burmese continent. But all these are not presently located along a suture but now occur as westward thrusted nappe occupying a high structural level (Acharyya et al. 1990; Acharyya, 1997). Subdivision of domains into 'Himalayan, Trans-Himalayan basins and Transverse mountains appear even more confusing. The natural and accepted tectonic domain boundary like Tsangpo Ophiolite has been ignored. It has nearly lost its identity. In map it is shown as isolated patches of σPg_1, and in legend as 'ultrabasic rock sequence', and thus neither its well established ophiolitic suite, nor geologic age are correctly reflected. To a reader these may give a false impression as early Paleogene ultrabasic intrusives in a continental domain! The Himalayan basin in its legend does not include its classical Tethyan Himalayan sediments e.g., Everest pelite to Mesozoic shelf and flysch. These have been grouped in 'Trans-Himalaya'! The late Mesozoic magmatic are representing most important tectonic element of Trans-Himalayan belt is lost in the legend and appears mixed up with Mesozoic Tethyan sequence! Similarly, the continuity of Trans-Himalayan granitoid belt to the Transverse mountains also does not get reflected. Recent studies indicate that the eastern end of Tsangpo Ophiolite belt can be traced nearly along the Tsangpo-Siang gorge and curving round Namche-Barwa gneissic dome (Berg et al. 1997) and connected to the mafic-ultramafic rocks from Tuting. From Tuting the belt can be traced along serpentine-bearing Tidding lineament and then through northern Myanmar to the ophiolite belt of Myitkyna (Acharyya, 1999). The Tidding serpentinites are tentatively shown as KT in age in Anon (1993, 1998), but the serpentinites from Tidding and those from north Myanmar are inferred to be of Carboniferous age (σC) by Nandy (1999). Similarly, in Central Burma belt also, the ophiolites from inner belt are shown as pre-Tertiary and Carboniferous serpentinites in the legend! Assignment of Carboniferous age to these ultramafic-mafic rocks is intriguing. This is also contrary to the way the belt is represented in the Geological Map of South and East Asia by the Commission on Geological Map of the World (CGWM) Subcommission for South and East Asia (Anon, 1990). Much of the arc volcanics from Central Burma are shown to be of Pliocene in age and not Ng-Q in age.

In Naga hills and Assam foothills, the nature and disposition of Tertiary sediments and the Mesozoic ophiolites differ in details between that shown by Nandy (1999) and Anon (1986, 1993, 1998). The ophiolites in this belt are mainly shown by $\Omega KPgx$ symbol in the map and their nature is not clarified in the legend, but a list of various types of exotics/olistoliths present is included. The olistostromal unit is well developed in Manipur hills. Based on youngest age of olistolith present the host unit is dated middle Eocene in age. This unit is not uniformly exposed in Naga hills. On the other hand, the dismembered ophiolite suite has been mapped in Naga and Manipur

hills and it ranges in age from late Jurassic to early Eocene in age (Anon, 1986; Acharyya, et al. 1990). In the rest of Indo-Burmese range also, ophiolite rocks are not highlighted in the map. Some isolated patches of ultramafic rocks (σ) of K and KPgx are shown.

Since earthquake hazard assessment is one of the stated objectives of Nandy's study, some emphasis on collision related structures in the map, in the Himalayan belt to the north and Indo-Burmese Range to the east, especially polarity of such structures in time and space, was expected. Recognition of neotectonic structures is also of importance. A number of major and minor lineaments has been recognised in Bengal basin (Nandy, 1999). This basin exposes number of Pleistocene highlands e.g. Barind, Madhupur, Lalamai hills etc. The western boundary of the Madhupur upland is located a little away from river Jamuna, and is affected by several active faults (Morgan, 1970; Alam et al. 1990). Nandy (1999) shows only the Madhupur tract and without these details, and not the others and the active faults affecting them. On the other hand, Nandy has depicted a chain of Pleistocene terraces along the southern boundary of Meghalaya hills. This would mean stability for the Meghalaya hills since Pleistocene. On the contrary, these are shown as Holocene gravel and sand flanking the uplifted Meghalaya hills (Alam et al. 1990). Further, in Meghalaya hills, Nandy shows the basement rocks as the Archaean, whereas only the Proterozoic ages have so far been recorded. The Proterozoic Shillong Group has also been presently recognised from wide areas in Mikir hills (Anon, 1993, 1998) and these details do not get reflected in the map of Nandy.

In the Lesser Himalayan belt, the Gondwana-equivalent rocks are shown by CPtd symbol and clarified as Talchir and Damuda sediments of the Gondwana Supergroup in the legend. The basinal and tectonic setting of these rocks in the Himalayan belt is distinct from those of the Indian shield. Their lateral continuity and paralic to marine facies are distinctive, whereas the nature of their diamictites and associated bimodal volcanics recognised at places indicate failed rift setting (Acharyya, 1973, 1996). This tectonic aspect has not been reflected in the legend. Nandy (1999) has not correctly represented the disposition of the Abor volcanics and other rocks in the Siang dome (Anon, 1993, 1998). The presence of marine Paleocene-Eocene sediments in the Siang window and as thrust slivers along the Main Boundary Thrust over significant length in Arunachal Pradesh foot-hills has great tectonic significance (Tripathi et al. 1979; Acharyya, 1994; Acharyya and Sengupta, 1998). Similarity of their marine fauna establishes their lateral continuity. Early Miocene fauna of open sea type have been also recorded from MBT zone from Tista river section Darjeeling foothills (Acharyya et al. 1987; Sinha and Srivastava, 1992). Although map outcrop of these rocks may be very insignificant, they ought to find a significant place in the tectonic map of the area and in its legend.

The map compiled and published by Nandy (1999) is thus out of date and even the author admits that the data source to be up to 1986 only. With these limitations, it is still acceptable and useful as a geological but not a tectonic map. It is hoped that Nandy would address many of these issues presently raised in his proposed writeup. I have cited many of my references in this writeup only to emphasize the extent of published data available from the region under reference which needs to be logically analysed in any compilation dealing with tectonics.

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ERRATA

Please make the following changes on page 458, Jour. Geol. Soc. India, v.54, 1999. Column 2 first paragraph. The sentence beginning "From the Table ...." should read as "From the Table it is seen that SiO_2 varies from 40.62 to 54.23%, MgO from 31.56 to 44.09%;"