Palk Bay: A future industrial complex site?

After a lapse of some years, foreign investors have returned to Sri Lanka as that attractive nation's economic prospects brightened during 2004. Reorganization of the traditional sea lines of communication between China and the Suez Canal are currently being planned by macro-engineers. Without the benefit of a proposed Kra Canal, small boats have already passed across an intervening peninsula![1] India has publicly examined the possibilities of significant commercial exports to China via a Rangoon–Mandalay–Kunming route. An overland railroad and a motor highway, affording China access to the Andaman Sea, would alter China's relationship with both India and Sri Lanka, and make a sea level Kra Canal unnecessary. Palk Bay, situated between India and Sri Lanka, may become an industrialized regional complex, consisting of complementary floating and land-fixed facilities, serving both countries during the early 21st Century. Eventually, the Palk Bay may become a base seaport servicing a funicular space elevator anchored to a floating passenger and freight station sited in calm waters at the equator[2]. India already has claimed a submarine deposit of poly-metallic nodules on the Southern Hemisphere seafloor almost due south of Palk Bay[3].

The Palk Bay and its vicinity are under close scrutiny by macro-engineers intending construction of various industrial facilities. From *circa* 1955, India experts recontemplated a 'Sethusamudram Ship Canal Project' (SSCP)[4], first proposed *circa* 1860 by Commander A. D. Taylor, which would let large ships reliably pass during all weather conditions through Adam's Bridge[5], a barrier of sorts that separates the Palk Bay from the Gulf of Mannar. The macro-engineering objective of the ~ 83 km-long channel-like passage must be met by rapid excavation of a well-marked, safe ship passage to reduce by ~ 500 km the distance ships travelling between India's east and west coasts must navigate. The SSCP would be ~ 800 m wide and ~ 10 m deep. Upon completion, the SSCP will cause an increase of the extant intra-national and international freight and passenger flow (along with participating corporate profitability) of India's major seaport Tuticorin (established 1974) is anticipated[6].

Adam's Bridge is a ~ 30 km-long shallow ridge of Holocene conglomerate and sandstone mantled with islands and shoals of shifting sand, which is all resting upon Miocene limestone; it has ~ 9 km of islands and shallows with ~ 21 km of open water. During the 23 December 1964 cyclone, the depth of water at Vankalai (near Mannar) rose 2 m owing to the cyclone's accompanying storm surge. Accurate prediction of bio-geomorphologic[7] and anthropo-geomorphologic[8] event-processes is still very difficult; quick mechanical removal of $\sim 664 \times 10^6\ m^3$ of spoils (and its simultaneous deposition as spoil somewhere else nearby) to create a safely passable SSCP might initiate geomorphic and ecologic reactions that are only a subject for macro-engineering speculation. Adam's Bridge is as complex structurally as its noteworthy analogue, the Florida Keys[9]; even its commonly proposed use as a transportation fixed link between India and Sri Lanka is very similar to the 'Railroad over the Ocean' that once used the Florida Keys as its conveyance foundation[10]. Critics of the SSCP allege publicly that such a quickly dug big trench will certainly cause a sudden tilt, drift, and a gravitational pull and, as well, that other violent geological event-processes will surely be instigated that might drastically alter the Miocene limestone bed of northern Sri Lanka and its islands thereabouts (Delft Island, Mannar). Since geophysical observations do not affect the geologic environment (and may be repeated as many times as required), the application of various monitoring devices to characterize the prevalent, dynamic, general event-processes (by isolating their deformational components) is indisputably necessary, no matter what the financial cost involved. All valid public fears concerning future negative structural geologic and various uncommon geomorphic event-processes must be allayed![11].

It may be possible to prevent and/or repair any massive disruption of the Miocene limestone underlying northern Sri Lanka if Roelof D. Schuiling's geochemical method of converting limestone to gypsum and, thereby, increasing the volume of the region's sub-surface geological environment by up to ~ 53% is utilized[12]. The 'Palk Strait Power Station' on Adam's Bridge proposed by Cathcart in 2003 absolutely requires that all foundations for the offshore wind turbines and hydro turbines be secure and permanent[13]. The biological response of Palk Bay to summer monsoon conditions has been only preliminarily examined[14]. Fringing coral reefs are present in the Gulf of Mannar and Palk Bay and this raises, literally, an interesting serendipitous secondary geochemical method for preserving and conserving islands in and about Adam's Bridge. Henry Theodore Cheever (1814–1897) first published his *Life in the Sandwich Islands: or, The Heart of the Pacific, as it was and is* (New York: A.S. Barnes & Co., New York, pp. 355) in 1851. At page 350, in the course of his encompassing remarks on coral reefs, Cheever asked the question, '[W]hy may we not employ the agency of the coral lithophytes to lay the foundations, for instance, of a lighthouse, or to form a breakwater where one is needed?' Wolf Hilbertz has answered Cheever's query by developing a technology to enhance the lithophytes depositions[15]. Hilbertz has been awarded a USA Patent, #4246075, on 20 January 1981, for 'Mineral Accretion of Large Surface Structures, Building Components and Elements'. The cost per kilogram of artificial coral forced to grow by Hilbertz' artificial electrical stimulation added to any Palk Bay island might be ~ 2004 USA $ 1, or a bit more costly than an equal amount of cement used to manufacture concrete. However, if the electrical power is local, very low-cost and provided freely by wind and ocean currents, then it may be possible to address SSCP foundational malfunctions with Hilbertz' methodology[16].

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Appropriate sampling design in palaeobotany for correlating floristics with stratigraphy

Palaeobotany, the study of plant fossils, is basically concerned with the morphological and taxonomical aspects of different types of plants preserved in stratified succession of rocks. However, recovery of morphologically distinct plant fossils at different time spans of the earth's history, enhances the significance of fossils in stratigraphic sequencing of sediments at particular time periods. Seward[1] has emphasized the role of palaeobotany as 'the distribution of plants in time, that is the range of classes, families, genera and species of plants through the series of strata which make up the crust of the earth is a matter of primary importance from a botanical as well as a geological point of view'.

In order to accomplish the two-fold task in palaeobotany, it is important to design appropriate sampling strategy for maximum stratigraphic coverage of the area, including all lithological variations. The technique helps analyse the plant association and relative changes in plant composition in time and space.

As such, there are no accepted principles or procedures for collecting rock samples for palaeobotanical analysis. The sampling design is based on the type of work, i.e. the study of megafossils covering leaf, fruiting body, stem, root, seeds, etc. and microfossils of pollen-spores, acritarchs, algae, fungi, diatoms, microplanktons, etc.

After establishing the nature of study, appropriate sample size and design are required to collect samples at different stratigraphic intervals in the field. Detailed stratigraphic work requires close sampling, whereas widely spaced samples are used for large stratigraphic intervals. The following sampling techniques are used to study the fossils in relation to superimposition or stratigraphic positions of rocks: spot sampling, channel sampling, core sampling and random sampling.

To locate fossiliferous horizons in a thick sequence of rocks, spot sampling is performed at regular intervals in a regular pattern (square, rhombic or rectangular spacing pattern) from the outcrops of the same lithology. Spot sampling helps identify the general floristic composition of a particular stratigraphic sequence known by thick shales, siltstones or limestones. The sections exposed in road cuts, rail cuts, or in naturally trenched streams and rivers, are suitable sites for spot sampling. The spacing between two samples sites depends on the thickness of the exposures and it can vary from a few centimetres to more than a metre or so. Where outcrop permits, the common practice is to collect spot samples at more or less uniform intervals vertically throughout the deposit; the interval is chosen on the basis of thickness and lithology of the outcrop[2]. Spot sampling is used during a reconnaissance survey or for comparative morphological studies and for supplementing or establishing reference collections.

Channel sampling is a well-established collecting technique for biostratigraphic work especially in palynological and micropalaeontological investigations. In this method, the outcrop is trenched to expose the fresh surfaces and then samples are collected at specified intervals from all stratigraphic columns normal to the bedding through the vertical thickness. In 1 m section, samples at a distance of 30 cm are suitable for study. However, when the outcrop section is not thick and there is a change in lithology at short intervals, close sampling at a regular distance of 2–3 cm provides better results[3].

Channel sampling can be applied at three stages depending upon the thickness and extension of the stratigraphic succession exposed in outcrop section[4]:

Reconnaissance: When the outcrop section is represented by a number of stratigraphic sequences, representative samples from all the horizons are collected to understand the fossiliferous nature of different stratigraphic successions.
Selective sampling: This is carried out at close intervals (1–5 cm) in a particular stratigraphic sequence to understand the comprehensive distribution of flora.
Bulk collection: When there is poor yield of fossils in a particular stratigraphic column, large amounts of samples (1–5 kg) are collected to examine the characteristic fossil contents. The method is useful in standardizing the biozonation of different rock types.

Core sampling is utilized in oil and coal industries to locate the stratigraphic position of sediments. Exact information of lithological changes, contact of different rock types and structural features (faults/folds) are clearly distinguishable in core samples.

Before proceeding to analyse the core samples, these are cleaned of dried mud contamination and sub-samples. The division of core samples in smaller units, labelling and documentation of exact length, core types and lithological variations are essential for undertaking palynological and micropalaeontological work.

Core samples are best suited for analysing floristics with stratigraphy. However, since the coring is carried out in commercially viable areas, the availabi-