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A re-assessment of Mesozoic Meta-sedimentary Successions in Singapore: Terrestrial to Deep Marine Depositional Environments and Stratigraphical Framework

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To address competing land-use requirements, and the needs of an ever-growing population, Singapore looks to the subsurface to meet many of its future development needs. The subsurface is now considered an attractive development space for, amongst other things, energy production and infrastructure, waste disposal and treatment, groundwater abstraction and water storage, transportation infrastructure, industrial manufacturing and logistics. Singapore aspires to become a 'smart' nation/city that integrates transportation, utilities and services infrastructure with information communications technology (ICT) in order to facilitate sustainable management of its societal assets. A comprehensive understanding of Singapore's geology is therefore critical to both future development and ongoing management of the subsurface.

The British Geological Survey (BGS) is working with Singapore Building and Construction Authority (BCA) to deliver that modern geological knowledge-base to benefit the widest possible stakeholder community, including the public and private sectors and academic institutions. BCA have implemented a new and comprehensive ground investigation programme, recovering drillcores from c. 100 deep boreholes (typically to 200 m depth) and acquiring conventional 2D seismic reflection data from across some 350 km^2 of ground. All of this new data provides an unprecedented opportunity to unravel the complex geological relationships that exist in the Jurong Group, a complex fore-arc succession which crops out in southwest Singapore and is a correlative of the Raub Group in Malaysia. This paper presents a summary of work to date by BGS to conduct a new sedimentological environment analysis of the Singapore outcrop of the Jurong Group, which will underpin a revision of the stratigraphical framework for Singapore. A revised structural framework for the Jurong Group is described in a companion paper also presented at this conference (Leslie *et al*. also in this volume).

The geology of Singapore is dominated by Permian to Triassic arc magmatism and sedimentation succeeded by collisional accretion tectonics in the latest Triassic to early Jurassic. The sedimentary successions, which are characterised by marked lateral and vertical variability, are interpreted to reflect deposition in a range of environments. The generalized vertical succession within the Jurong Group on Singapore is now understood to consist of the following components, in chronological order.

1. A shallow marine, cyclic carbonate and siliciclastic environment that is succeeded by a range of deep, shallow and marginal marine environments, and by a terrestrial-fluvial environment. This association of depositional settings is characteristic of a basin margin. The products of contemporaneous volcanism - including air-fall and ignimbritic pyroclastic rocks and tuffites - are a common feature in much of the succession, forming deposits up to around 200 metres thick.

2. Thickly bedded carbonates, thin siltstones, and minor tuffs that were deposited within a relatively restricted basin when compared with the underlying succession. The basin then experienced renewed siliciclastic input from terrestrial fluvial systems, which acted to shut down carbonate production. The siliciclastic sediment was re-worked in marginal marine to shallow marine settings. Limited accommodation space resulted in basin shallowing, with fluvial processes gradually becoming dominant. The upper portion of the succession is dominated by fluvial/alluvial and/or fluvio-lacustrine deposition, during which a vast quantity of immature sediment was brought into the basin through activation of alluvial fans.

3. Two early Cretaceous (Berriasian and Barremian), mainly terrestrial, successions overlie a significant unconformity, and overstep the collisional tectonic structures. Dextral strike-slip tectonics in the mid-Cretaceous (?Cenomanian) produced brittle faulting across Singapore which may have resulted in alluvial fan rejuvenation, particularly in the hanging walls of developing normal faults.

A revised stratigraphical framework will be constructed through a combination of: litho-facies analysis; an appreciation for sedimentological variability

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in 3D space and time; and constraining the age of key units and boundaries within the sequence introducing an important element of chronostratigraphical control. Furthermore, the variations observed and documented in this paper are being developed alongside, and greatly complement, recent advances in the understanding of the structural framework, presented in Leslie *et al.* (also in this volume). These new integrated studies will redefine the stratigraphic framework for Singapore, enabling it to be properly placed within the regional geological context.