HYDROCARBON POTENTIAL PF CRETACEOUS TETHYAN REALAM IN MYANMAR

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Abstract

Occurrence of organic matters in the Cretaceous marine fossiliferous limestones, viz., Thaungpwet Taung limestones exposed at the Second Defiles of Ayeyarwady River and Paungchaung limestones exposed at the eastern foothill of Mt. Victoria are studied. The identified fossil assemblages indicate that the paleobiogeographic locations of the two units were in the northern Tethys Sea during Cretaceous. Both lithofacies and biofacies analysis reveal that the light bluish grey limestones (Thaungpwet Taung Formation) were deposited in an opened lagoonal basin in the shallow marine shelf underlain by the well-oxygenated subsoils and later, the organic matters accumulated in the limestones were eventually replaced by calcites during diagenesis. The dark brownish grey limestones (Paungchaung Limestone Formation) were deposited as distal carbonate ramps in deeper sea with euxinic floor and later enrich with organic matters due to the worldwide oceanic anoxic event (OAE) which is indicated by the high ratio of smaller planktic foraminifers and dinoflagellates to the smaller benthic foraminifers, and occurrence of iron sulphide (pyrite) in the chambers of planktons' test. In addition, the planktic foraminiferal biostratigraphic zones recognized in the Paungchaung limestones indicate a coincidence with the mid-Cenomanian OAE which caused a large accumulation of organic carbon across the Tethyan realms. It is contrasted, that above two types of limestones have different amount of organic matters though a global event provided similar euxinic condition. Therefore, in can be regarded that the geometry of individual basin was major controlling factor to the physiochemical condition of each basin. Present study evidenced that Paungchaung limestones with high organic matters were accumulated during the mid-Cenomanian OAE occurred across the Tethys Sea. Indeed, these limestones underlie the Tertiary clastic sequences of Central Myanmar which are being drilled for the hydrocarbon industries.

Keywords: Cenomanian, organic matters, oceanic anoxic events,

Introduction

Mesozoic rocks deposited in the Tethyan realm are very interested for their hydrocarbon potential as source rocks for the oil and gas exploration. It was noted that Tethyan realm provides about 70 per cent of the world petroleum reserves. Therefore, paleodepositional configuration of the Tethyan realm has been prepared to understand the controlling parameters for the accumulation of organic carbon. With reference to that integrated works, a microfacies analysis and paleodepositional synthesis is carried out with comparative study on the Myanmar Mesozoic rocks with those prolific units reported from the other Tethyan realm.

Most of the hydrocarbon source rocks are marine sedimentary rocks, e.g., limestone and shale, which are rich in primary organic matters. Both organic carbon and inorganic carbon are accumulated in the marine sediments. The organic matters derived from the terrestrial sources and also from the marine sources are deposited and then changed into the organic carbon during the diagenesis.

During Cretaceous, marine sediments with high organic carbon content were deposited widely in the Tethyan Sea as well as in the epi-continental seas of Boreal region. The depositional basins were formed in a variety of paleo-bathymetric configuration. The widespread and synchronous occurrence of these organic carbon-rich deposits in various basins with different geometry indicates that organic carbon accumulation is not strictly controlled by the basin

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geometry but much provided by a worldwide mechanism, certainly, Oceanic Anoxic Events (OAEs) (Gambacorta *et al*., 2016).

Objectives of the present research

During Cretaceous, there were three salient events, of which tremendous accumulation of organic matters in the marine carbonate and shale. These three events were known as (OAE 1) occurred in the Early Albian, (MCE) occurred at mid-Cenomanian and (OAE2) began near to the end of Cenomanian. In Myanmar, marine fossiliferous limestones with Albian-Cenomanian fossils are found in the northern and western Myanmar and hence, those limestones are re-examined for present research with following objectives;

(i) lithofacies and biofacies analysis done for the regional correlation of studied Myanmar limestones with those of the Tethyan realm,

(ii) paleo-depositional synthesis carried out to decipher the controlling factors on the accumulation of organic matters in the limestones.

Study areas and the methods of study

In Myanmar, the Cretaceous Tethyan realms are recognized by the presence of globally distributed smaller planktic foraminifers, nannofossils, and dinoflagellates which were boomed in the Tethys Sea. Profuse numbers of these zooplanktons and phytoplanktons are observed in the limestones exposed along the Tagaung-Myitkyina track, in the Jade-mines area, in the Pinlebu-Banmauk area, and at the eastern foothills of Mt. Victoria. Among them, fossiliferous limestones of Thaungpwet Taung Formation exposed at the Second Defile of Ayeyarwady River (study area 1 in Figure 1), and Paungchaung Limestone Formation near Saw (study area 2 in Figure 1) were re-visited and re-examined in year 2017 and 2019. Both megascopic and microscopic analyses of lithofacies and biofacies were done and some rock-samples are being processed for the TOC analysis.

Cretaceous Tethyan marine sediments in Myanmar

During Cretaceous the Shan-Thai Block is a particular domain which was amalgamated into the Indochina Block of Eurasia Plate. The succeeding oceanic part behind the Shan-Thai Blocks became a shallow marine shelf for the deposition of fossiliferous Cretaceous limestones and later it was amalgamated into the foregoing Shan-Thai Block. The oceanic fragment underlying the present western Myanmar, west of the East Kachin ranges and Shan Plateau, was evolved as Burma Block after Cretaceous.

During Triassic and Jurassic, the posterior margin of the Shan-Thai Block was passive continental margin and accommodated for the deposition of mudstone-dominated turbidites (i.e., Shweminbon Formation and its homotaxial) and volcaniclastic silici-clastics (i.e., Loi-an Formation and its homotaxial). The block was regarded to be in the tropical Tethys Sea as suggested by the fauna and the occurrence of red-beds (i.e., Kalaw and Hsipaw red beds).

The proto-Burma Block comprising with ophiolitic basement (i.e., Ngapyawdaw Chaung Formation and its homotaxial) and overlying Thaungpwet Taung limestones, Namakauk limestones, Paungchaung limestones, Kyigone/Kabaw shales and Falam turbidites was developed as a narrow shallow marine shelf in the northern tropical (arid) Tethys Sea as shown in Figure 2. Therefore, present studied limestones were deposited in the northern Tethys Sea and observed for aminifers analogues to the affinities of western Tethyan realms described from the Tibet, Alps, Spain, Zagros (Iran). By contrast, Myanmar Cretaceous foraminiferal assemblages are different to

the assemblages described from the India's east coast and Tunisia, which were southern Tethyan realms (Thura Oo, 2000).

The northern Tethyan realm in Myanmar are recognized by the presence of globally distributed planktic foraminifers, nannofossils, and dinoflagellates which were boomed in the Tethys Sea. Profuse numbers of zooplankton and phytoplankton assemblages leading by the Albian and Cenomanian foraminiferal index species and zone species are observed in two limestone successions exposed at study area 1 and 2, respectively.

Thaungpwet Taung limestones

Albian-Cenomanian limestones exposed at the Second Defiles are thinly laminated to poorly bedded light bluish grey bioclastic and micritic limestones (lime mudstone-wackestone-packstone-grainstone-floatstone) (Figure 3) (Than Than Thwe and Thura Oo, 2020). Intense diagenesis and tectonic deformation are observed. The comprising mega-fossils are; gastropods, bivalves, bryozoans and Scleractinian corals. The foraminiferal assemblages represent *Orbitolina concava* Biozone and *Hedbergella planispira* Biozone (Thura Oo, 2000). Both carbonate lithofacies and biofacies analyses indicate that majority of the limestones are proximal carbonate ramps, deposited in an open lagoonal shelf. Rich population of larger and smaller benthic foraminifers with other bottom dwelling organisms, viz., bivalves, gastropods, corals, bryozoans and algae indicate a well-oxygenated subsoil and bottom water. Presence of nannofossils and dinoflagellates also suggests well-access to the opened sea and nutrient-rich basin-water-circulation (Than Than Thwe, 2010, 2011).

Though, the limestones are fossiliferous, original organic matters, such as, shells, tests and algal mat, were totally replaced by the calcite, and the chambers were filled with sparry calcite and lime-mud. Therefore, most of the organic matters accumulated in the sediments were already transformed during the diagenesis. In addition, some lime-mud or micrite were replaced by the sparry calcite and plant-derived organic matters were already decayed, too. No salient organic matters were observed in thin-sections of the limestones (Figure 3).

Paungchaung limestones

Albian-Cenomanian limestones exposed in the Paung-nge stream in Saw Township are well bedded dark brownish grey bioclastic and micritic limestones (lime mudstone-wackestone) intercalated with thin dark grey calcareous mudstone and fine-grained sandstone (Figure 4) (Than Than Thwe and Thura Oo, 2020). Moderate diagenesis and tectonic deformation are observed. The biotas contained in the limestones are planktic foraminifers and dinoflagellates with minor radiolarians. The planktic foraminiferal assemblages represent *Hedbergella planispira* Biozone together with occurrence of *H. delrioensis*, *Rotalipora* spp. *Textularia* spp. (Thura Oo, 2000). Both carbonate lithofacies and biofacies indicate that the limestones are distal carbonate ramps, deposited on a slope with minor as well as intermittent muddy turbidity currents. No larger benthic foraminifers have been found in present study. Therefore, the subsoil might be less-oxygenated and unfavourable for the bottom dwellings. However, presence of smaller planktic foraminifers and dinoflagellates suggests opened sea and nutrient-rich upper water.

Though, most of the shells and tests of the foraminifers were replaced by the calcite, the chambers of the tiny tests were filled with pyrites. In addition, most of the organic matters accumulated in the sediments were preserved and found as dark brown amorphous organic matters in thin-sections. The controlling factors on the depositional paleo-environmental might prohibit the bottom oxygenation and bottom habitats by prevailing a euxinic condition.

Findings and Concluding Remarks

The identified fossil assemblages in the limestones indicate that the depositional environment of the two units were in the northern Tethys Sea during mid-Cretaceous. Both lithofacies and biofacies analyses of the limestones reveal that the Thaungpwet Taung Formation was deposited in an opened shallow marine shelf with lagoonal condition which was underlain by the well-oxygenated subsoils. Therefore, the organic matters accumulated in the limestones were eventually replaced by calcites during diagenesis.

The Paungchaung Limestone Formation was deposited as distal carbonate ramps in deeper sea with euxinic floor. At the same time, it was considered that the arid and warm climate with high pCO_2 provided from the volcanisms prevailed highly productive and nutrient-enrich upper water while deeper water on the base of the continental slope and abyssal plain condition were reducing and anoxic caused large accumulation and preservation of organic matters. This worldwide OAE is indicated by the high ratio of smaller planktic foraminifers and dinoflagellates to the benthic foraminifers, and the occurrence of iron sulphide (pyrite) in the micron-sized chambers of planktic foraminifers' test.

In addition, among the Albian-Cenomanian planktic foraminiferal biostratigraphic zones, the *Hedbergella planispira* Zone was well-recognized in the Thaungpwet taung limestone and Paungchaung limestones. In the western Tethyan realm, the occurrence of mid-Cenomanian OAE (MCE) overlapped with this biozone.

It is noted that both limestones have similar stratigraphic position and were deposited in northern Tethyan realm, physiochemical condition of the bottom-waters which was largely controlled by the basin geometry caused oxidizing condition to the shallow shelf while a worldwide anoxic condition of the sea was occurred. Therefore, it is contrasted, that above two types of limestones have different amount of organic matters though a global event provided similar euxinic condition. Therefore, in can be regarded that the geometry of individual basin was major controlling factor to the physiochemical condition of each basin.

Organic carbon-rich sediments were developed worldwide in pelagic sedimentary sequences of Early and mid-Cretaceous Tethys, oceanic plateaus, basins, continental margins and shelf. They were deposited in a variety of paleodepositional and basin geometry. The widespread occurrences of these large accumulation in short interval of Cretaceous were regarded to be a product of Cretaceous OAEs but there were modification prevailed by the local basin geometry. In addition,

Based on the study of the Mesozoic rocks exposed along the east, northeast, north and western margin of the Cenozoic Basin of Myanmar, the oil and gas producing reservoirs are underlain by the Cretaceous fossiliferous marine sediments and ophiolitic basement (Thura Oo, 2000). Therefore, these Cretaceous limestones are being paid much attention for the source rocks identification as well as origin and migration of the hydrocarbon.

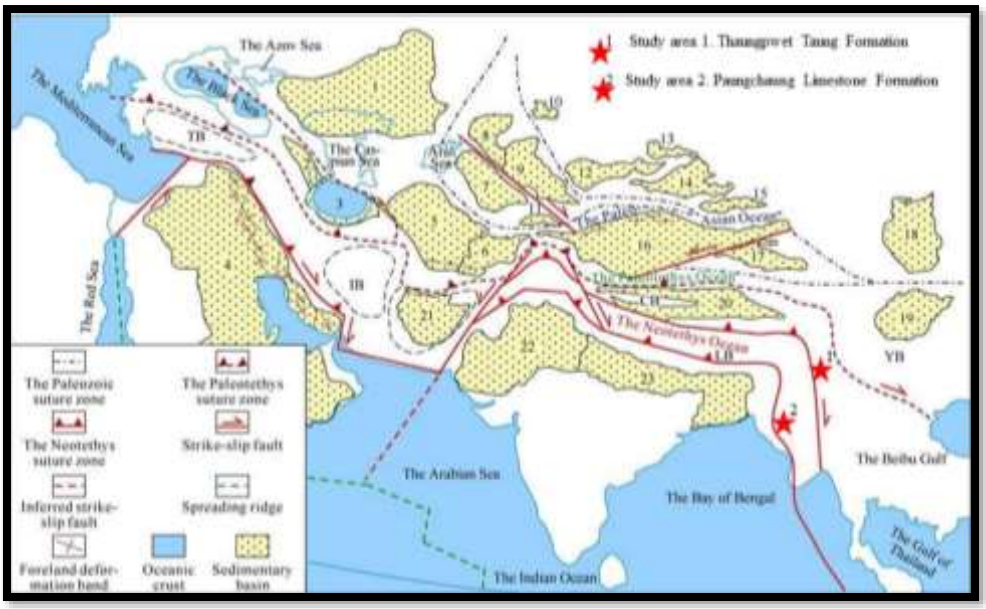

Figure 1 Locations of the present study areas (red stars) demarcated on the Map of the modern spatial distribution of the Tethys structure domains (Chengzao *et al*., 2018).

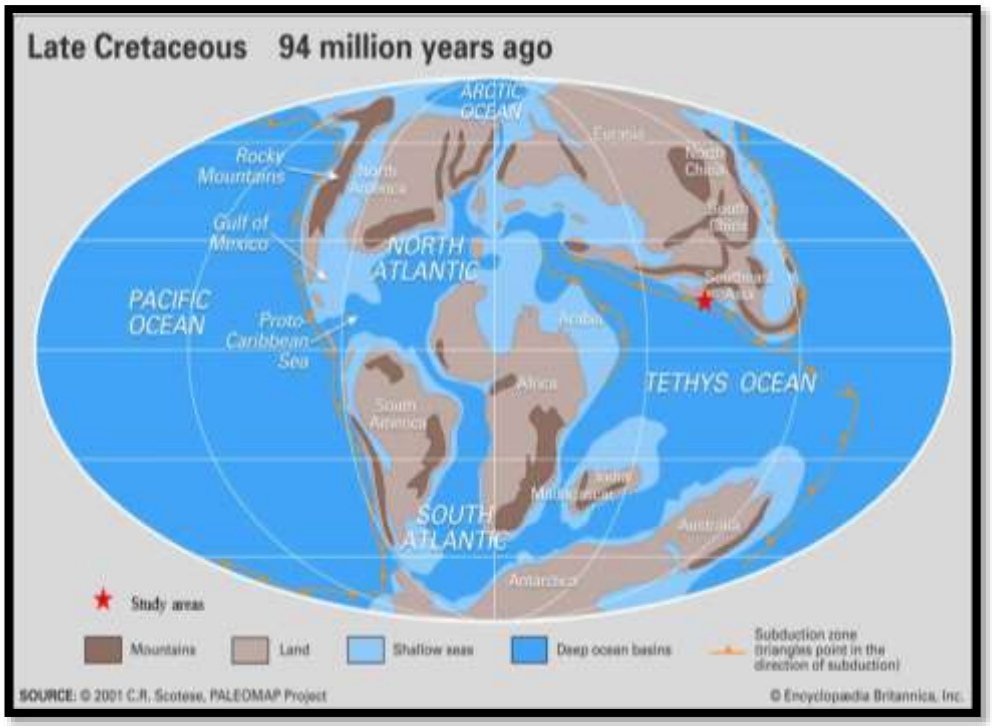

Figure 2 Showing the study areas on the reconstructed paleogeographic map of the Earth for Late Cretaceous to recognize their position in Tethys Ocean.

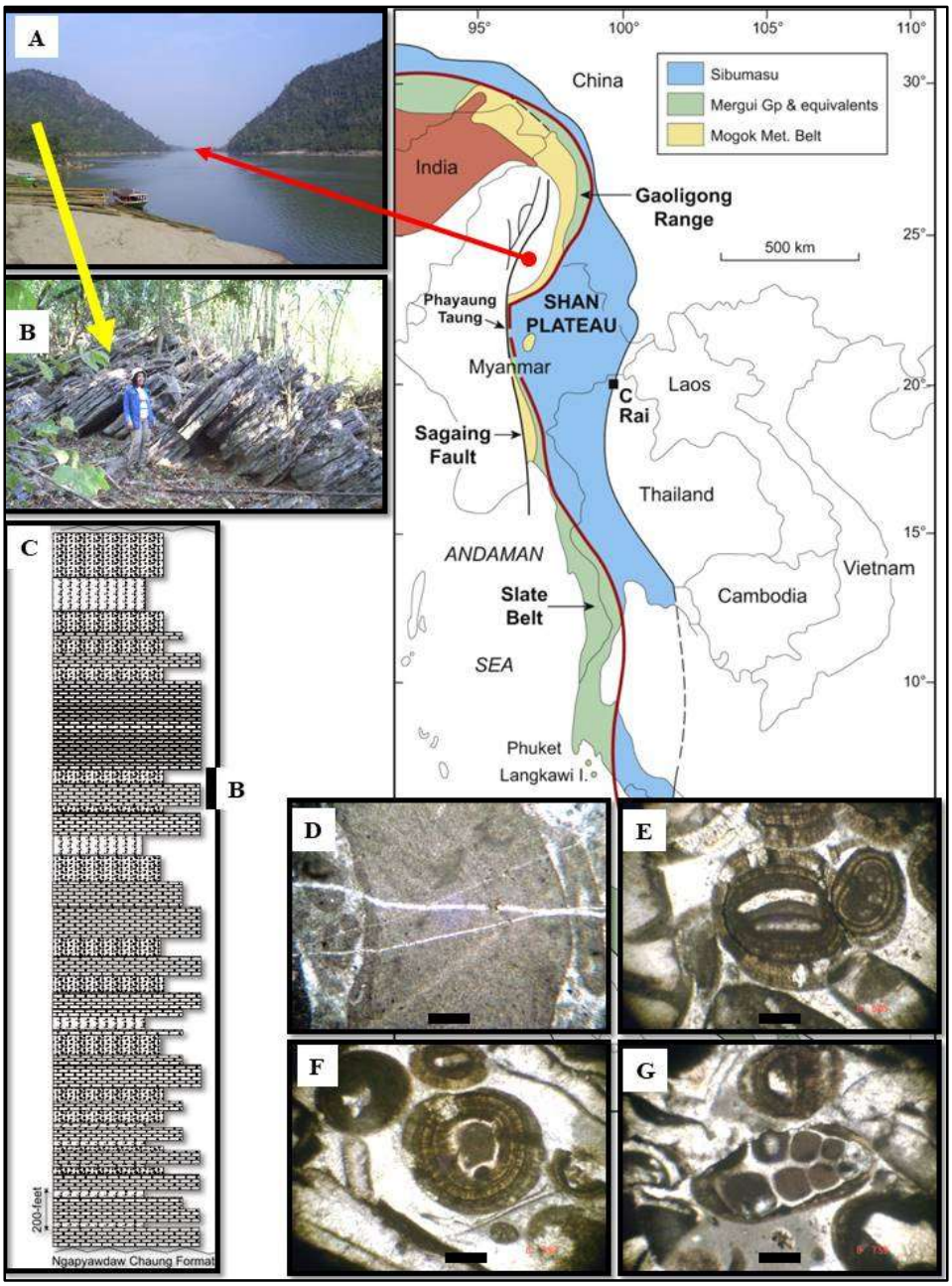

Figure 3 Thaungpwet taung limestones exposed at the Second Defile of Ayeyarwady River. The inserted tectonic domain map (Mitchell, 2018) is used to show the location of sampled limestones. (A) The Defile. (B) The thin-bedded bioclastic floatstone-grainstone-rudstone. (C) The measured lithostratigraphic column of the Formation at the defile, the stratigraphic position of the outcrop (B) is indicated. (D-G) Microphotographs showing the biotas including organic carbon are already replaced by the calcite. All scale-bars are 0.1 mm in length.

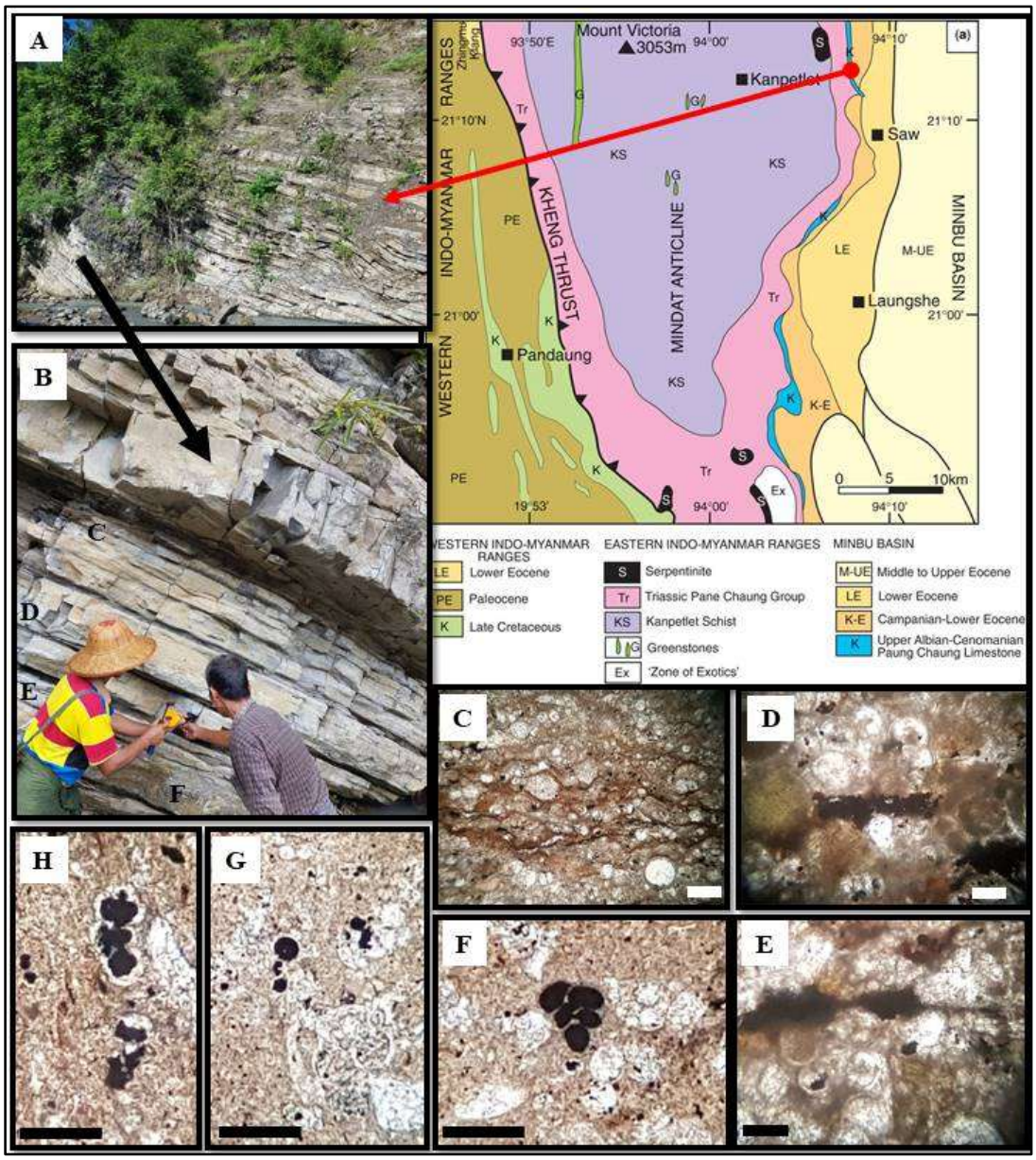

Figure 4 Paungchaung limestones. The inserted geological map of southern Mt. Victoria (Mitchell, 2018) is used to show the location of sampled Paungchaung Limestone Formation, well-bedded limestones intercalated with thin calcareous mudstones and fine-grained sandstone, exposed on the northern cliff of Paung-nge stream. (B) The outcrop of thin-bedded bioclastic wackestones. (C-E) Microphotographs showing organic-rich laminations and amorphous organic matter. (F-H) Microphotographs showing pyrite-filled chambers of foraminifers' tests. All scale-bars are 0.1 mm in length.

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References

Chengzao, JIA, ZOU Caineng and *et al*., (2018) Significant progress of continental petroleum geological theory in basins of Central and Western China, *PETROL. EXPLOR. DEVELOP*., vol. 45, p. 573-588.

Gambacorta, G., R. Bersezio, H. Wlissert and E. Erba (2016) Onset and demise of Cretaceous oceanic anoxic events: The coupling of surface and bottom oceanic processes in two pelagic basins of the western Tethys. *Paleoceanography*, vol. 31, p. 732-757.

Mitchell, A.H.G. (2018) *Geological Belts, Plate Boundaries, and Mineral Deposits in Myanmar*. Elsevier, 509 pp.

Than Than Thwe, (2010). *Lithofacies and biofacies analysis of the Thaungpwet Taung Formation, Second Defile of Ayeyarwady River, Myanmar*. Ph. D. Thesis, University of Yangon (unpublished)

Than Than Thwe, (2011). Paleodepositional Environment of the Thaungpwet Taung Formation, Second Defile of Ayeyarwady River. *Universities Research Journal*, vol. 4.

Thura Oo, (2000). *A biostratigraphic synthesis on the Cretaceous Foraminifers in Myanmar*. Ph. D Dissertation, University of Yangon (unpublished)

Thura Oo and Than Than Thwe, (2020) Reinvestigation on the Cretaceous marine lithostratigraphic units of Myanmar. *University Research Journal*, vol. 11, 2, pp 268-281.