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SEQUENCE STRATIGRAPHIC IMPLICATION OF THE NAPENG FORMATION EXPOSED AT NAPENG – NAMON AREA, KYAUKME TOWNSHIP, NORTHERN SHAN STATE

Cho Cho Lwin[1] and Zaw Win[2]

Abstract

Napeng-Namon area is mainly consisting of carbonate and silicilastic sedimentary rocks of Late Permian to Late Triassic age. In this paper, lithofacies and sequence stratigraphy of the Late Triassic of Napeng Formation are studied in detail. The sequence boundary between Nwabangyi Dolomite Formation and Napeng Formation is type I sequence boundaries (SB) which is represented by a significant unconformity. In the present study, the Napeng section contains stacked depositional cycles consisting of characteristic succession of sedimentary facies and facies associations. Based on detailed measurement, these sliciclastic-carbonate facies are deposited by shallow marine tidal current. Seven fourth-order shallowing upward, parasequence cycles can be recognized by environmental changes within Napeng section; by the graduality of the change in lithology, facies composition and faunal content. Features formed during the transgression, such as hardgrounds, iron-stained surface, and mollusk bearing siltstone are more prominent than the subaerial exposure features. Sequence in these outcrops display fewer paleokarst features and more pyritized and erosional hardgrounds at flooding surfaces and transgressive surfaces. The deposition of the Late Triassic (Napeng Formation) can be regarded as the progradational stacking pattern with some aggradations and these homoclinal ramp stack may show vertical accretion, but individual sequence seldom develop in a keep-up style.

Keywords: shallowing upward, transgression, progradation, homoclinal ramp

Introduction

The Napeng-Namon area is situated about 7 miles, south-east of Kayukme, northern Shan State. In Napeng-Namon area, most shallow marine sections of Late Triassic age were formed in mixed carbonate-siliciclastic systems, and shallow marine limestones as a homoclinal ramp, which has been studied from a sequence-stratigraphic view point of Napeng Formation. Sequence stratigraphy is a powerful tool for explaining the relationships of allostratigraphic units that analyses the sedimentary response to base-level changes. Through the recognition of boundary surfaces, genetically related facies (system tracts) can be identified. Lithofacies can be correlated accounting to where each unit is positioned along an inferred curved that represents base-level fluctuations.

From the establishment of the fundamental concepts of sequence stratigraphy by Vail *et al*. (1977), the relation between sediment supply and carbonate production, and accommodation space largely determines the facies distribution. The purpose of this paper is to express and discuss data on lithofacies, depositional systems and sequences stratigraphy and a detailed analysis of the evolution, anatomy and sedimentology. The studied sedimentary sequences belong to the Late Triassic units (Napeng Formation) of Napeng- Namon area are shown in Fig. (1)

[1] Dr, Associate Professor, Department of Geology, Panglong University
[2] Dr, Associate Professor, Department of Geology, Panglong University

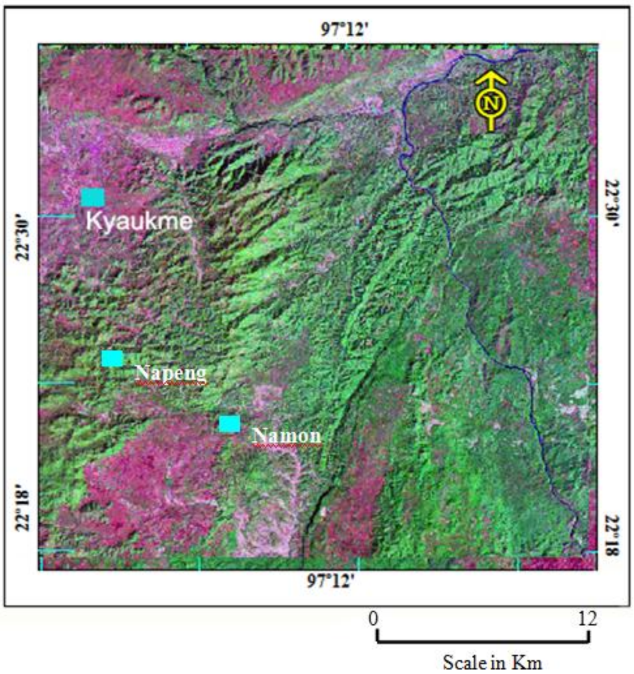


Figure 1 Satellite image of the study area and its environs. (Source: Google Earth, 2010)

Methods of Study

The studied transect in Napeng-Napong car road section, Napeng-Naungleng road section and west of Naungleng section, exposed at Napeng-Namon area, is based on large outcrops that expose most or the entire Napeng Formation (Late Triassic). Identification of the sedimentary facies must depend on thin sections of some samples obtained from outcrops.

Petrographic classification of Dunham (1962) and Embry and Klovan (1971) are used in the present study. Microscopic description is based on Adams and Mackenzie (1984). The paleoenvironments and their vertical distribution were identified on the basis of microfacies analysis, microfauna and macrofauna content in the Late Triassic units. The sequence stratigraphic interpretation follows classic concepts (e.g Van Wagoner *et al*., 1988; Vail *et al*., 1991; Handford and Loucks, 1993 in Weidlich *et al*., 2003) with emphasis on carbonate and siliciclastic system.

The key measured sections were carried out by bed by bed analysis and details of associated mineralization and the more important fauna in each unit. Sequence boundaries, parasequence boundaries and maximum flooding surface were emphasized in each measured section.

Sequences Stratigraphic Implication and Interpretation

The sequence stratigraphic interpretation is mainly based on the sedimentary facies analysis and section measurements were done in well-exposed representative rock units and their interpretation with regard to sedimentary dynamics. The sequence boundaries marine flooding surfaces and depositional systems tracts were achieved by using the sedimentologic column and facies analysis. Water depth is measured between the sea-level change (change in accommodation) and change in sediment supply (Myers and Milton, 1996). The facies changes in the study area depend on the tectonic movement, the basin topography, sediment source shifting and sea-level change. The sedimentary sequences developed in the Napeng-Namon area indicate that the south-eastern part is shallower than the north-western part because of the higher topography of south eastern portion.

Therefore, deepening trends are considered as Transgressive System Tracts (TST), whereas shallowing trends are held to be Highstand System Tracts (HST). Moreover, the change from deepening to shallowing is interpreted to be maximum flooding surface (mfs).

The sudden superposition of transgressive beds upon prograding one is thought to represent a cycle boundary (CB). Seven, fourth–order shallowing upward depositional sequences are recognized in the Napeng succession (Fig.2). Parasequence stacking patterns were identified on the basis of vertical trends in facies composition. As a result, this study focused on depth trend to identify stacking patterns, much as is commonly alone in siliciclastic sequence startigraphic studies (Van Wagoner et al, 1990).

Detailed measured-section and distribution of facies association of the Napeng Formation exposed at Napeng-Napong and Napeng-Naungleng sections.

In Napeng-Namon area, the common cycles that are typified are upward coarsening cycles. At the top of Napeng-section, mostly packstone and wackestone passes into mudrocks and then shale and siltstone as shallow-marine tidal and wave progarded across platforms. Variations of the sedimentary patterns are due mainly to sea-level changes reflected by the up and down movement across the ramp. So, these shallowing upward cycles appear to be the dominant cycle type on unrimmed shalves, especially homoclinal ramps through the geological record (Lohman., 1976).

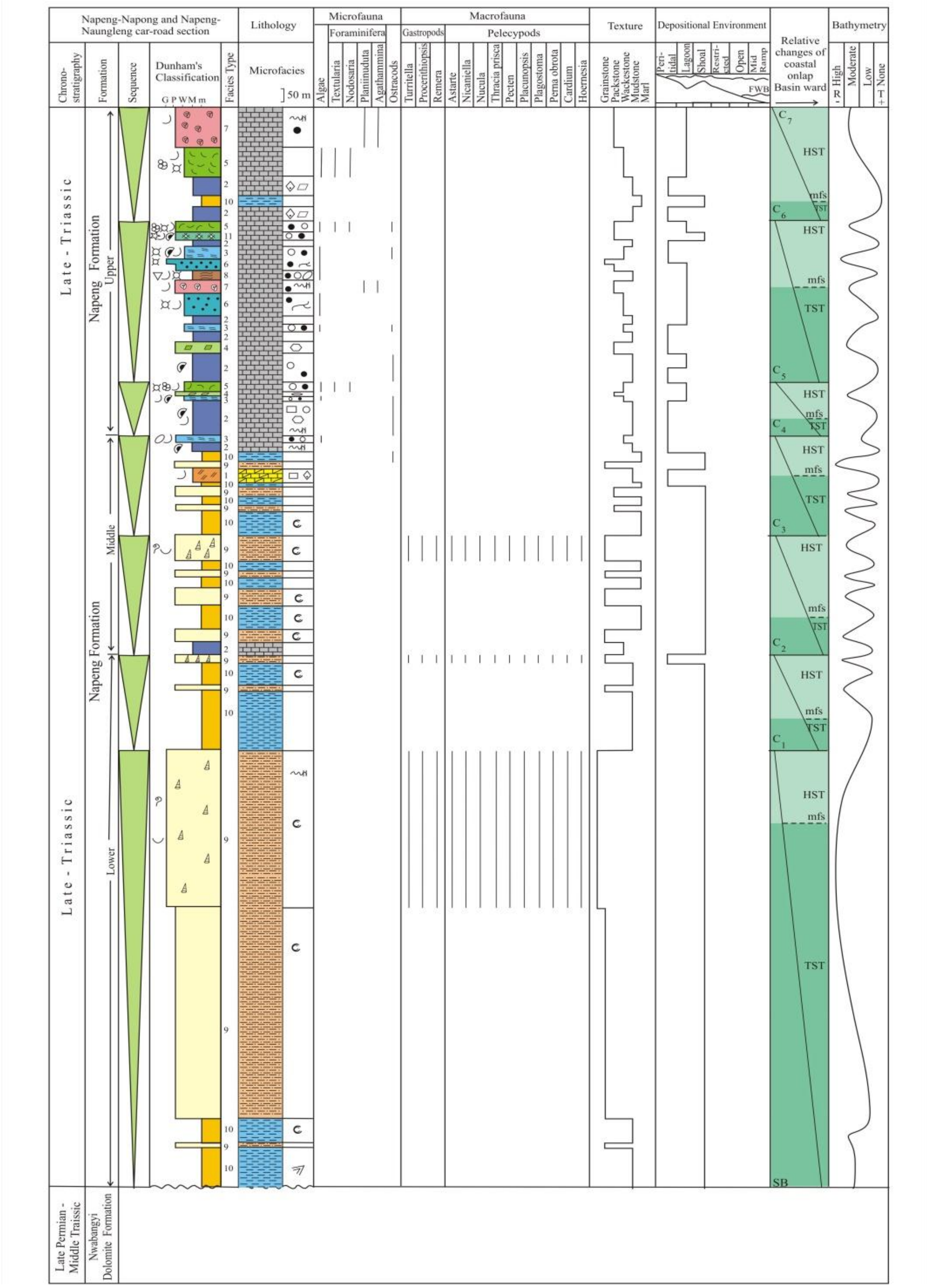
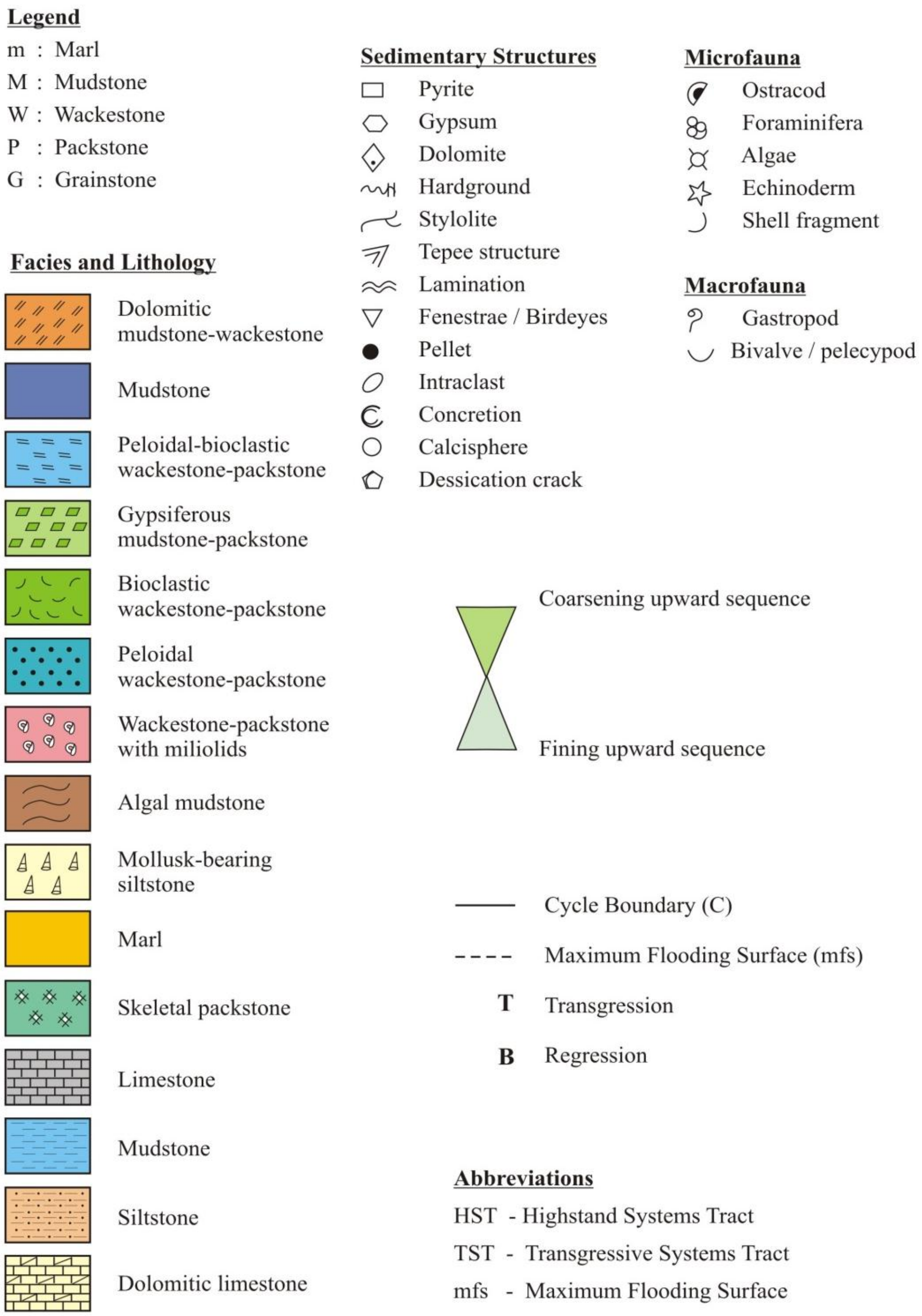


Figure 2 Sequence stratigraphic interpretation of the Late Triassic sections of Napeng Formation exposed at Napeng-Namon Area



Field Expression of Sequences

Seven fourth order depositional sequences are recognized in the Late Triassic exposed on the northern and north-eastern parts of the study area. These sequences are realized and correlated on the basis of parasequence stacking patterns and by apparent features of sequence boundaries and trangressive surfaces. The most prominent stratigraphic features of contact between Nwabangyi Dolomite Formation and Napeng Formation is type I sequence boundaries (SB) which is represented by a significant unconformity (Fig.3). Recognition of this unconformity and its significance as a sequence boundary can be related to changes in eustatic sea level, global climate and oceanic state.

Figure 3 Photograph showing the unconformity between Napeng Formation and Nwabangyi Dolomite Formation at the base of the Ngwetaung Hill.

Eleven microfacies are defined in the Napeng Formation on the basis of detailed sedimentologic and macrofossils logging of sedimentary structures, Flügel's (2010) model and Wilson's (1975) classification. Terminology and definition introduced by Dunham (1962) are used in this paper. The microfacies distinguished are: 1. Dolomitic mudstone-wackestone, 2. Mudstone, 3. Peloidal-bioclastic wackestone-packstone, 4. Gypsiferous mudstone-wackestone, 5. Bioclastic wackestone-packstone, 6. Peloidal wackestone-packstone, 7. Wackestone-packstone with miliolids, 8. Algal mudstone, 9. Mollusck bearing siltstone, 10. Marl and 11. Skeletal packstone.

The depositional environment of the Napeng Formation is interpreted as a shallow carbonate platform with a gentle slope. Much of the Napeng Formation in the Napeng-Namon area was deposited in peritidal, lagoon and shoals in an inner ramp environment.

Depositional Sequences and Cycle Boundaries and Transgressive Surfaces

Seven cycle boundaries are identified in the Late Triassic sediments, which can be divided into seven parasequences: (CB-1 to CB-7) (Fig. 2). Cycle boundaries are demarcated by contact between the progradational parasequence sets (Highstand) and retrogradational parasequence sets (Transgressive). It is apparent that the sudden superposition of transgressive beds upon prograding one is thought to represent a cycle boundary (CB). Based on this fact, in the Napeng succession, the cycle boundaries are marked on the top surface of the shallowing upward cycles. In other word, the boundary is placed at the thickening upward or coarsening upward cycles. It is designated by dolomite (diagenetic caps) and depositional cycles such as changes from lithofacies, grain size and bed thickness (Fig.4,5&6). Shallowing upward Late Triassic units have been used by their vertical outcrop (Fig.7). The indicator for the evidence of subaerial exposure is the presence of hardground surfaces (Fig.8&9). Therefore, sequence boundaries have to be inferred from major shift of depositional systems and stacking patterns. The Napeng succession are the inner ramp sequence and show little potential for vertical (keep-up) growth during flooding event.

Figure 4 An outcrop showing grey color, fossiliferous limestone in middle part of the Napeng section.

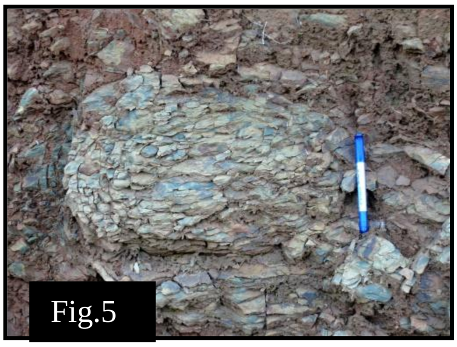


Figure 5 Concretionary clay in siltstone exposed at the lower part of the Napeng section.

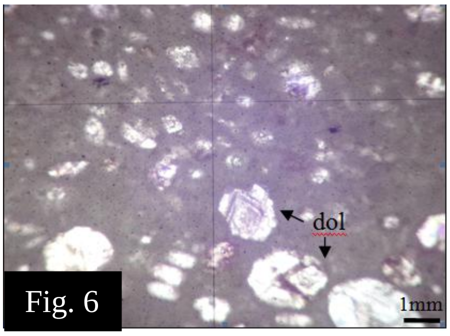


Figure 6 Photomicrograph showing dolomite (dol) (diagenetic cap) indicating the sequence boundaries in Bioclastic wackestone-packstone facies. Under PPL.

Figure 7 An outcrop photograph showing the thickening upward sequence of Napeng section.

Figure 8 Photograph showing erosional hardground with iron-stained surface at sequence boundary in the middle part of Napeng section.

Figure 9 Photograph showing burrowed Limestone with erosional surface at the middle part of Napeng section.

Maximum Flooding Surface (mfs)

The maximum flooding surface represents the last of the significant flooding surfaces found in the transgressive system tract.The mfs coincides with maximum abundance of fossils, intense bioturbation (Vail ., 1991).

In this study, mfs are defined by using change in lithologic unit, or change in facies, the presence of intense bioturbation (Fig.10) mostly indicates the beginning of progradation. In many other carbonate studies, mfs imply a slow drop in rates of accommodation from the rapid rates during the TST to the slow rates during the early HST.

Figure 10 Intense bioturbation indicating the maximum flooding surface (mfs) in the upper part of the Napeng Formation at Napeng-Namon area.

System Tracts

A sequence can be subdivided into distinctive units that are called system tracts. The term systems tract was first introduced by Brown and Fisher (1977), as a linkage of contemporaneous depositional environments. Transgressive systems tract (TST) and highstand systems tract (HST) are observed in the study area whereas the lowstand systems tract is missing because of no distinctive exposures are recognized.

Transgressive System Tracts (TST)

The transgressive systems tract consists of a retrogradational set of parasequences. It is underlain by the TS and overlain by the mfs. The TST is bounded at the base by transgressive surface display features attributable to subaerial exposure (Fig.11). In the Napeng successions, the TST is capped by black carbonaceous shale (Fig.12) and iron-stained surfaces.

The TST in the cycle-1 characterized by shaol and lagoonal facies sediments of marl, siltstone and mollusk bearing siltstone. The TST of cycles 2, 3 and 4 are composed of the alternation of marl and siltsone sediments. This system tract, cycles 1, 2, 3 and 4 start the aggradational stacking patterns, in this condition the rate of sediment supply subequal to the rate of accommodation. The cycle-5 is made up of peritidal carbonates facies to lagoonal facies and TST of this cycle also indicate that the aggradational stacking pattern. The TST of the cycle-6 is characterized by the paritidal to lagoonal facies. The last cycle-7 is typically comprised of peritidal carbonate to shoal facies sediments. This last cycle provide that aggradational stacking patterns to progradational sediment supply which is greater than rate of accommodation space.

Highst and System Tract (HST)

Highstand systems tracts are defined by either aggradational or progadational parasequence sets. The mfs is the basal surface of the system tract. The top surface of the HST is transgressive surface as well as cycle boundaries CB (Fig. 13). The aggrading HST occurs when the rate of sediment supply closely matches the amount of accommodation space being created by rising sea-level (Emery & Myers, 1996). These highstand tracts are capped by karstic surface and intense bioturbation which become more pronounced upwards within the stack as the upper sequence boundary is approached.

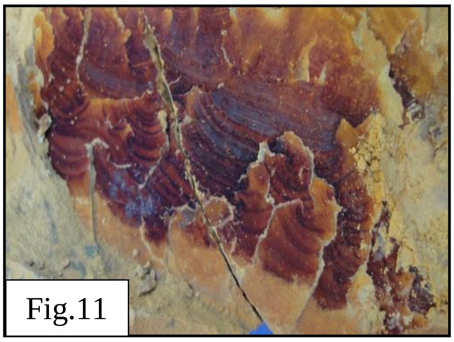


Figure 11 Photograph showing erosional surface indicating the sedimentation break on siltstone at Napeng area.

Figure 12 Photograph showing black carbonaceous shale indicating the marine transgression in the lower part of Napeng section.

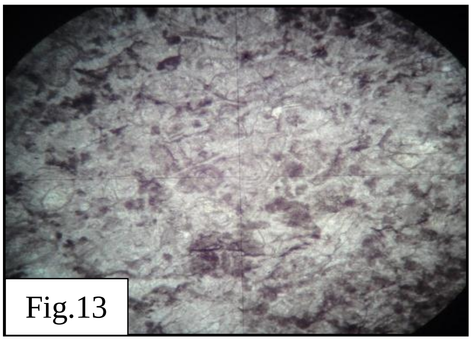


Figure 13 Photomicrograph showing intense bioturbation in wackestone-packstone with miliolids facies exposed at the upper part of the Napeng section. Under PPL.

In the Napeng succession, the HST in cycle-1, 2 and 3, is characterized by shoal and open-marine facies and the aggradational parasequence sets occur. Therefore, the sediment supply and rate of creation of topset accommodation volume are roughly balanced. The HST cycles – 4, 5, 6 and 7 are mainly composed of parasequences of peritidal, lagoonal and shoal facies. Therefore, when the early stage of these system tracts is interpreted as rate of sediment supply exceeds rate of accommodation and later these are roughly balanced. The Napeng-Namon area, HST cycle is described by peritidal to shoal facies. In measured section, HST is typified by both aggradational and progradational stacking patterns.

Discussion

In Napeng-Namon area, according to the occurrences of significant unconformity, the sequence boundary between Nwabangyi Dolomite Formation and Napeng Formation may be type I sequence. According to the lithofacies analysis, eleven facies are categorized in Napeng Formation at Napeng-Namon area. These were grouped into three facies associations representing as peritidal, lagoonal and shoal and slightly open-marine environments.

Seven fourth-order shallowing upward, parasequence cycles can be recognized by environmental changes within the section. The facies variations were used for the sequence stratigraphic interpretations of the succession. In the description of the section, deepening trends (retrogradational stacking) are considered Transgressive Systems Tracts (TST), shallowing trends (progradational stacking) are held to be Highstand System Tracts (HST), and the change from deepening towards shallowing is interpreted as maximum flooding surface (mfs). Cycle boundaries were recognized abrupt from shallowing-upward to deepening-upward reflect to an increase in sea-level fluctuation. Such shifting of parasequence boundary is marked by the transgressive surface and beginning of the transgressive system tract. In the Napeng section, the lowstand system tract is missing.

Many of the cycle boundaries coincide with transgressive surface which are associated with pyrite, iron-stained surface and hardground surface and surface display intense bioturbation. The deposition of the Late Triassic units exposed in Napeng-Namon area can be regarded as the progradational stacking pattern with some aggradations and these ramp stack may show gross vertical accretion, but individual sequences seldom develop in a keep-up style.

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