CHAPTER VI

THIN SECTION ANALYSIS

This chapter presents a detailed analysis of the rock subunits in the Ban Thung Samed section. By utilizing thin section descriptions and interpretations, it offers valuable insights into the environmental conditions that influenced the formation of these rock units.

6.1 Thin section analysis

The rock samples, collected from conodont study, which is limestone, were prepared into 4 thin sections per sample. The samples included U1L, U1M, and U1U from lower, middle and upper of the lower subunit; U2L and U2U from lower and upper of the middle subunit; and U3L, U3M, and U3U from lower, middle and upper of the upper subunit. These thin sections were examined using a polarized-light microscope, following the classification outlined by Dunham (1962) (Figure 6.1).

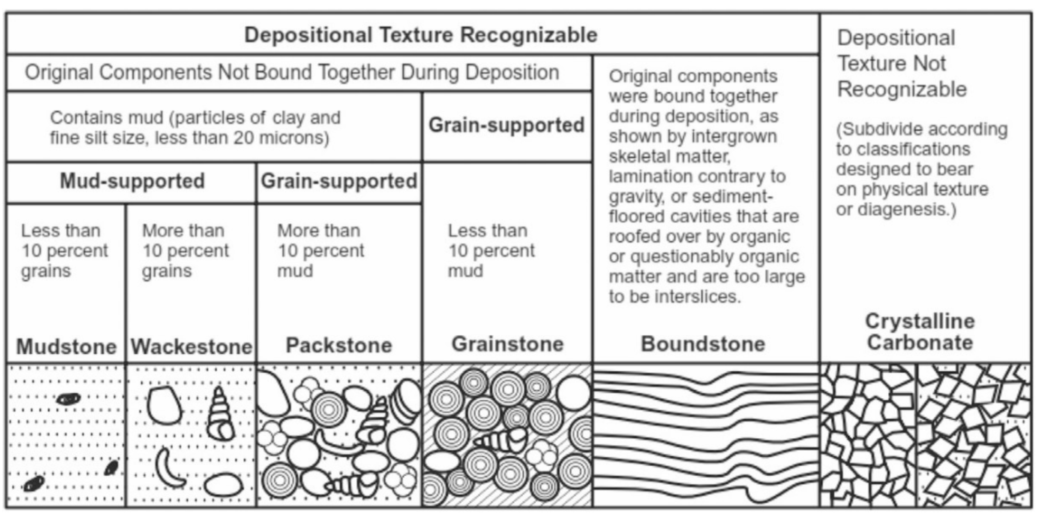

Figure 6.1 Dunham’s carbonate rock classification (Al Omari et al., 2016).

Dunham's (1962) classification defines carbonate rocks based on their texture and the ratio of grains (allochems) to matrix (mud/micrite). Mudstone is characterized by less than 10% grains, with the rock being predominantly matrix-supported. Wackestone contains more than 10% grains while remaining matrix-supported; if grain content is below 50%, it is classified as sparse wackestone, whereas grain content above 50% qualifies as packed wackestone.

Packstone is a grain-supported limestone that contains more than 10% matrix, indicating some remaining micrite, while Grainstone is also grain-supported but contains less than 10% matrix, reflecting a well-washed and compact texture.

Boundstone refers to carbonate rocks where grains were bound together during deposition and includes reef-building organisms as well as microbial structures like stromatolites.

Crystalline Carbonate encompasses limestone or dolomite that has undergone diagenetic processes, which obscure the original depositional texture.

6.1.1 The lower subunit

The limestone of lower subunit composed of unsorted, fine-grained bioclasts, most of which are less than 1 mm in size and are embedded in a lime mud matrix. These bioclasts contribute between 10% to 50% of the total volume, with

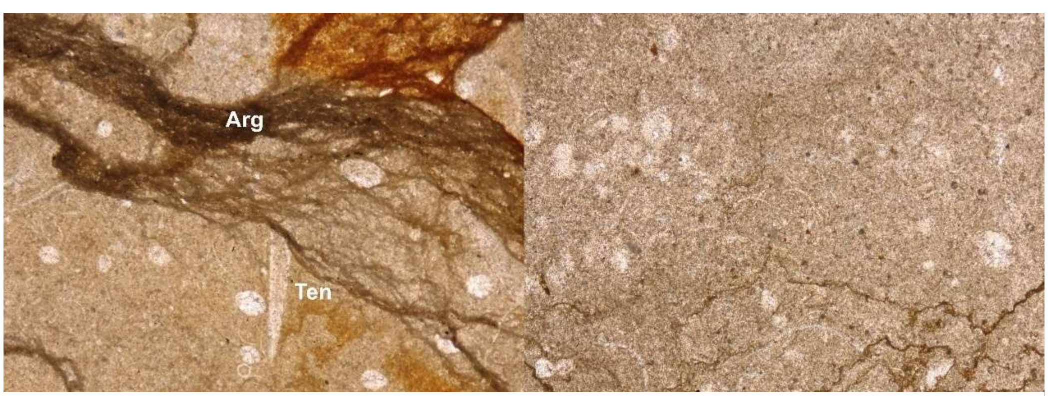

Figure 6.2 Photomicrographs of sample U1L under ppl, scale bar = 1 mm. A. bioclastic wackestone with argillaceous seams (Arg), tentaculitoid (Ten), and microfilaments. B. bioclastic wackestone with argillaceous seams (Arg) and microfilaments.

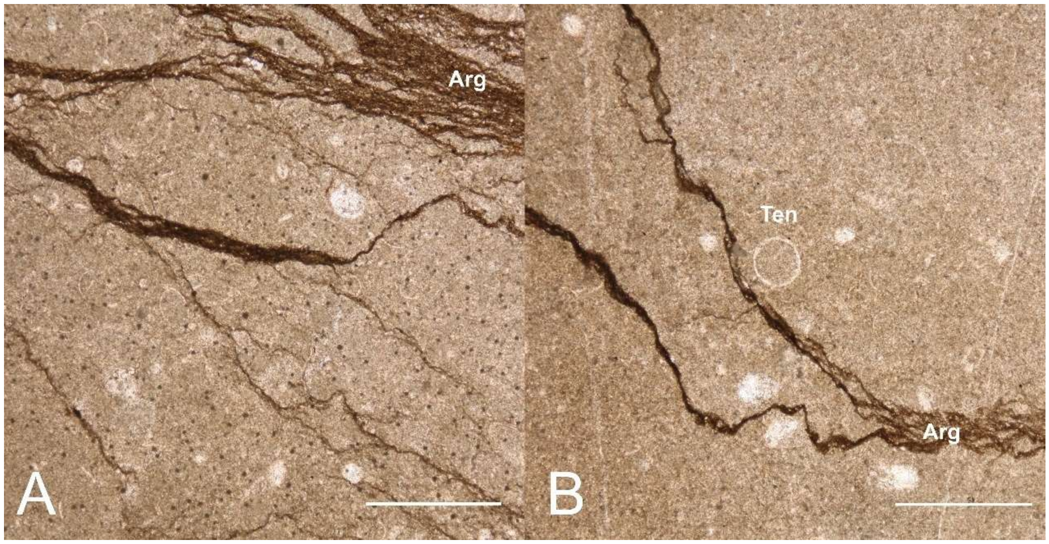

Figure 6.3 Photomicrographs of sample U1M under ppl, scale bar = 1 mm. A. bioclastic wackestone with argillaceous seams (Arg) and microfilaments. B. bioclastic wackestone with argillaceous seams (Arg), transverse cross-sectioned tentaculitoid? (Ten) and microfilaments.

sample U1L ranging from approximately 15-40%; sample U1M from 10-20%; sample U1U from 15-30%. Based on this composition, the subunit is classify as fine-grained bioclastic sparse wackestone. Argillaceous seams are observed in all samples and appear to have formed after lithification, as they frequently crosscut multiple bioclasts. Their development may be attributed to pressure solution processes (Figures 6.2-6.4). The bioclasts includes tentaculitoids (Figures 6.2A, 6.3B, 6.4A), gastropods (Figure 6.4B), trilobite fragments (Figure 6.4B), and microfilaments (Figures 6.2-6.4). The microfilaments are difficult to precisely identify, as they may originate from bivalves, brachiopods, or ostracods (Figures 6.2-6.4).

The fine-grained bioclastic sparse wackestone of lower subunit can be compared to standard microfacies (SMF) 8 of Flügel (2010), characterized by "wackestone with whole fossils and well-preserved infauna and epifauna, burrows are common". According to Wilson's facies zone (FZ), SMF 8 can occur in shallow open shelf lagoon or just below fair-weather wave base (FZ 7), deep open shelf (FZ 2) (Flügel, 2010).

The presence of unsorted, fine-grained bioclasts suggests deposition in a low energy environment, where limited transport prevented significant grain sorting (Flügel, 2010). based on regional stratigraphic studies, carbonate deposition from the Late Ordovician to Silurian in the area occurred in subtidal ramp to deep shelf settings under cool-water tropical conditions, which continued into the Devonian (Department of Mineral Resources, 2018). This broader paleoenvironmental context indirectly supports the interpretation of SMF 8 in this study as representing deposition in subtidal below the fair-weather wave base to deep open shelf environment. A regression to lagoonal conditions is unlikely, particularly given the absence of large skeletal fauna typically associated with shallow, high-energy settings such as inner ramp shoals and lagoons (Flügel, 2010). Although burrows are absent in the lower subunit thin section, the presence of diverse benthic taxa (e.g. gastropods, trilobites, microfilaments), along with bioturbation reported by Itsarapong et al. (2023), suggests normal bottom-water

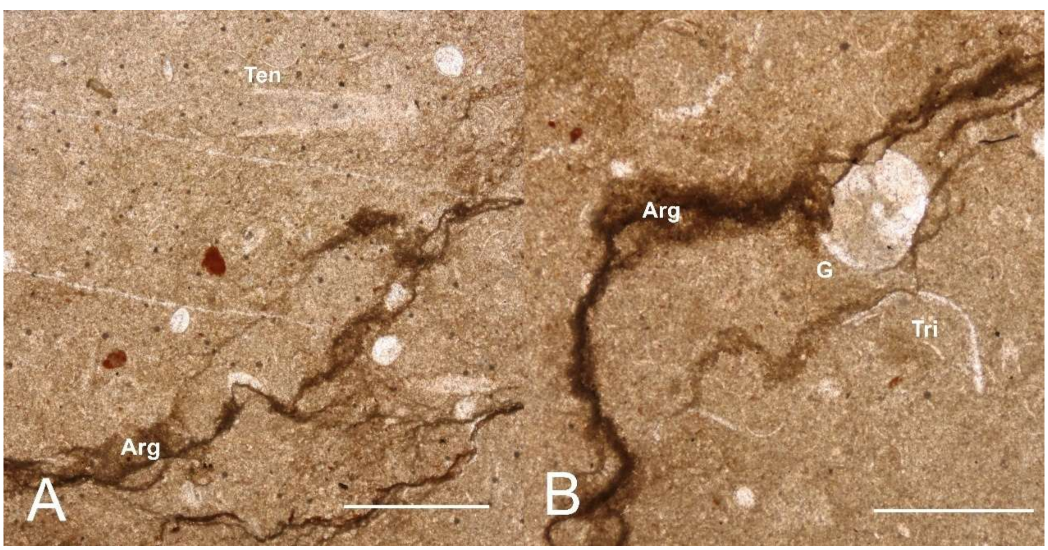

Figure 6.4 Photomicrographs of sample U1U under ppl, scale bar = 1 mm. A. bioclastic wackestone with argillaceous seams (Arg), longitudinal cross-sectioned tentaculitoid (Ten) and microfilaments. B. bioclastic wackestone with argillaceous seams (Arg), gastropod (G), trilobite (Tri) and microfilaments.

oxygenation (Allison et al., 1995). The scarcity of pelagic organisms such as tentaculitoids, coupled with the dominance of benthic fauna, points to a shallower setting than the deep shelf. This supports an interpretation of deposition in subtidal settings below the fair-weather wave base, rather than in deeper waters where pelagic microfossils are typically more abundant (Flügel, 2010).

In conclusion, SMF 8 represents subtidal open marine conditions below the fair-weather wave base. The faunal assemblage suggests a moderately deep, well oxygenated, low energy environment, rather than a deep shelf or restricted lagoonal setting.

6.1.2 The middle subunit

The middle subunit is composed of limestone interbedded with black shale. However, thin section analysis was limited to the limestone, as samples from the black shale beds were not successfully obtained. The limestone comprises unsorted, fine-grained bioclasts, most of which are less than 1 mm in size, with a minority exceeding 1 mm, within a lime mud matrix. These bioclasts make up more

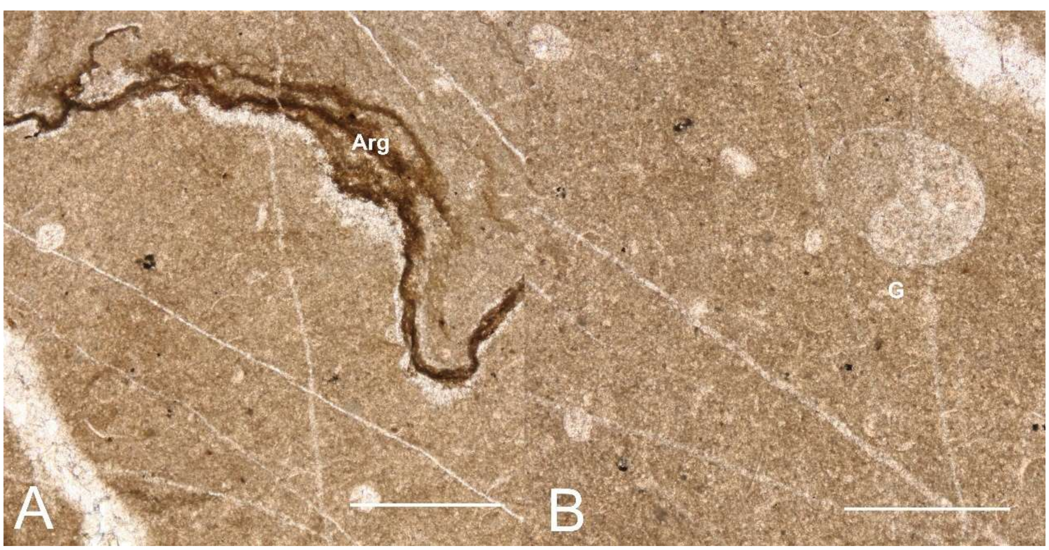

Figure 6.5 Photomicrographs of sample U2L under ppl, scale bar = 1 mm. A. bioclastic wackestone with argillaceous seams (Arg) and microfilaments. B. bioclastic wackestone with gastropod (G) and microfilaments.

than 10% but less than 50% of the total volume, with sample U2L contributing approximately 10-25% and sample U2U contributing 30-40%, classifying the subunit as fine-grained bioclastic sparse wackestone. Argillaceous seams, likely the result of pressure solution processes, are observed in all samples (Figures 6.5A, 6.6A). The bioclast assemblage includes gastropods (Figure 6.5B), tentaculitoids (Figure 6.6), ostracods (Figure 6.6A), echinoderms (Figure 6.6A), and microfilaments (figures 6.5, 6.6).

The fine-grained bioclastic sparse wackestone of the middle subunit can be compared to SMF 8 and likely indicates subtidal open marine conditions below the fair-weather wave base, as the thin section features are consistent with those of the lower subunit. However, this subunit was likely deposited in a slightly deeper setting, as suggested by the lithological shift from bedded limestone to interbedding with black shale.

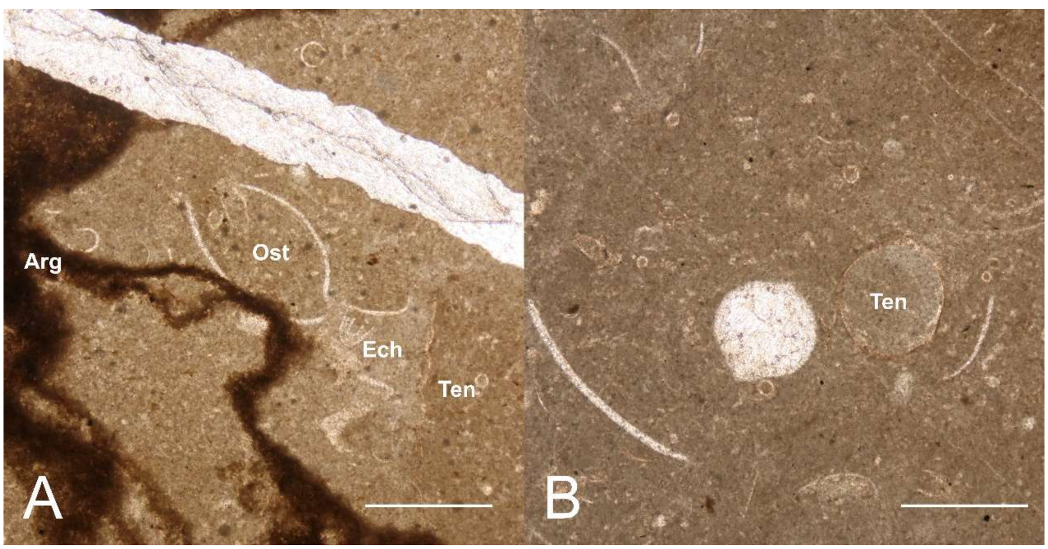

Figure 6.6 Photomicrographs of sample U2U under ppl, scale bar = 1 mm. A. bioclastic wackestone with longitudinal cross-sectioned tentaculitoid (Ten), echinoderm (Ech), cross-sectioned ostracod shell (Ost), argillaceous seams (Arg) and microfilaments. B. bioclastic wackestone with transverse cross-sectioned tentaculitoid (Ten) and microfilaments.

In conclusion, the middle subunit is interpreted as having been deposited in a subtidal below the fair-weather wave base, low energy conditions to deep marine environment, representing a shift to a deeper depositional setting relative to the lower subunit.

6.1.3 The upper subunit

The upper subunit consists of limestone interbedded with black shale. Thin section analysis was limited to the limestone, as samples from the black shale beds could not be successfully obtained. The limestone contains unsorted, fine-grained bioclasts with size variations between samples. Most bioclasts are less than 1 mm in size; however, sample U3U shows a higher proportion of bioclasts exceeding 1 mm, all embedded within a lime mud matrix. These bioclasts contribute more than 10% of the total volume, with sample U3L contributing approximately 30–50%, sample U3M 50–60%, and sample U3U more than 50%. Based on this composition, the subunit is classified as fine-grained bioclastic sparse wackestone for sample U3L, and bioclastic packed wackestone for samples U3M and U3U. While Figure 6.11 depicts packed

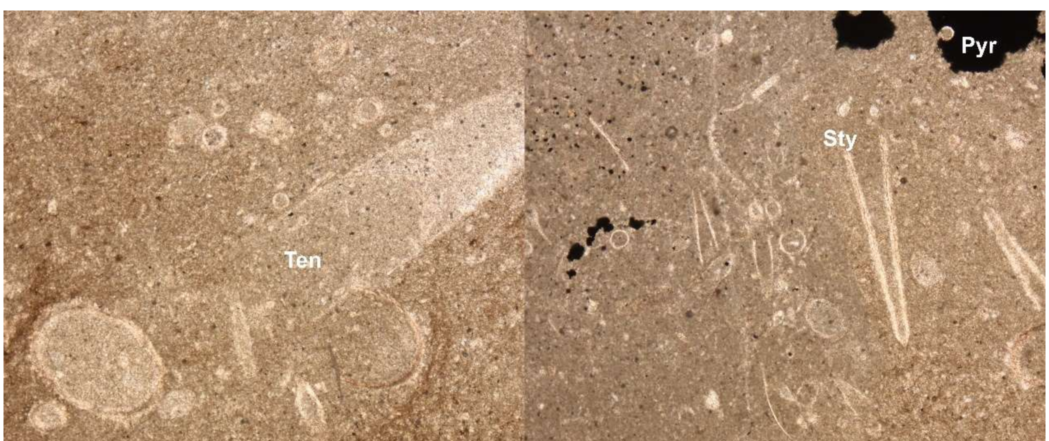

Figure 6.7 Photomicrographs of sample U3L under ppl, scale bar = 1 mm. A. bioclastic wackestone with longitudinal cross-sectioned tentaculitoid (Ten) and abundant cross-sectioned tentaculitoid (circular or ellipse shape). B. bioclastic wackestone with longitudinal cross-sectioned *styliolina* (Sty), pyrite (Pyr) and cross-sectioned of other tentaculitoid (circular or ellipse shape).

tentaculitoids resembling a grain-supported texture which only occurs in a thin layer, the overall composition of sample U3U supports classification as packed wackestone when the sample is considered in its entirety. The bioclasts in the upper subunit are predominantly composed of tentaculitoids, with occasional trilobite fragments (Figure 6.9B). Argillaceous seams are still observed in sample U3M (Figure 6.9), while pyrite is present in all samples (Figures 6.7–6.9, 6.10A).

According to Flügel (2010), fine-grained bioclastic wackestone dominated by pelagic organisms such as tentaculitoids corresponds to SMF 3-TENT. This microfacies is typically associated with basin (FZ 1-B) and open deep shelf (FZ 3) settings within Wilson's facies zone.

In the lower part of the upper subunit, the occurrence of minor benthic organisms (e.g. trilobites), along with bioturbation and brachiopods reported by Itsarapong et al. (2023), suggests an open deep shelf setting where benthic life persists

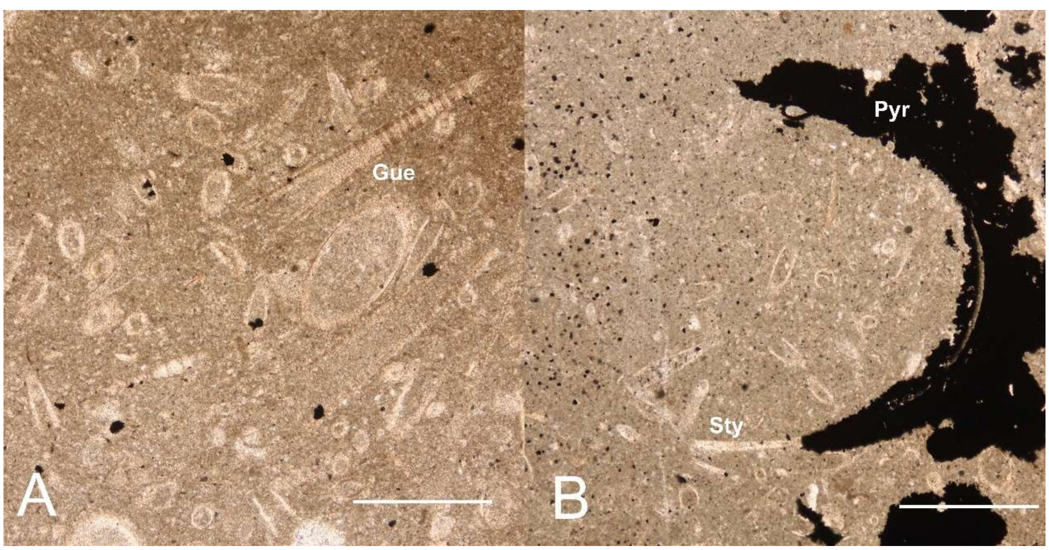

Figure 6.8 Photomicrographs of sample U3L under ppl, scale bar = 1 mm. A. bioclastic wackestone with longitudinal cross-sectioned *Guerichina* (Gue) and abundant cross-sectioned tentaculitoid (circular or ellipse shape). B. bioclastic wackestone with longitudinal cross-sectioned *styliolina* (Sty), pyrite (Pyr) and cross-sectioned of other tentaculitoid (circular or ellipse shape).

(Flügel, 2010). The presence of bioturbation and benthic fauna, despite the dominance of pelagic organisms, rules out anoxic conditions that would typically eliminate benthic communities (Allison et al., 1995). Moreover, pyrite within this subunit, observed replacing or surrounding fossils (Figures 6.8B, 6.10A), likely reflects bacterial sulfate reduction of organic matter rather than persistent euxinic conditions. As noted by Berner (1984), under euxinic conditions (absence of oxygen, elevated hydrogen sulfide) pyrite can form throughout bottom waters regardless of organic matter position.

In the upper part of the upper subunit, bioclasts remain dominated by tentaculitoids (dacryoconarids), consistent with SMF 3-TEN. The matrix is composed of a dark, organic-rich substrate, accounting for approximately 50% of the matrix volume. Some layers display thin, tentaculitoid-rich beds (Figure 6.11) that are devoid of benthic fauna. This shift reflects a transition to a deeper marine environment, where declining oxygen levels likely suppressed benthic activity and bioturbation.

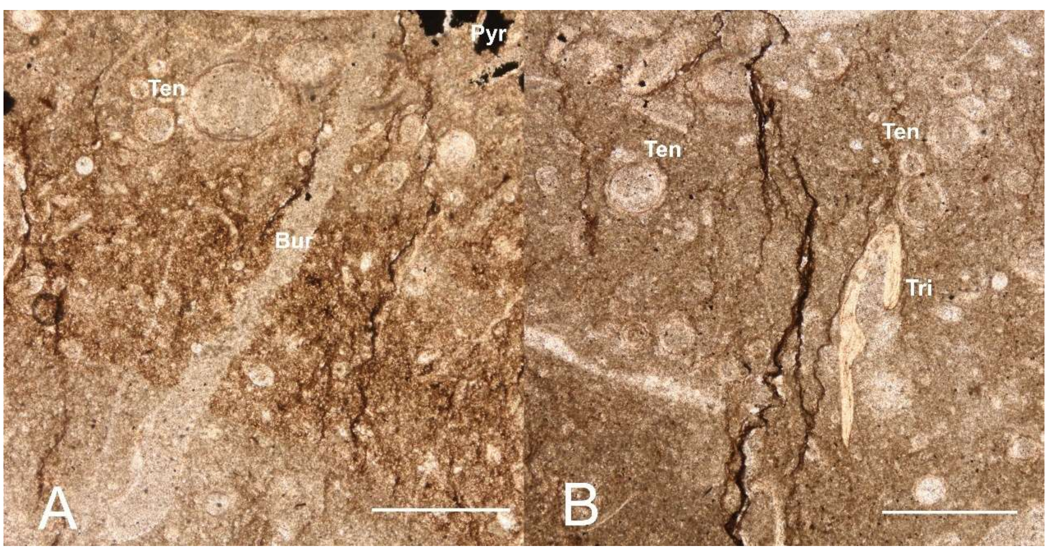

Figure 6.9 Photomicrographs of sample U3M under ppl, scale bar = 1 mm. A. bioclastic wackestone with abundant cross-sectioned tentaculitoid (Ten), pyrite (Pyr), argillaceous seams and burrow (Bur). B. bioclastic wackestone with abundant cross-sectioned tentaculitoids (Ten), trilobite fragment (Tri) and argillaceous seams.

In conclusion, the upper subunit is interpreted as a deep marine environment. The lower and middle part retain enough oxygen to sustain benthic communities, but the upper part reflects a significant shift to low-oxygen conditions, effectively reduces or eliminates benthic organisms, particularly within the tentaculitoid-rich beds.

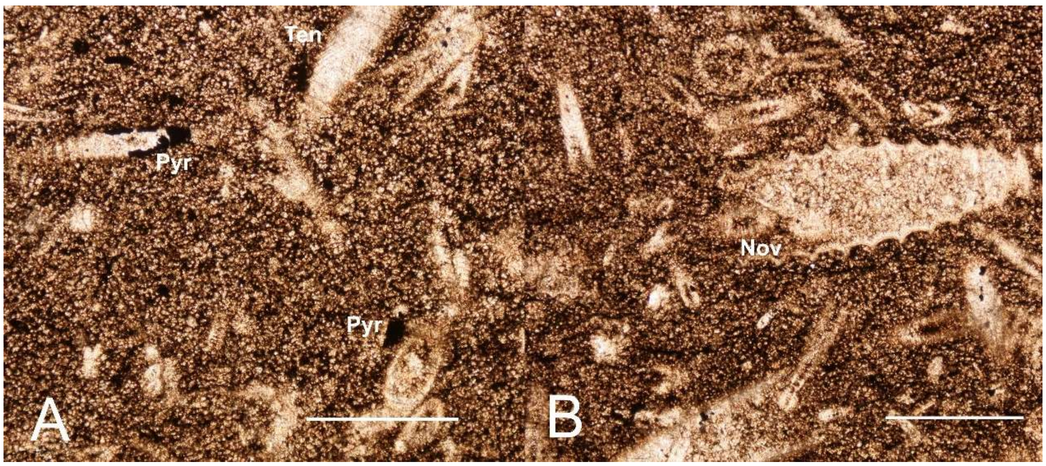

Figure 6.10 Photomicrographs of sample U3U under ppl, scale bar = 1 mm. A. abundant longitudinal cross-sectioned tentaculitoids and *Nowakia* (Nov). B. abundant longitudinal cross-sectioned tentaculitoids and the cross-sectioned *Nowakia* (Nov) and *Styliolina* (Sty).

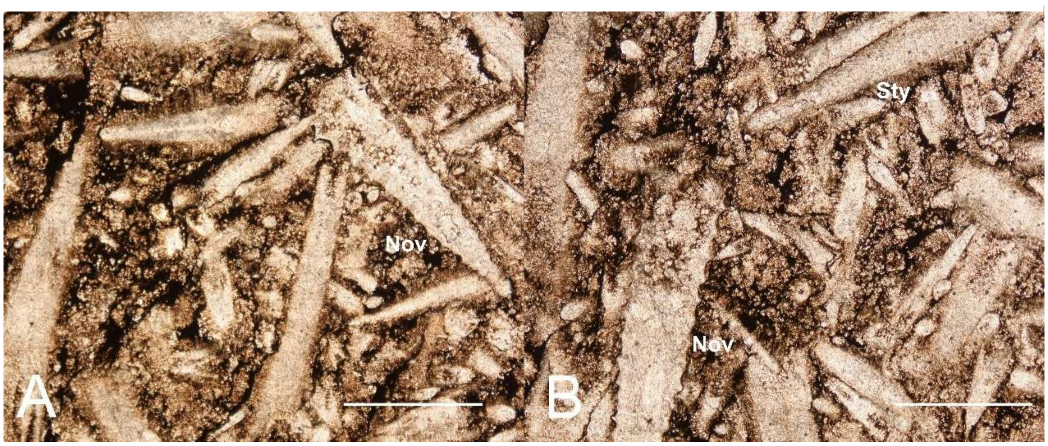

Figure 6.11 Photomicrographs of sample U3U under ppl, scale bar = 1 mm. A. bioclastic wackestone with abundant cross-sectioned tentaculitoids (Ten) and pyrite (Pyr). B. bioclastic wackestone with abundant cross-sectioned tentaculitoids and cross-sectioned *Nowakia* (Nov).