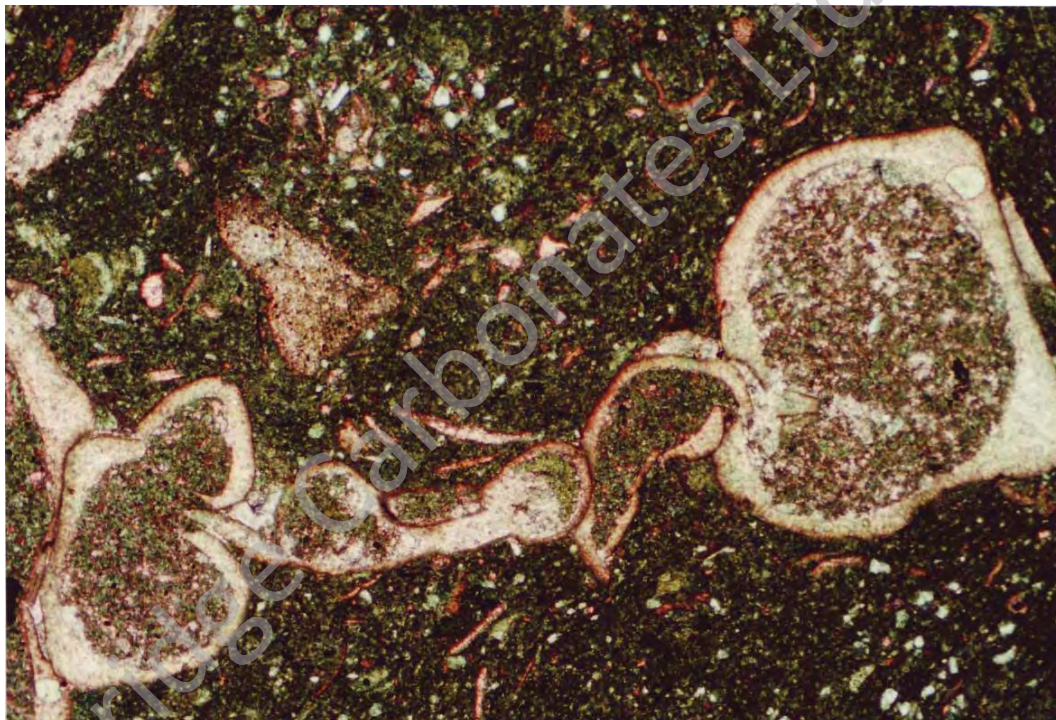




CONFIDENTIAL

Multiclient Report for

XXXXXXXX



Peter Gutteridge

Late Palaeozoic Sedimentology of 7128/6-1

Volume 1



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3.6. Kapp Duner Formation

The depositional facies and environments are summarized in the following table.

Detailed facies descriptions are given in the Appendix.

Facies	Depositional environments
Anhydritic dolomite	Evaporative tidal flat
Sandstone	Siliciclastic input from attached ramp
Bioclast packstone	Subtidal, inner to mid carbonate ramp
Bioclast packstone/wackestone	Subtidal, mid to outer carbonate ramp
Tubiphytes/beresellid boundstone	Mid carbonate ramp bioherm
<i>Palaeoaplysina</i> boundstone	Mid carbonate ramp bioherm

The depositional model of the Kapp Duner carbonate ramp system is shown by Figure 8. Input of siliciclastic sediment to the ramp system is greatly reduced compared with the underlying formations.

The innermost ramp environments are represented by stromatolitic limestone and dolomicrite containing displacive nodular anhydrite which probably originated as gypsum. These were deposited in hypersaline inter- and supratidal environments. Occasional intraclastic limestones may represent tidal channel deposits. Stromatolites were growing on intertidal flats and in the very shallow subtidal environment. Occasional sandstones are interpreted as sheet floods derived from the emergent hinterland which washed over the tidal flat.

Well reworked bioclastic limestones with occasional ooids, oncoids and glauconite peloids were deposited above normal wave base in adjacent offshore areas. These are associated with occasional shoreface sandstones. These shallow marine limestones and sandstones occasionally contain evidence of subaerial exposure including:

- *Microcodium* that is a microfossil-like structure of uncertain affinity (it may be a diagenetic structure) associated with calcrete. Some *Microcodium* have been encrusted by *Tubiphytes* suggesting that the calcrete formed a hard ground on the sea floor after later submergence (Plate 66).
- Calcrete structures that include the pervasive replacement of matrix and grains by calcrete micrite, micritic coating of grains and rhizcretions (Plate 64).

- **Framework porosity:** this is supported by *Palaeoaplysina* plates or between phylloid algae. Framework porosity is best developed in the D and M boundstone.
- **Inter and intragranular porosity within internal sediment:** this is best developed in the M boundstone which contains the highest proportion of internal sediment of the three boundstone types. Intragranular porosity is present within foraminifera and brachiopods (Plate 8). Micropeloidal micrite contains microporosity between peloids.

There is very little early marine cementation within the *Palaeoaplysina* bioherms. The best-developed primary porosity in the intermound facies is found in the peloid oncoid bioclast packstone microfacies (Plate 10). This contains abundant micritised grains which provide a poor substrate for the precipitation of cement which has reduced early marine cementation in other microfacies. Primary porosity in inter- and off-mound facies is otherwise generally poor.

4.4.2. *Later diagenetic controls on porosity*

Much of the porosity described above survives into the burial regime. There is some development of mouldic porosity formed by dissolution of phylloid algae, fusulinids and other bioclasts in mound core, intermound and off bioherm facies. Minor fracture porosity resulting from compaction and tectonism is present. Intercrystal and mouldic porosity has also been generated as a result of dolomitisation.

Post-dolomite cements include non-Fe calcite spar and coarsely-crystalline poikilotopic anhydrite that infills primary, mouldic, intercrystal and fracture porosity cement. The phase of anhydrite cementation is the most significant factor reducing primary and secondary porosity both in the *Palaeoaplysina* bioherm and other facies of the Kapp Duner Formation (Plates 15). Both the non-Fe spar and the anhydrite are interpreted as burial cements. Compaction is generally minimal, mainly as a result of stylolites which post-date the precipitation of non-Fe spar and anhydrite. There is an episode of silicification which post-dates dolomitisation and occurs both as a replacement of bioherm facies and as a chalcedonic cement infilling primary,

5.5.3. Controls on permeability

Permeability within peloidal bioclastic carbonate sands is between 5-50mD which corresponds with a high degree of intergranular porosity (Figure 25). Permeability within bioclast wackestone / packstone is between 1-10mD which is the result of poor depositional porosity. Some later dissolution of former aragonite bioclasts produced some vuggy porosity which had little effect on permeability. Minor tectonic fracturing has produced local improvements in permeability. Permeability has been locally reduced by poikilotopic anhydrite cementation.

5.6. Hambergfjellet Formation

5.6.1. Pore types and distribution of porosity

Figure 26 shows that both connected and vuggy porosity is mainly between 1-5% (maximum 15%).

There is insignificant porosity present within argillaceous packstone/siltstone that represents distal, clay-rich ramp deposits. Bioclastic limestones deposited below wave base have intergranular porosity of between 1-5% which is due to the presence of carbonate and siliciclastic mud. *In situ* sponges and corals which grew in this facies are often silicified which tends to reduce porosity, however, silicification is also associated with the development of vuggy porosity. A sponge-bryozoan bioherm within this facies association contains minimal porosity.

Porosity in shallow water bioclastic carbonate sands is generally less than 5%. These carbonate sands are crinoid-rich and therefore prone to early cementation by overgrowths of calcite.

Occasional tectonic fractures are present which have been incompletely infilled with calcite cement.

Primary porosity of up to 15% occurs in the oncoid peloid packstone microfacies that is associated with the transgressive surface separating two progradational units

faster rate than it can be infilled by sedimentation. The subsequent shallowing phase of each unit can be regarded as a high stand systems tract (HST) when accommodation space is infilled by sedimentation. HSTs are represented by bioclastic limestones and sandstones deposited in various near shore carbonate and siliciclastic sand bodies, beach and shore face settings. Marginal marine environments are occasionally developed which include dolomitised evaporitic peritidal carbonates. The facies geometry within each HST is likely to be a series of stacked offlapping packages.

These shallowing-up intervals are often terminated by abrupt deepening events that are interpreted as transgressive surfaces or the down dip equivalent of sequences boundaries. Facies types in TSTs are off-shore subtidal argillaceous carbonates and distal siliciclastics with resedimented bioclastic carbonates and occasional sandstones deposited below normal wave base in generally low energy conditions. This facies association occasionally contains *Palaeoaplysina* and other bioherms.

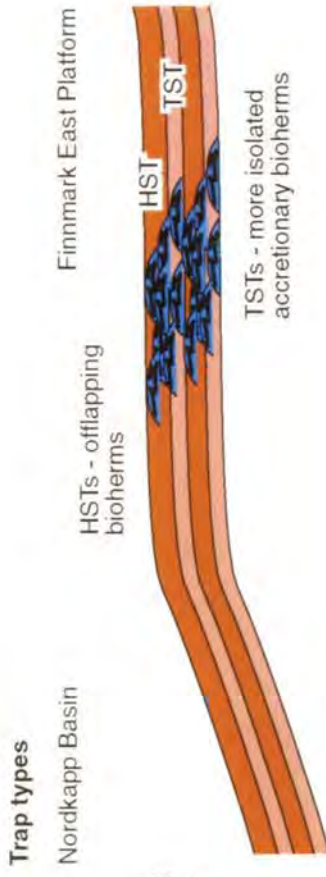
7.2. High resolution sequence stratigraphy of the late Carboniferous to Permian succession

7.2.1. Sequence A (Kapp Kåre to basal part of the Kapp Hana Formations)

This is equivalent to the sedimentary sequence S-1 of Ehrenberg et al. (1998). Only the HST of sequence A was cored and consists mainly of siliciclastic sediment deposited in shallow marine subtidal and shore-face environment that contains occasional *Tubiphytes*-phylloid algal bioherms. Regionally, this sequence represents the erosion and infill of fault-block topography (Ehrenberg et al. 1998).

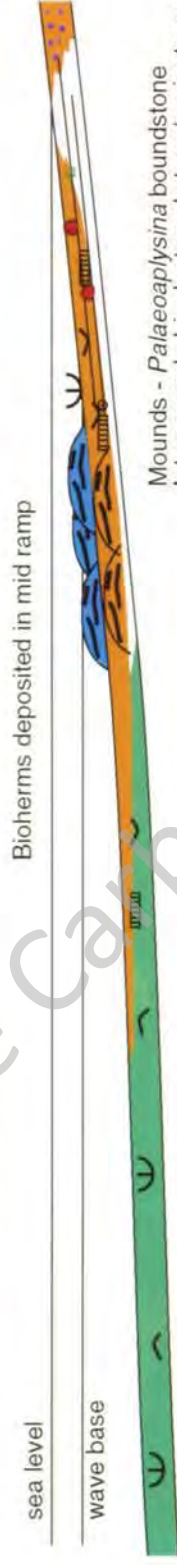
The top of sequence A is sequence boundary at the top a *Palaeoaplysina*/phylloid algal bioherm may be equivalent to the boundary between the Carboniferous and Permian. This sequence boundary is correlatable on log signature and was recognized as a locally unconformable sequence boundary Ehrenberg et al. (1998).

Figure 3. *Palaeoaplysina* play.



- Sakmarian - Asseljian
- main episode of bioherm development in Kapp Duner equivalent
- initiated during transgressions, main growth during high stands
- stacked offlapping growth in mid ramp setting
- hydrocarbon residues present
- good primary porosity enhanced by dolomitisation

Controls on *Palaeoaplysina* bioherm geometry



Mounds - *Palaeoaplysina* boundstone
 Interfjord - bioclast packstone/grainstone
 Offfjord - argillaceous wackestone - possible local source

Porosity and permeability

- intergranular porosity (10-25%)
- framework porosity (10-25%)
- intercrystal porosity (5-20%)
- biomouldic porosity (5-15%)

Porosity improved by dolomitisation

Porosity reduced by late anhydrite cement

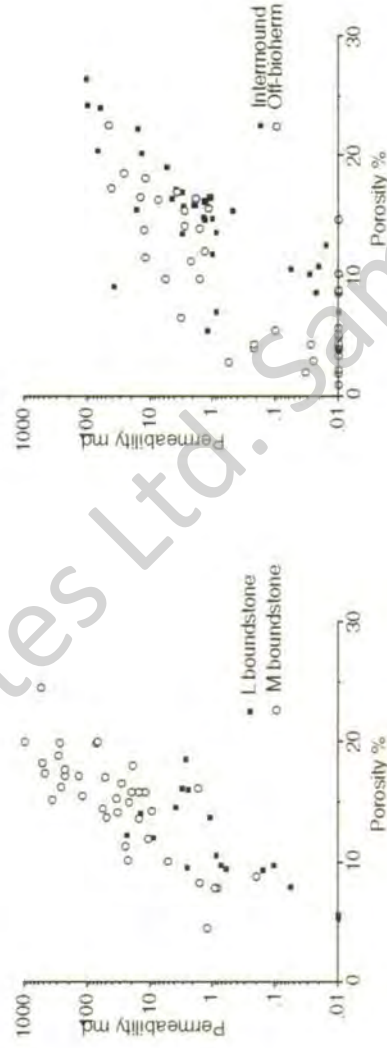
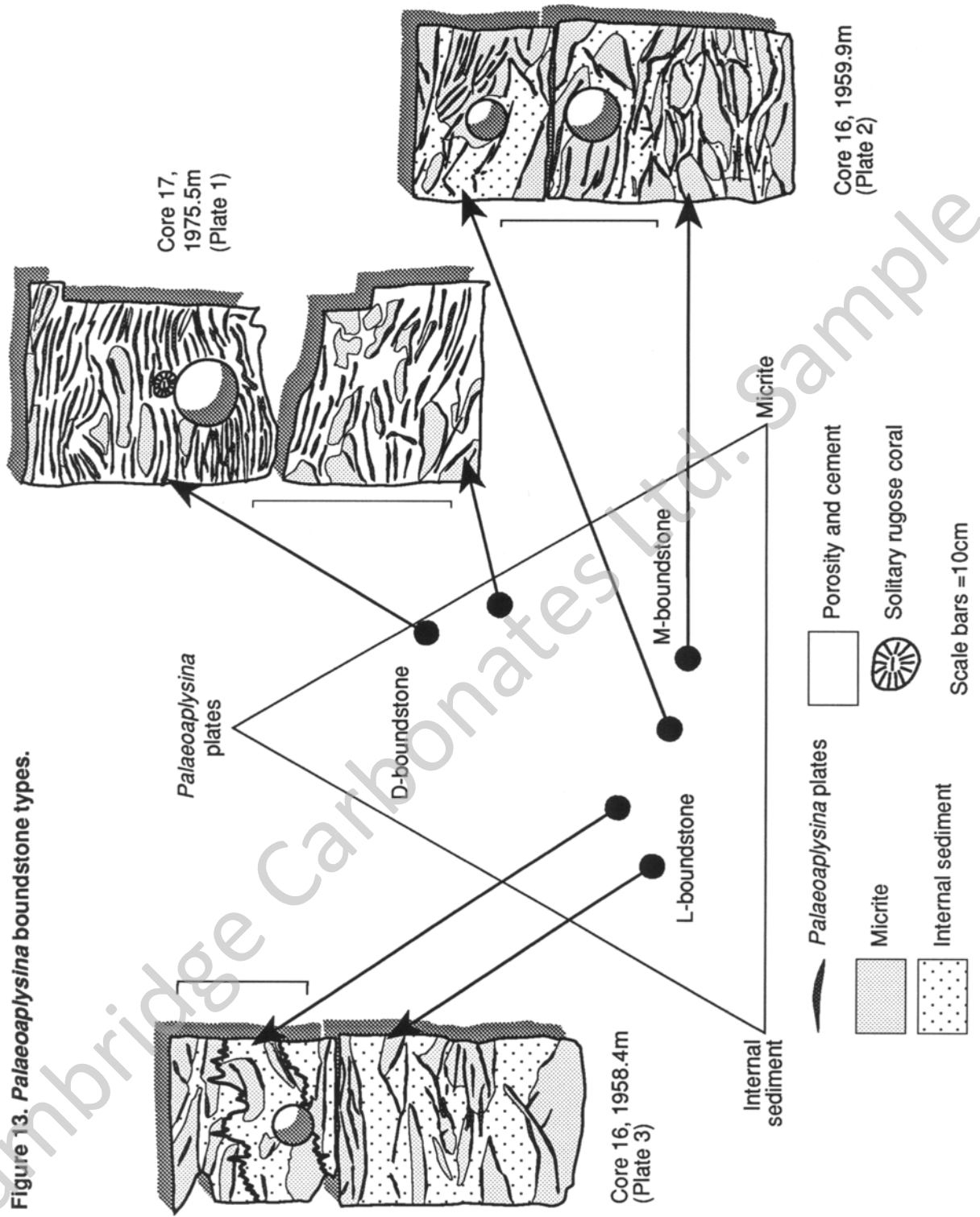


Figure 13. *Palaeoaplysina* boundstone types.



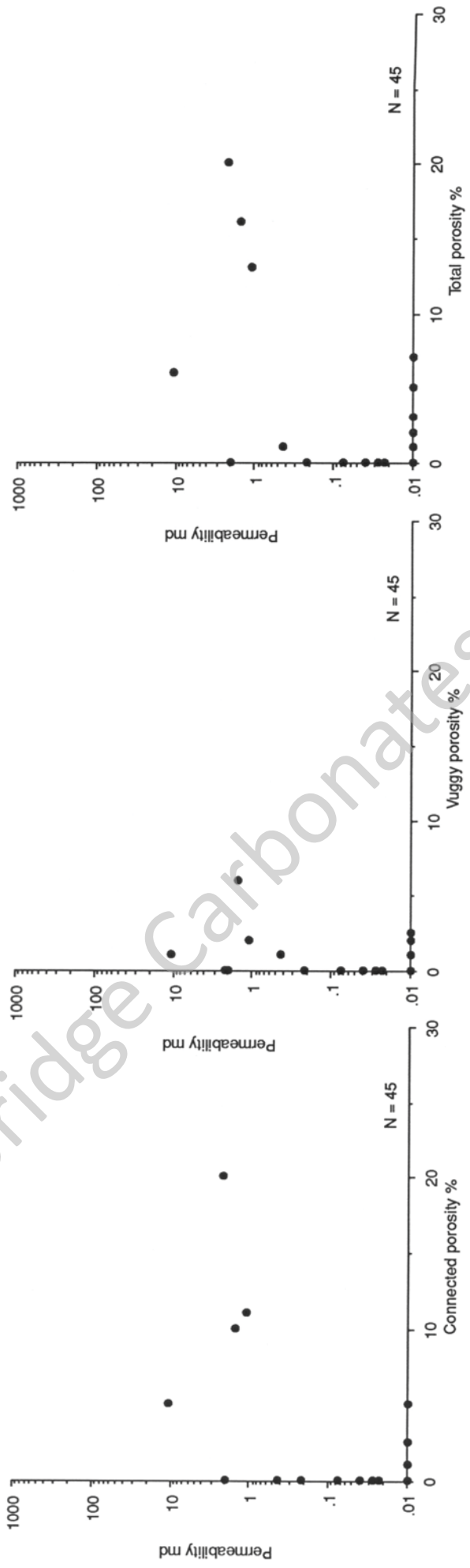


Figure 23. Porosity / permeability relationships: Kapp Hana Formation.

Cambridge Carbonates Ltd. Sample

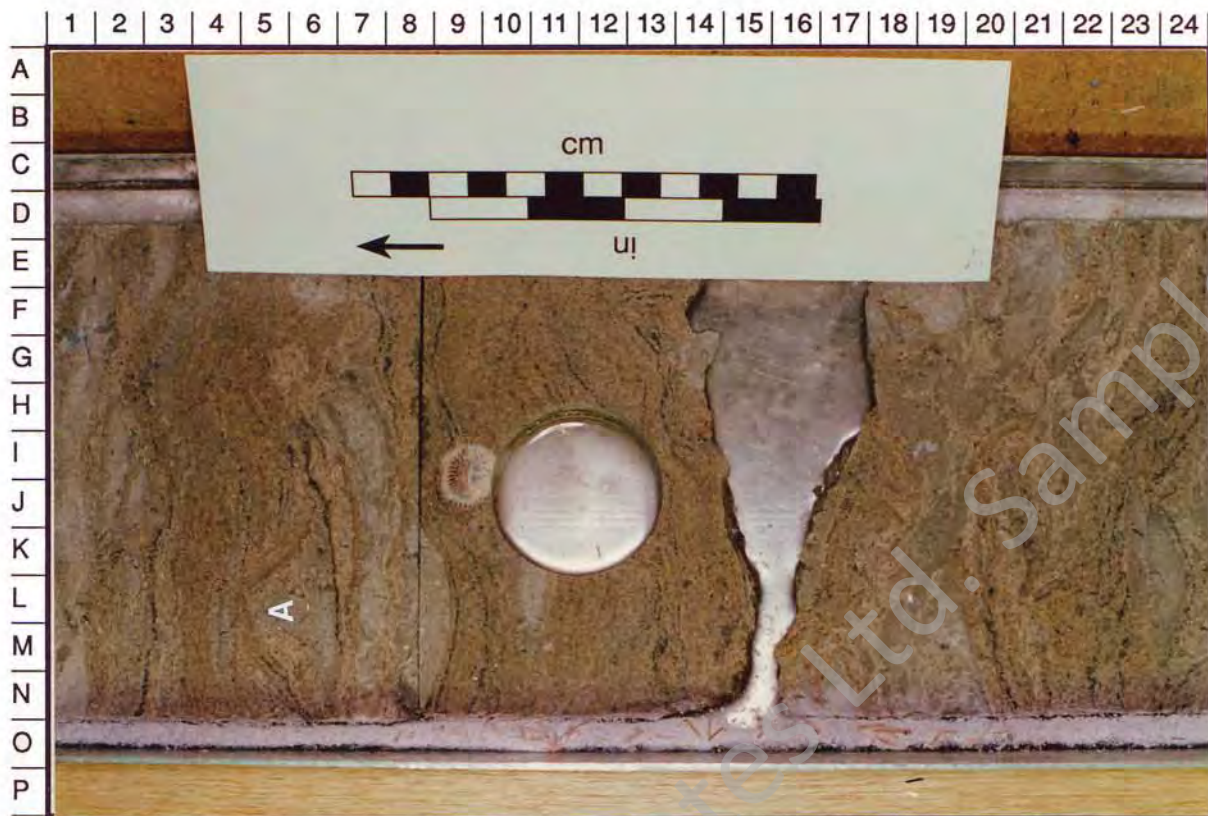


Plate 1: Core 17, Sakmarian to Asselian, 1975.5m. D/M boundstone with small *Palaeoaplysina* plates with an "arch" (L5) and solitary rugose coral J9. (See also Figure 13).



Plate 2: Core 16, Sakmarian to Asselian, 1959.9m. M-boundstone with large *Palaeoaplysina* plates (E14) and micrite (grey). Remainder of boundstone is mainly internal sediment. (See also Figure 13).

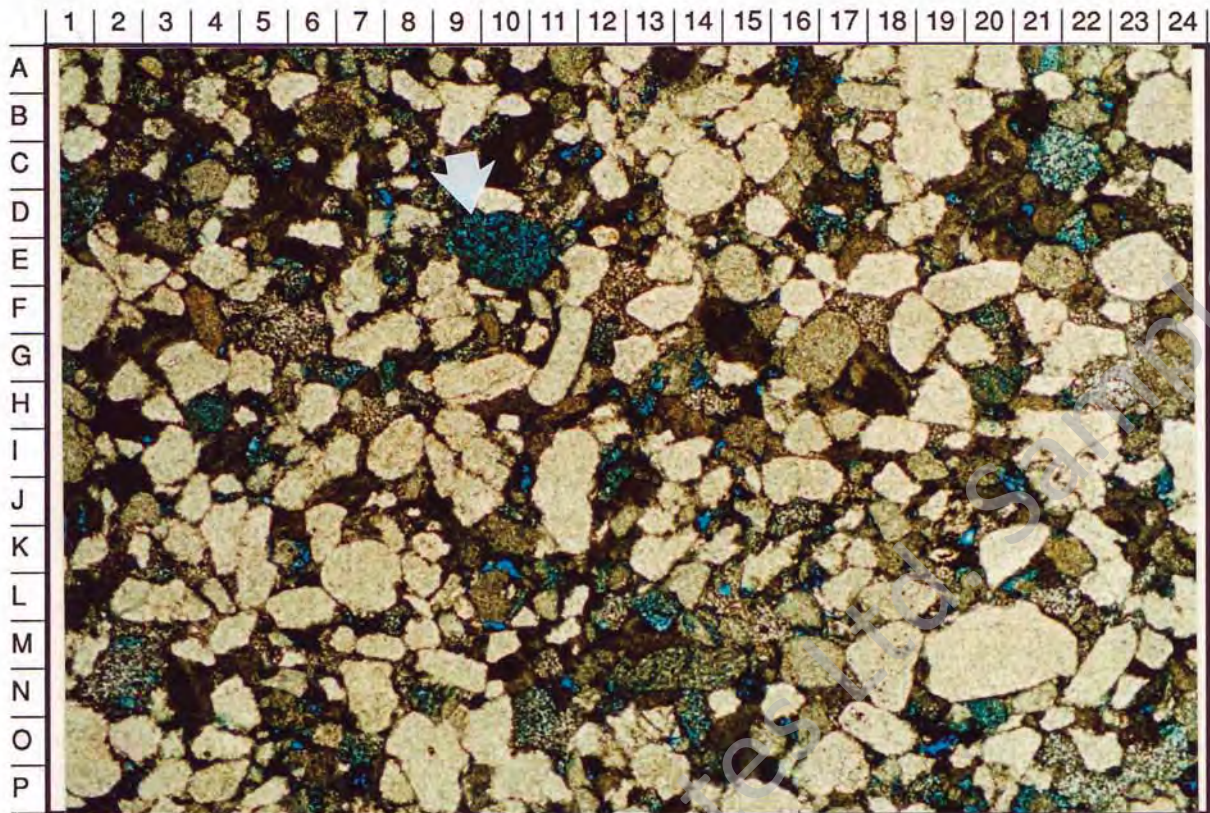


Plate 21: Kapp Kåre Formation, 2131.0m. Sandstone deposited in subtidal shore face setting. Primary porosity reduced by compaction. Secondary porosity was generated by leaching of feldspar (E10). Field of view 5mm.

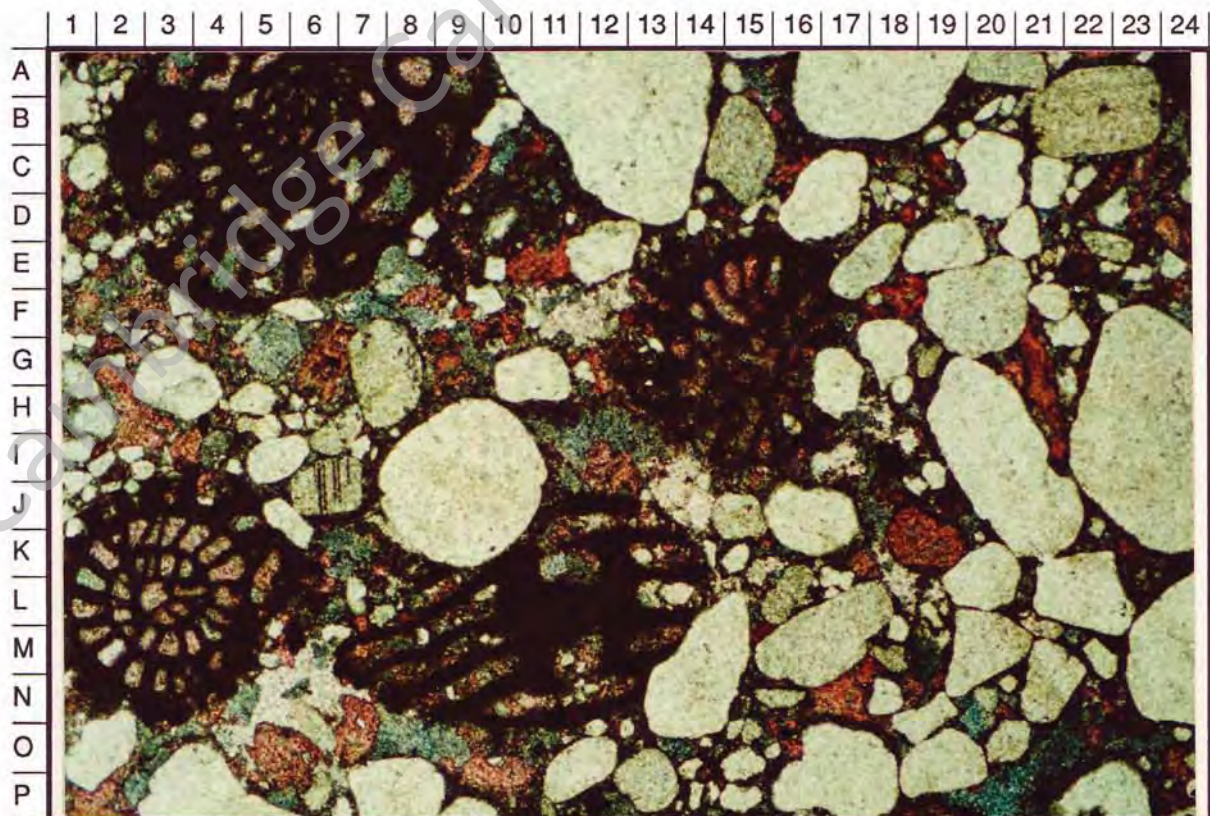


Plate 22: Kapp Hana Formation, 2100.25m. Poorly sorted bioclastic sandstone with well-rounded reworked grains and fusulinids. Porosity has been reduced by compaction and cementation by Fe- and non-Fe-calcite. Field of view 5mm.