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Multiclient Report for

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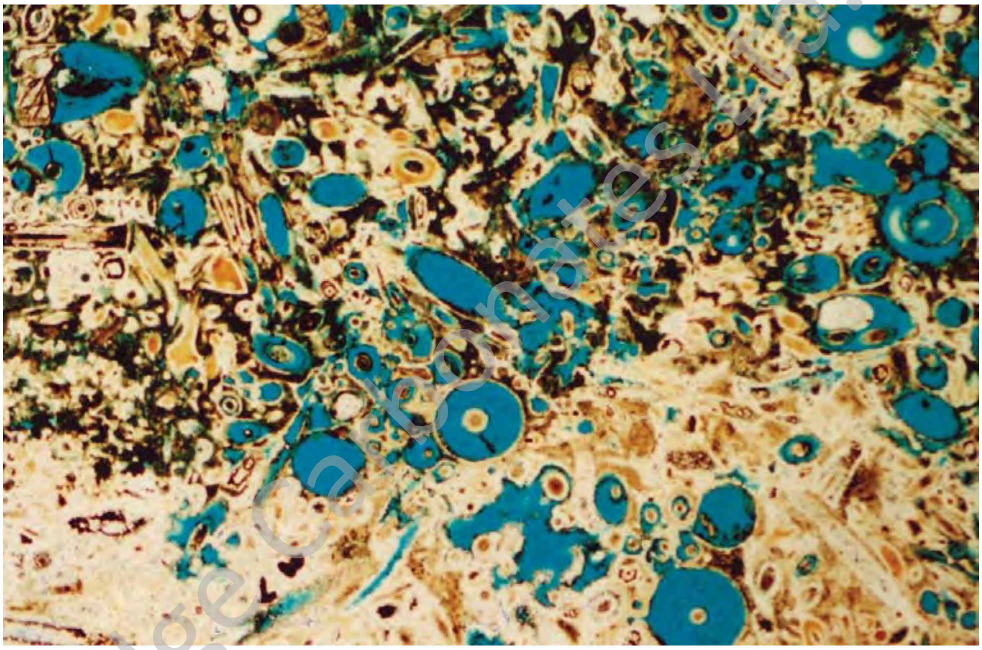

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Late Palaeozoic Sedimentology of 7128/4-1

Contents

4. DEPOSITIONAL ENVIRONMENTS: NON-CORED INTERVAL

4.1. Lithostratigraphic sub-division

The interpretation of the depositional environments of the non-cored late Palaeozoic succession is based on a microfacies study of sidewall cores and the lithological interpretation of wire line logs in the interval 1500-2530m. The stratigraphic succession is summarized by figure 4. Detailed descriptions of the microfacies are given in Appendix A.9. The following four informal lithostratigraphic units have been identified from the bottom upwards:

4.2. Billefjorden Group 2033.0 -2510m

The base of this unit is interpreted at a gamma log break at 2510.0m MD. The position of the top has been constrained by sidewall cores. This unit has been divided into two sub-units on the basis of sand content.

4.2.1. Lower sand-rich sub-unit 2395.0 -2510.0m (base not seen)

Sidewall cores from this interval are mainly coarse, poor to moderately-sorted sandstone and occasional siltstones of the terrestrial sandstone/siltstone microfacies. These were deposited in channel, crevasse splay and overbank settings in a fluvial system. The log signature suggests that this interval consists of thickly-bedded sandstone with some thin shale and siltstone beds. This suggests that this sub-unit is dominated by channel and proximal crevasse splay sands with minor overbank sandstone and siltstone. This sub-unit includes core 5 that is interpreted as a rotational collapse of overbank sediment adjacent to a major channel.

4.2.2. Upper sand-poor sub-unit 2033.0 -2395.0m

The base of this unit is picked at the top of the uppermost thick sandstone which marks the boundary between the sand-dominated succession (below) and the sand-poor succession (above). Sidewall cores from this interval are mainly medium to fine, moderately-sorted micaceous sandstone and occasional siltstone of the terrestrial

Reservoir potential in the bioclastic unit is moderate to poor. The reservoir facies are restricted to shallow ramp setting where they form layered sheet-like bodies which thin up dip and down dip. This passes up dip into porous marginal facies which are likely to form a poor up dip seal.

6.4. "Late Permian" siliciclastic unit

6.4.1. Basal sandy sub-unit

This sub-unit has minimal reservoir potential. Depositional porosity in bioclast grainstone and glauconitic sandstone is generally good but has been eliminated by compaction and cementation (Plate 38). Depositional porosity in the spiculitic bindstone is very poor and has been reduced by compaction and cementation by silica (Plate 42). Sponge spicules have been dissolved and infilled by silica cement.

6.4.2. Middle bioclastic sub-unit

This sub-unit has minimal reservoir potential. Depositional porosity in bioclast packstone / grainstone is poor to moderate and has been reduced by progressive compaction and cementation by non-ferroan and ferroan calcite cement in the form of a blocky mosaic and as overgrowths on echinoderms.

6.4.3. Upper spiculitic sub-unit

Figure 12 shows the distribution of pore types through the cored part of the spiculitic facies. Spicule moulds form the most abundant pore types. Fracture porosity has mainly been produced by compaction of dissolved sponge spicules and minor intergranular porosity is present throughout.

The intergranular pores are lined by early microcrystalline silica cement that preserves the spicule moulds. This was followed by dissolution of sponge spicules producing abundant microvuggy porosity with low connectivity (Plate 36). The connectivity was locally increased by compactive fracturing of spicule moulds. A phase of pervasive cementation by microquartz and chalcedony followed which base of the anhydrite is marked by 1cm thick stylolitised shale parting; the anhydrite passes transitionally upwards into the laminated dolomicrite facies.

Microfacies: Anhydrite nodules are made up of a felted mass of tabular to acicular pseudomorphs after gypsum. The stringers and wisps of sediment between the anhydrite nodules are made up of a densely peloidal dolomicrite (Plate 19).

Interpretation: The nodular anhydrite formed by displacive growth of finely crystalline gypsum within peloidal micritic or dolomicritic sediment. The lack of bioclasts and the early growth of gypsum indicate hypersaline conditions. The depositional setting is interpreted as a evaporitic tidal flat or sabkha.

Diagenesis: This facies contains no porosity. The gypsum was later replaced by anhydrite. There is a later partial replacement of the anhydrite by euhedral and subhedral megaquartz. The host sediment may have been an original dolomite mud or may have been dolomitised subsequently.

Occurrence: Core 3 1840.44-1839.25m

8.7. Laminated carbonate mudstone facies

Core: This is a carbonate mudstone which comprises mm to 0.5cm thick laminae separated by wispy partings. Nodular anhydrite is present as a partial replacement in the lower part of this facies (Plate 20). The laminae show a low relief domal structure, the crest of which is penetrated by a sub-vertical fracture infilled by calcite and anhydrite spar. No bioclasts are present.

Microfacies: Not sampled.

Interpretation: The absence of biota suggests that this facies was deposited in a hypersaline setting. The laminations may be algal in origin. The domical structure may represent an original growth form of the algal mats or may represent a teepee that formed by alternating desiccation and wetting. This facies was probably deposited in an intertidal setting.

Occurrence: Core 2 1814.8-1816.2m, 1819.6-1824.0m, 1828.35-1828.93m and 1831.35-1832.3m. Core 3 1846.5-1847.3m, 1850.0-1852.3m, 1854.9-1856.1m, 1858.0-1861.9m and 1864.95-1865.7m

8.15. Bioclast wackestone / packstone facies

Core: This is a bioclast wackestone which contains layers and lenses of reworked bioclasts. Occasional whole and fragmented solitary rugose corals, calcitised gastropods, disarticulated bivalves and articulated brachiopods, crinoids, fusulinids and beresellids are abundant in some intervals. Solitary and colonial rugose and tabulate corals and sponges are occasionally preserved *in situ*. Allochems are occasionally partly coated by *Tubiphytes*. This facies occasionally contains an argillaceous matrix and terrigenous grains. The limestones are heavily bioturbated which is picked out by the disorganized orientation of bioclasts and also by mottling defined by the distribution of clay and micrite (Plate 32). Bedding planes sometimes show intensive bioturbation which have been penetrated by clay-lined burrows. Beds of this facies are between 0.15 to 1.0m in thickness and are separated by occasional shale partings, stylolites and occasional beds of the bioclast grainstone / packstone facies. The bases of these beds are sharp and sometimes show evidence of scour.

This facies is partly dolomitised; the boundaries between dolomite and limestone are formed by a bedding plane, stylolite or shale parting, or are transitional over a vertical distance of up to 0.2m (Plate 32).

Microfacies: This facies has been divided into two microfacies types (not distinguishable in core).

- Non-micritised bioclast packstone / wackestone which contain disarticulated, fragmented and abraded bioclasts including brachiopods, crinoids, fusulinid and other foraminifera and fenestrate bryozoans. Whole bioclasts include gastropods, rugose and tabulate corals and articulated brachiopods. There is no micritisation or boring of allochems and occasional coating of bioclasts by *Tubiphytes* (Plate 33). There are occasional silt to very fine-grains quartz grains.

10. APPENDIX C: PALAEOHYDRAULIC FORMULAE

The following empirical relationships have been used to estimate fluvial channel and meander belt widths from the thickness of the channel sandstone body in core 4.

h = Channel depth

$w = 6.8h^{1.54}$

w = Channel width

$W_m = 64.6h^{1.54}$

W_m = Meander belt width

Relationships from Collinson (1986).

Depth m	Sample	Texture	Fen bry frags	Ramose bry	Crinoid oss	Echinoderm plates	Echinoid spines	Brachiopod shell	Brachiopod spine	Bivalves	Endothyrid forams	Archaediscid forams	Tetrataxid forams	Unserial forams	Tubiphytes	Ungdarellids	Calcispheres	Ostracods	Monoaxon spicules	Tetraxon spicules	Micritised grains	Peloids	Glauconite peloids	Siliciclastic sand	Siliciclastic silt
1574.15	Core 1	P/G	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	5	0	0	0	4	0	3
1574.45	Core 1	P/G	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	2	0	2
1574.90	Core 1	P/G	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0	0	0	2	0	4
1575.06	Core 1	P	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	2	0	2
1575.23	Core 1	P	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	5	0	0	0	1	0	2
1575.34	Core 1	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	2	0	2
1575.65	Core 1	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	1	0	1
1575.73	Core 1	P/G	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	5	0	0	0	2	0	1
1576.03	Core 1	P/G	0	0	0	2	0	2	1	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
1576.21	Core 1	P	0	0	0	2	0	2	1	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	1
1548.00	SWC	f/ms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3
1550.00	SWC	f/ms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4
1557.00	SWC	silt/fs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
1562.00	SWC	silt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5
1570.50	SWC	G	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
1571.50	SWC	G	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
1573.00	SWC	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
1579.00	SWC	P	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
1582.00	SWC	G/P	1	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0

Appendix B1: 7128/4-1 Microfacies data, core 1.

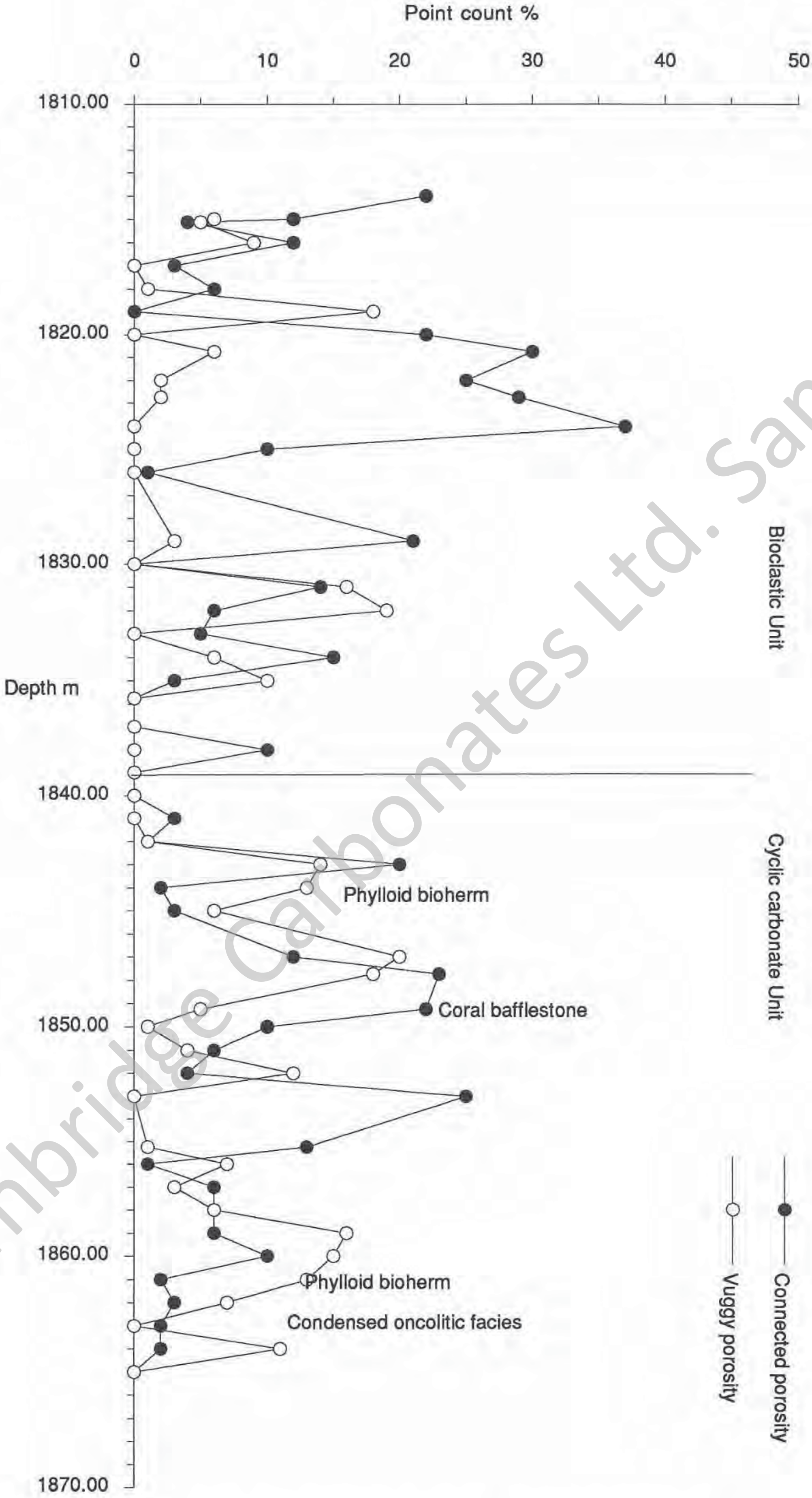

Figure 9. Pore types and depositional facies: cyclic carbonate unit cores 2 and 3.

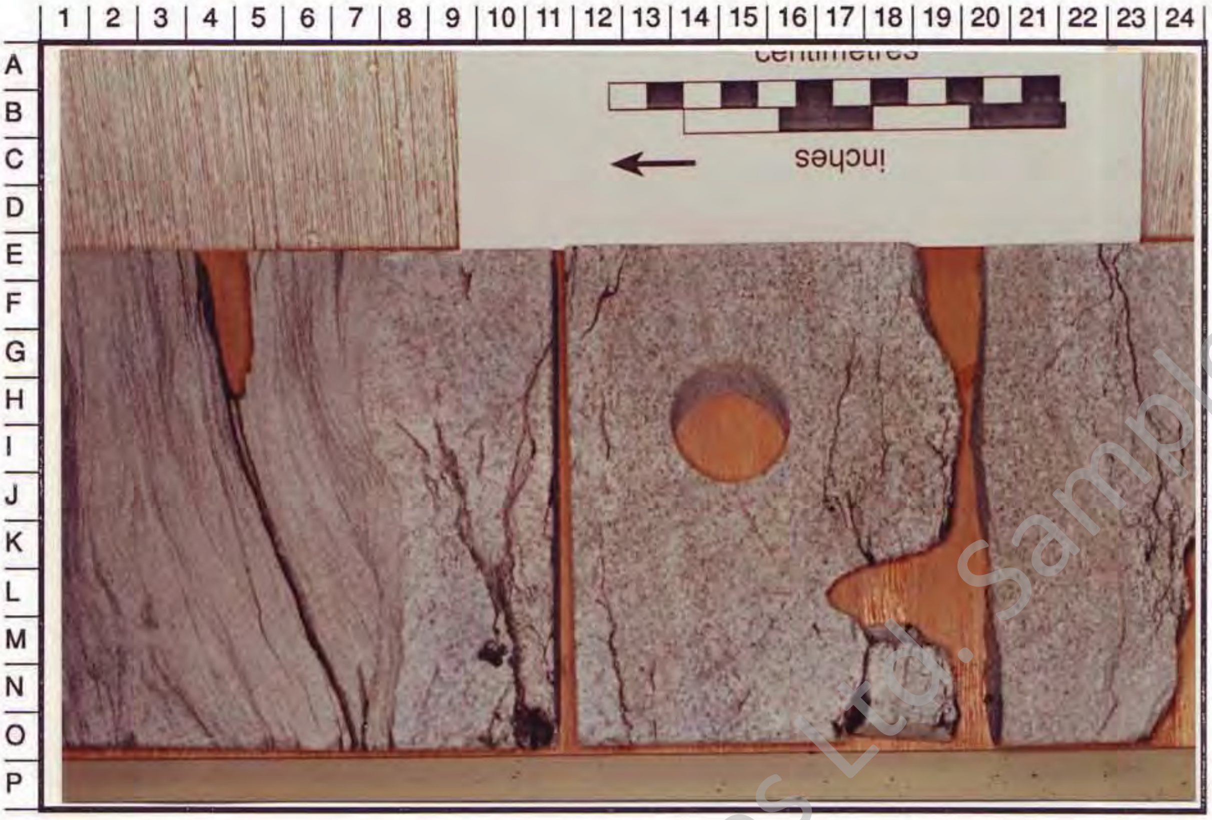

Plate 9: Core 4, 2380.50m. Composite sandstone facies. Very coarse grained structureless sandstone overlain by dewatered cross-bedded sandstone, deposited in proximal crevasse splay setting.

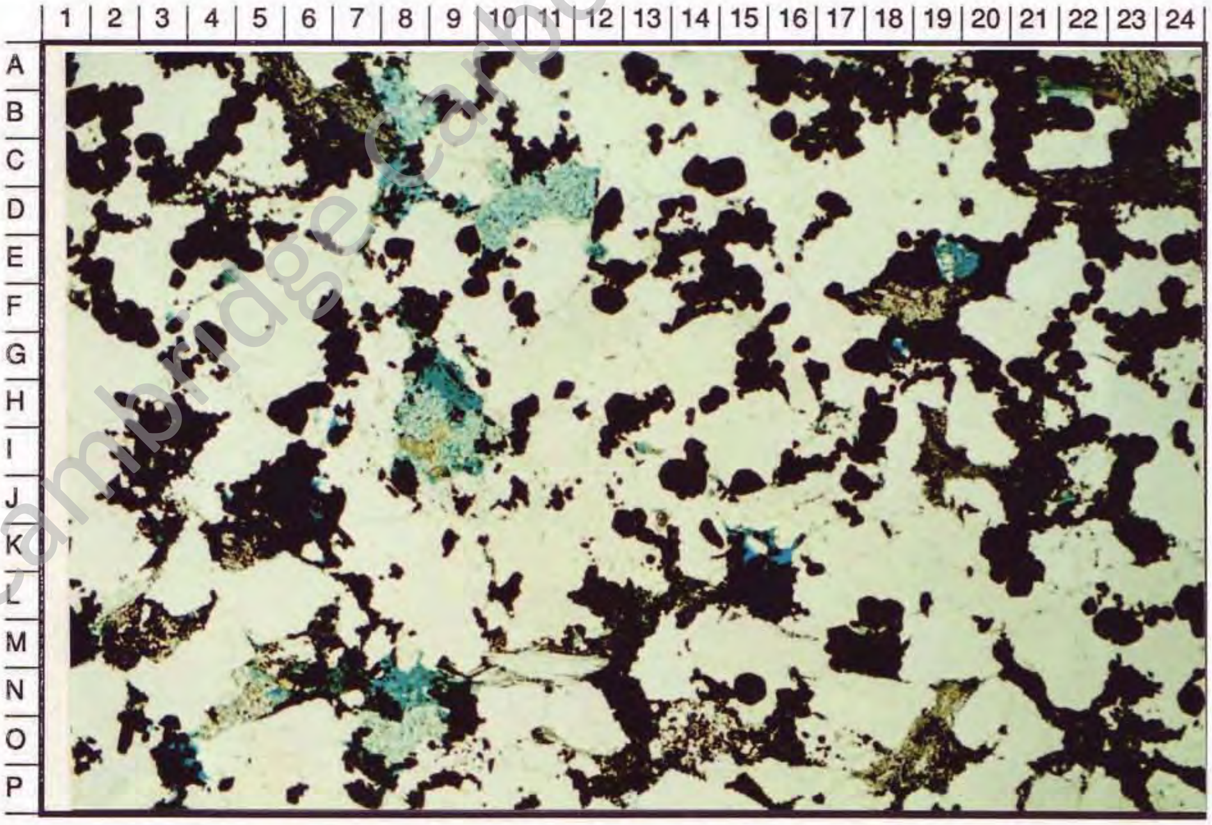

Plate 10: Core 4, 2384.25m. Composite sandstone facies, well sorted sandstone with relict intergranular (E19) and feldspar mouldic porosity infilled by kaolinite (H8). Pyrite cemented. Field of view 5mm.

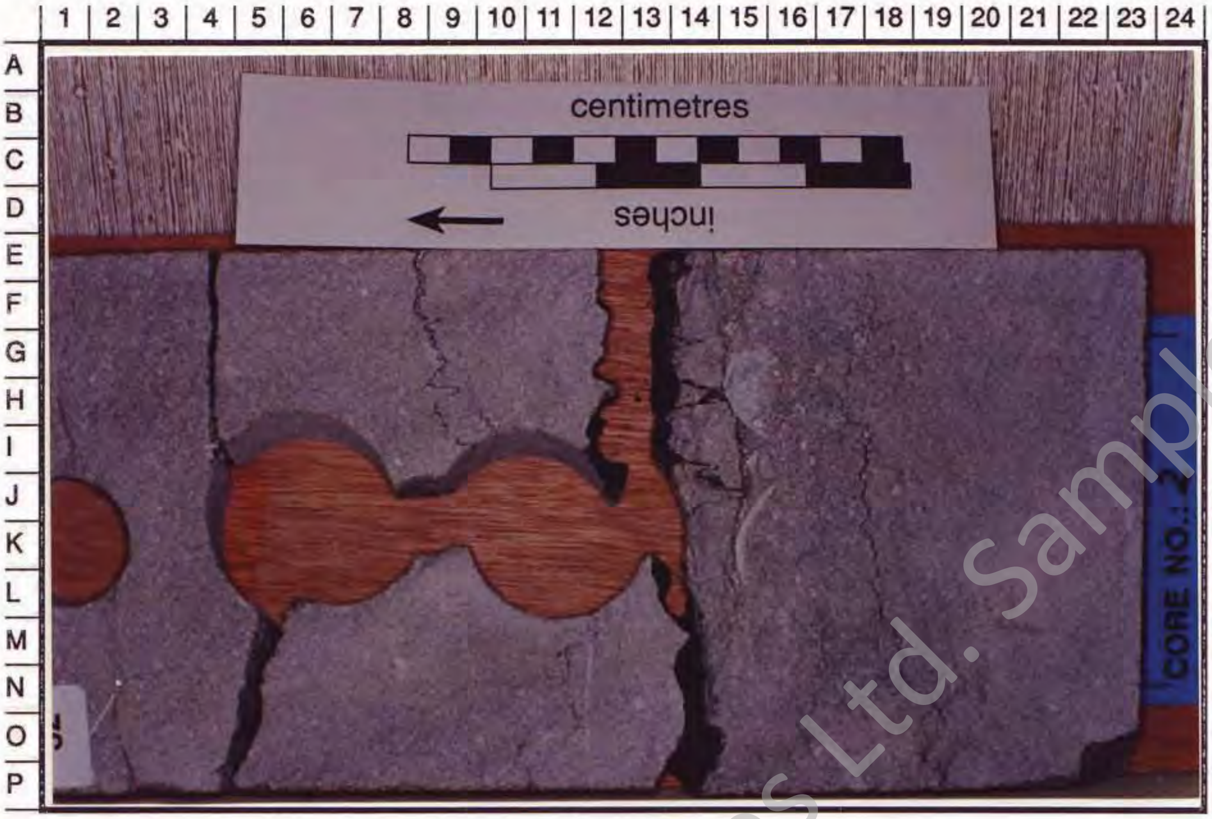

Plate 29: Core 2, 1821.90m. Bioclast grainstone / packstone facies. Layer of whole, abraded bioclasts within sorted bioclastic grainstone.

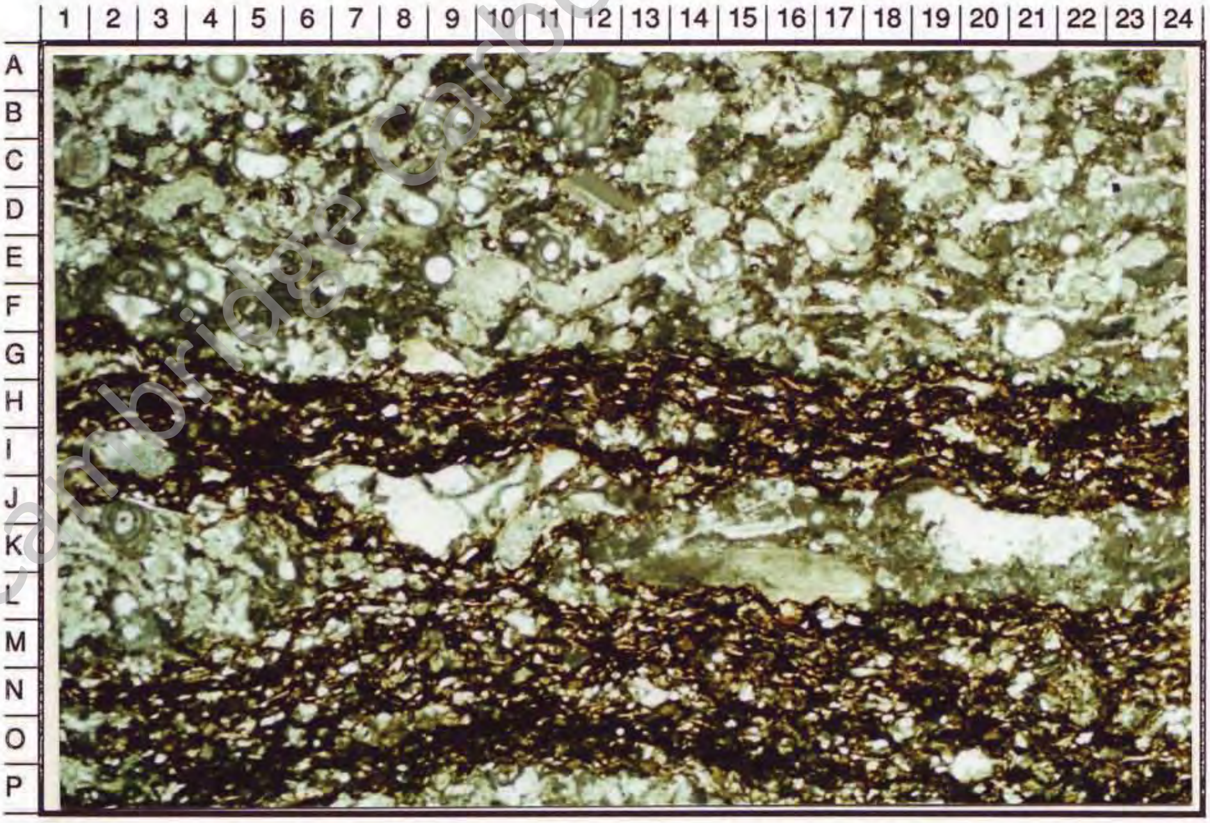

Plate 30: Core 2, 1815.13m. Bioclast grainstone / packstone facies. Scoured base of non-micritised bioclastic limestone overlying bioclastic shale. Field of view 5mm.