

Report for: Oxford Archaeology
Contacts: Ruth Shaffrey; Lisa Brown
Your Reference:
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**Petrology of limestone artefacts rescued from the
Coombe Down Stone Mines, Bath**

by

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Preamble

You asked me to visit the Oxford Archaeology operation at Coombe Down to discuss sampling of recovered limestone artefacts in Autumn 1998. Subsequently you asked me to return to take samples for thin-section work from a selected range of these artefacts. This was done in June 2009.

Material

The following items were sampled (copied from Ruth Shaffrey's field log):

Sample	SF	Ctx	Area	Stub	Notes	Photos	Dating of area	Location of area
1	718	749		34	balustrade fragment		2 1730s	
2	398	5298		504	Coping stone		2 post 1830s	
3	664			Road 5 (long road not on plans)	Silt trap		2 post 1830s	
4	883			S8	Architrave		1730s but possible later 2 tipping of 1810-20	
5	881		K30A				mostly 18th but with 3 early 19th tipping	
6	945			C17	Sink		main cartway not closely dateable but probably 19th	
7	597			103 C15	candle Box		2 1830s-1860s Neville doesn't know	
8	908	12165		031 (Set 61)			4 yet	
9	750				Large storage box	of whole box and separate lid	Probably 1830s	south east corner
10	858				sash window			
11	855				37 surround			
					37 Scappled block		early 1730s date	May eliminate this as found very
12					Massive block		0 Note this is of a different petrographic character to other s	
13	835			S17	Pillar, possibly mullion roughout			1806 onwards
14	670	95			Crane base			
15	139	456		16				
16	697			E5	baluster block			
17	358	4117		406	Waster from ridge /coping stone			

Preparation and Treatment

Stone samples, each about 5mm thick and the size of a postage stamp, were cut from the artefacts using a tile saw. The sample was cut across the sedimentary lamination of the stone where this was clearly defined in the artefact. Each sample was trimmed down to thin section size and impregnated under vacuum with clear epoxy resin. Standard 30 micron thin sections were made and photographed in plane polarised light on a Leitz 12 POL photomicroscope.

Results and petrographic description

The mines were excavated in the upper part of the Coombe Down Oolite, which constitutes the lower part of the Great Oolite Formation of the Bath region. It forms a unit up to 14 m thick in the vicinity of Coombe Down, but thins rapidly southwards (Green, G.W. & Donovan, D.T. 1969. *Bull. Geol. Surv. G.B.*, 30, 1-63.). The galleries from which the artefacts were recovered are in the upper part of the formation, where the dominant limestone lithology is pure and laterally extensive. Horizons of coral debris or burrows which have been recorded by other workers seems to have been deliberately avoided or rejected by the quarry workers.

The individual photographs of the samples 1-17 are shown below in Appendix 1. These correspond to SF 1-17 in Ruth Shaffrey's field-log reproduced above. Most of the samples collected were very similar to one another petrographically, and the description that follows covers nearly all of them. The exception is Sample 11, discussed separately below.

Depending on which scheme is used for the description and naming of the limestone, it is an oolitic calcarenite, an oolitic grainstone, an oobiosparite, or even an oolite. It was deposited as a lime sand (medium grain-size, most grains between 0.1 and 1.0 mm in diameter) on a shallow, current-agitated sea-floor that deepened towards the south, during the Bathonian stage in the Middle Jurassic period of geological time (c. 166 million years ago).

Grain Types: 1, ooliths. Ooliths dominate amongst the grains. They are ovoid to spherical, depending on the shapes of their nuclei. The nucleii are shell fragments or peloids, and some have only a thin oolitic cortex (superficial ooliths). They range up to c. 0.8 mm across. The cortex is porous, as seen in some of the photomicrographs below in which the resin impregnation has been only partial. The calcite crystals that make up the cortical layers are orientated radially, though this becomes most apparent towards the top bed of the Coombe Down oolite and is not conspicuous in the worked stone. The porous nature of the ooliths makes them soft and crumbly on freshly-exposed surfaces, covering it with a chalky dust. This soon washes off to leave a surface on which the former positions of the ooliths are marked only by their impressions in the enclosing cement (so-called spar-prominent texture).

Grain Types: 2, shell fragments, or bioclasts. Broken-up shell debris forms the nuclei of many ooliths, but also forms a subsidiary grain type in its own right. A few of these bioclastic fragments are large enough to identify the animal group from which they were derived, but most are small, rounded by sea-floor attrition, and unattributable. They consist both of material that was originally composed of calcite (primary shell structure still apparent), and material originally of aragonite (dissolved and replaced by clear calcite cement inside a micrite envelope during the burial history of the rock). The calcitic fragments are from echinoderms, oysters (and maybe scallops), and rare brachiopods and bryozoans. The replaced aragonite fragments were probably derived from molluscs (mostly gastropods and bivalves), and maybe corals.

Texture and Lamination: The grains support one another at point contacts and the sediment is clean-washed and winnowed so that no fine-grained material occupies the pore spaces between the sand grains. 5mm – 10mm scale lamination based on grain size and density is present, such that layers of oolith rich and layers of shell debris rich material alternate. In some of the larger artefacts, the lamination is seen to be representative of medium-scale trough cross bedding. Only minimal bioturbation is seen. There is no sign of grain interpenetration at the contacts, nor any other sign of overcompaction before cementation.

Cementation: Pore space between the grains is filled with a clear cement of crystalline calcite spar that grew out from the grain edges (drusy texture). The texture forms larger blocky crystals of overgrowth cement where it grows on echinoderm fragments. Because of the mechanical weakness of the individual ooliths (see above), the strength of the overall stone is derived from this dense interconnected crystalline cement matrix.

Exception: Sample 11. Sample 11 is strongly overcompacted, and the grains have been forced into one another and internally fractured, at some time after the first thin generation of calcite cement was deposited on their surfaces. This is sometimes seen in other Bath Stone samples. It is likely that areas of the stone which display this petrography are close to early fracture zones in the stone that were caused by local tectonic movement. The fractures became cemented by subsequent cement growth, to produce the calcite veins that are so characteristic of many of the varieties of Bath Stone.

Borehole Cores

Attempts to study complete cores from well-located boreholes close to the mine area were not successful because of poor curation. Only random lengths from a variety of the boreholes had been preserved. It was nevertheless possible to recognise several features of the Coombe Down oolite interval from surviving lengths, and from discarded material.

1) The oolite was of a uniform clean-washed grain-supported character towards in the upper few metres of its thickness. This was the most suitable building stone, and corresponds to the level where the mines were developed.

2) Toward the bottom of the Coombe Down oolite, and the passage down into the Fullers Earth, impure and clayey limestones become more common. These were clearly unsuitable for building or carving.

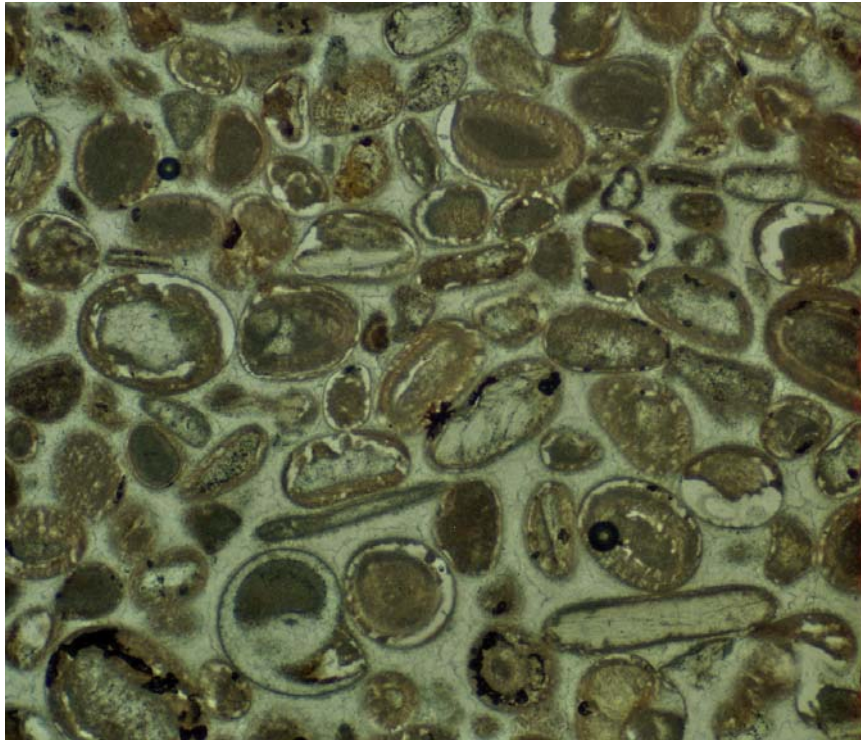
3) The top of the Coombe Down Oolite is marked by a hardened, iron-stained layer that is perforated by contemporaneous mollusc and worm borings (a hardground). In thin-section, this hardground shows a thin cement coating adjacent grains, and opaque fine-grained sediment filling the rest of the intergranular porosity (see Sample 18 below).

4) One metre below this surface, the petrographic characteristics of the hardground surface were no longer apparent, and the stone in thin-section appeared like that seen in the artefacts (see Sample 19 below).

Conclusion

Stone from the Combe Down Oolite quarried to the south of Bath should be easy to recognise in thin section if encountered in other contexts. The uncompacted, clean-winnowed, laminated, unbioturbated texture, with porous ooliths and a minimum amount of large bioclastic material are typical. It is interesting to note that the material quarried from the same horizon in the Corsham area, used widely in the 19th century under the name of Box Ground Stone (and other names), seems to have more, and larger, recognisable shell fragments. This apparent difference deserves a closer study.

Appendix 1. Thin section photographs.



Sample: 1

SF: 718

Item: lathe-turned baluster

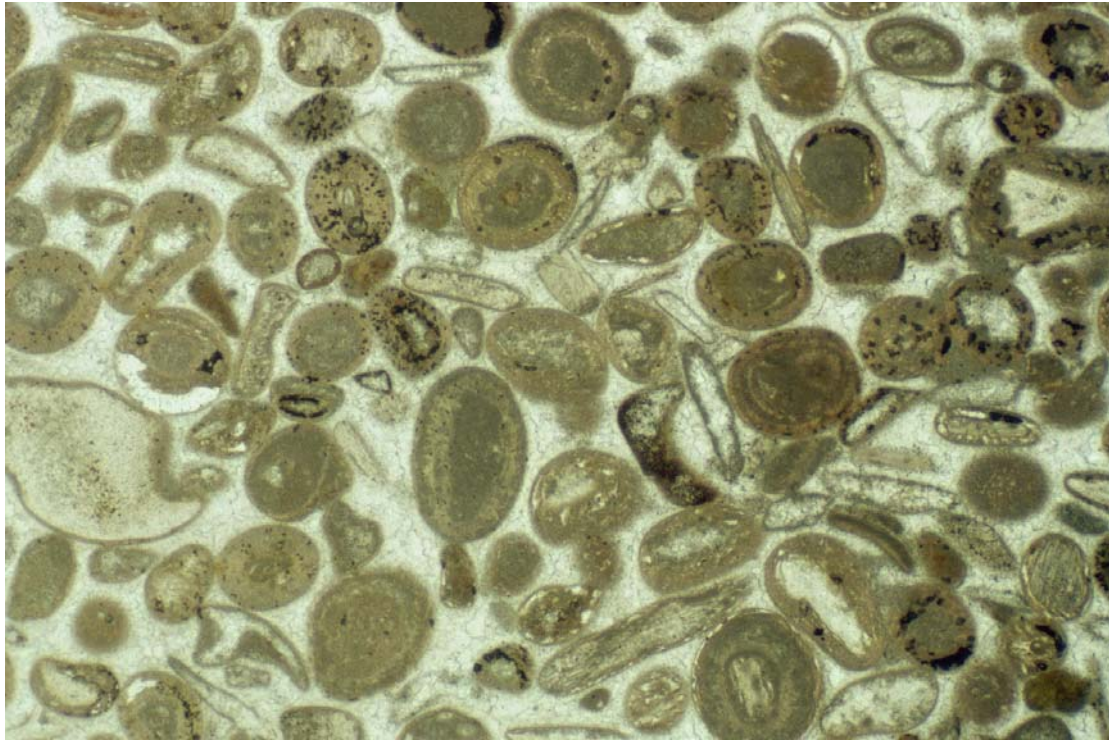
Width of View of Picture: 2.8 mm

Petrographic type: oolitic grainstone with drusy spar cement

Grain overcompaction: none

Areas of white space in some of the oolite cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: micromorphic gastropod.



Sample: 2

SF: 398

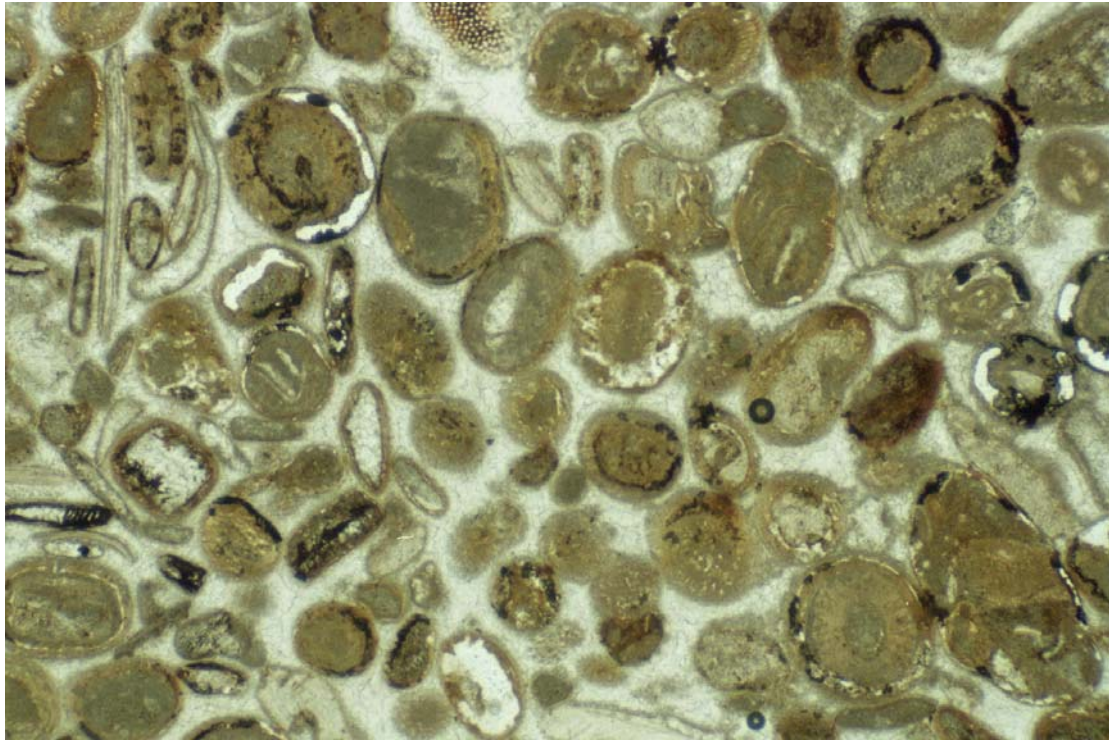
Item: ridge stone tile

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: echinoderm; miscellaneous calcite-replaced molluscs; probable oyster.



Sample: 3

SF: 664

Item: uncompleted sump

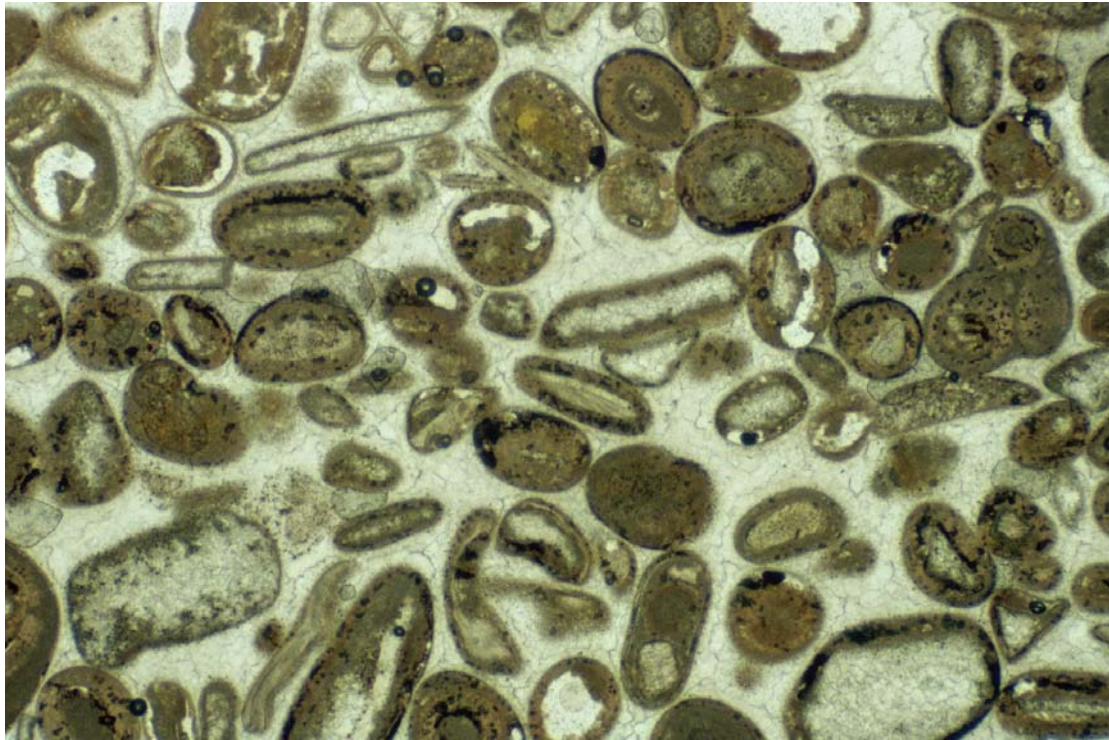
Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Areas of white space in some of the oolith cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: echinoderm; miscellaneous calcite-replaced molluscs; probable brachiopod.



Sample: 4

SF: 833

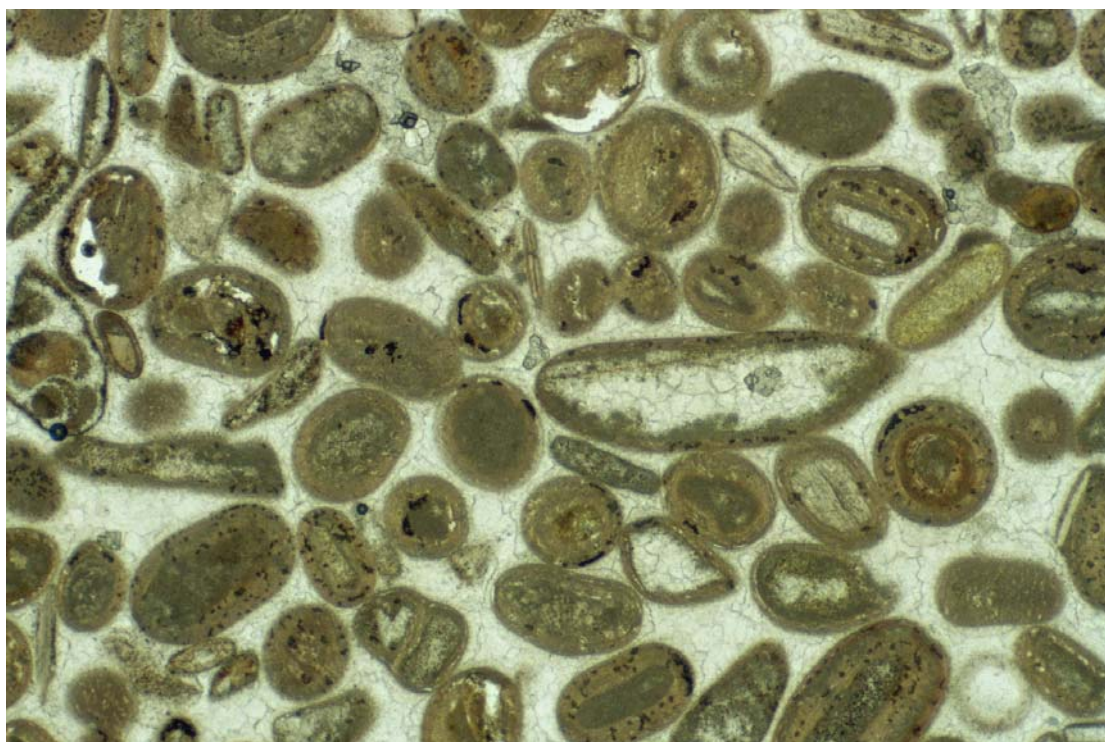
Item: cornice / architrave

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: miscellaneous calcite-replaced molluscs.



Sample: 5

SF: 881

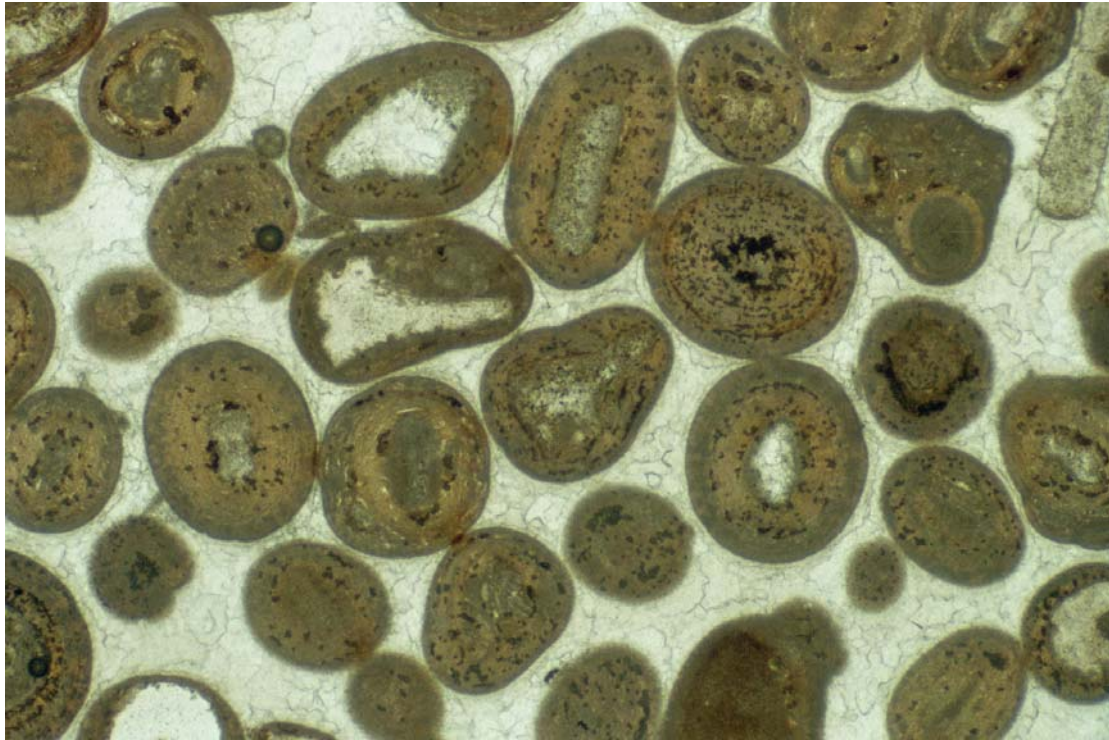
Item: window moulding with glass groove

Width of View of Picture: 3.4 mm

Petrographic type: oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: micromorphic gastropod; miscellaneous calcite-replaced molluscs.



Sample: 6

SF: 945

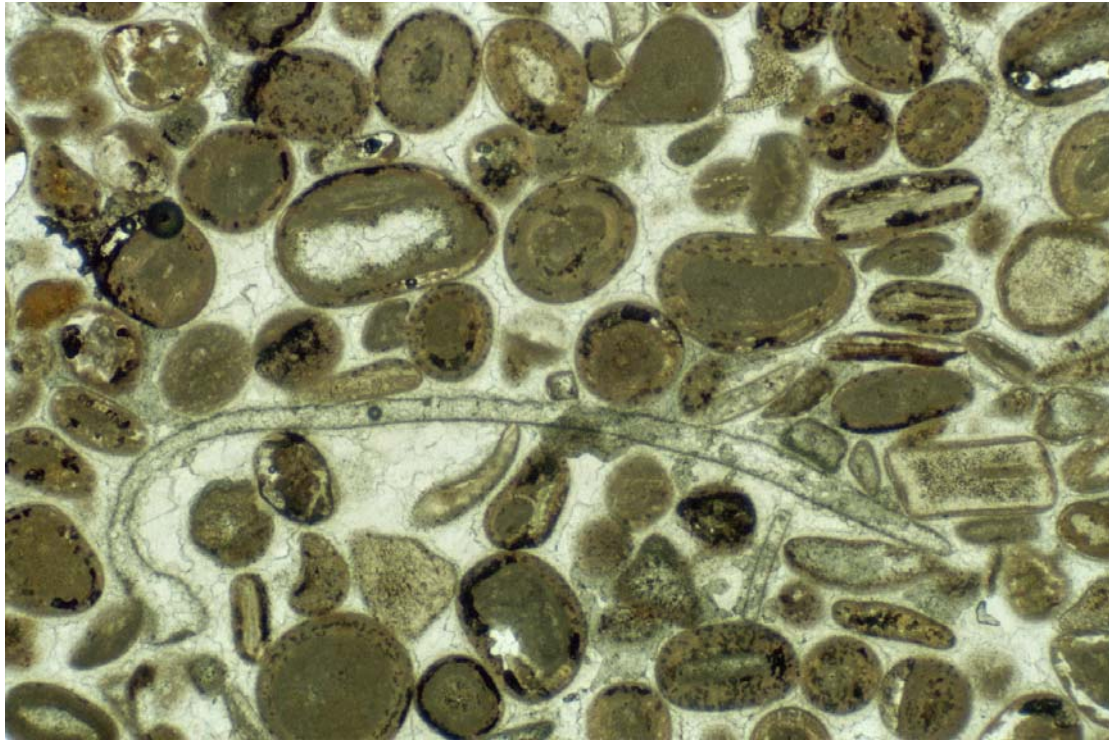
Item: lip of sink

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: calcite-replaced oolith nuclei, probably originally aragonite molluscs.



Sample: 7

SF: 597

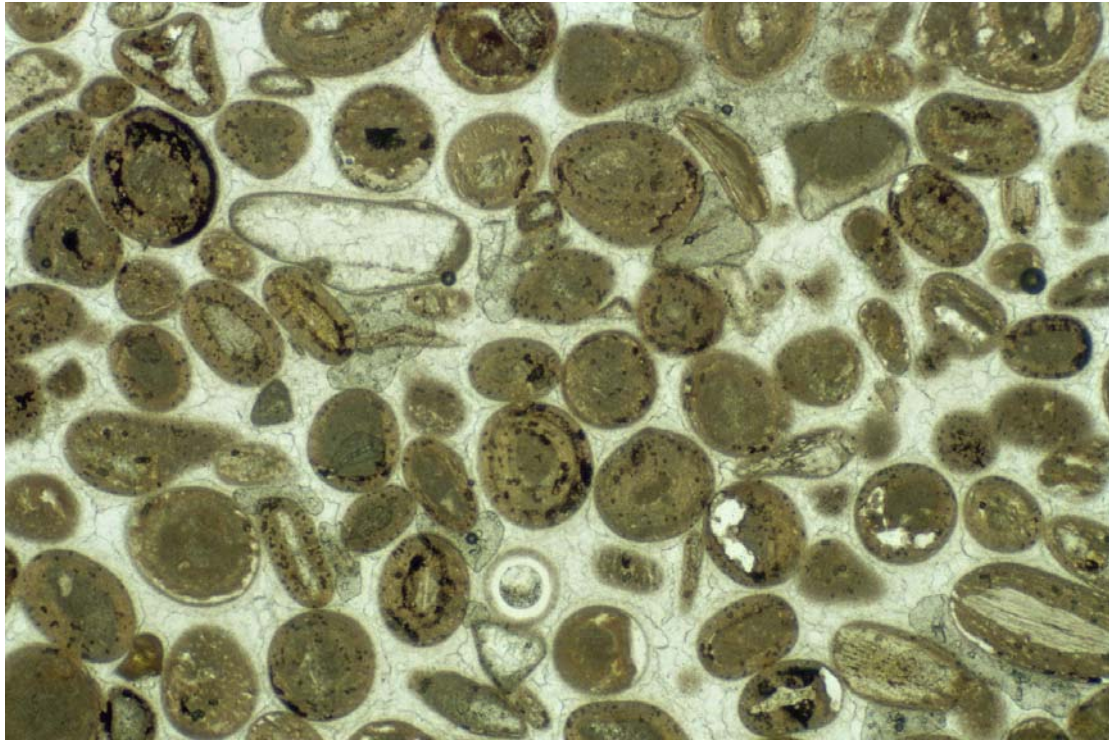
Item: lip of candlebox

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: echinoderms; miscellaneous calcite-replaced molluscs, including large example across middle of frame.



Sample: 8

SF: 908

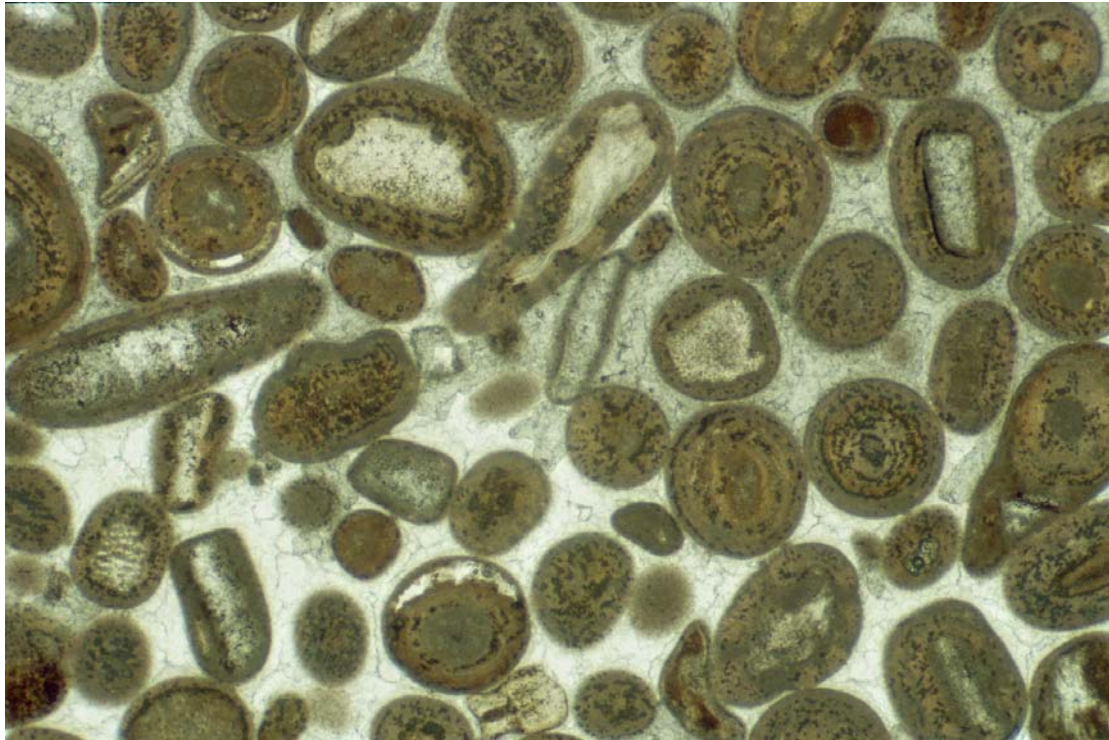
Item: architrave

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: echinoderm; probable calcite-replaced molluscs (upper left centre); probable oyster forming oolith nucleus at lower right corner.



Sample: 9

SF: 750

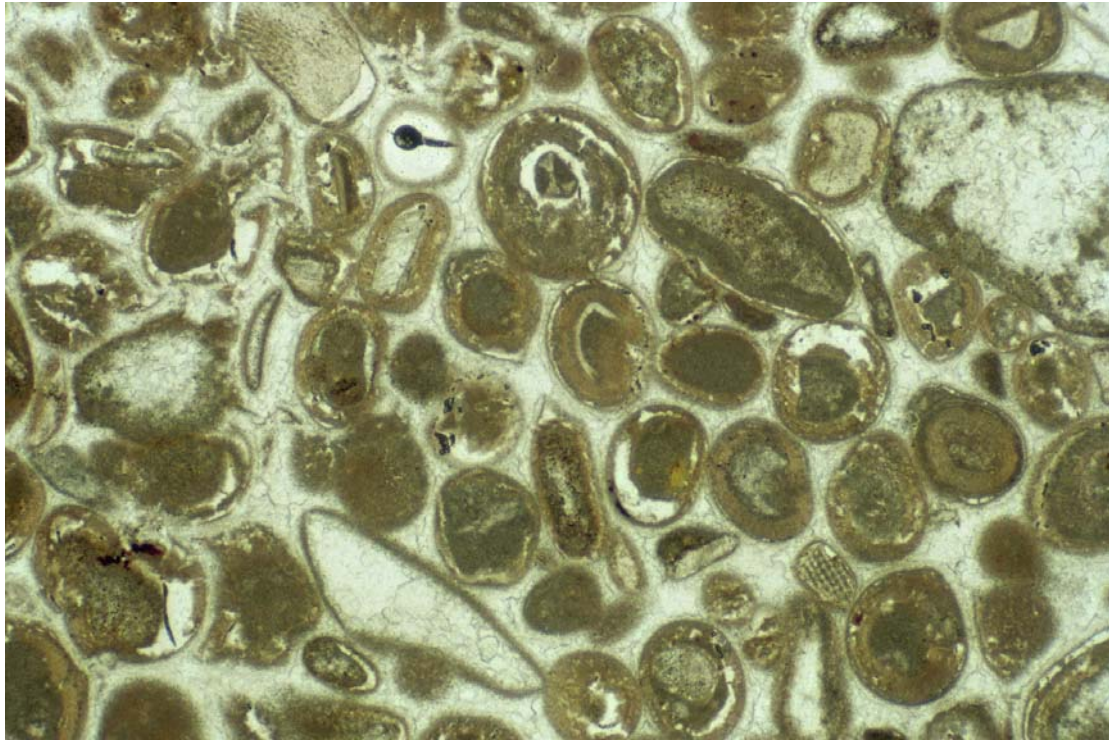
Item: large box, post 1850

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: miscellaneous calcite-replaced molluscs as oolith nuclei; probable oyster forming oolith nucleus upper centre



Sample: 10

SF: 858

Item: large moulding

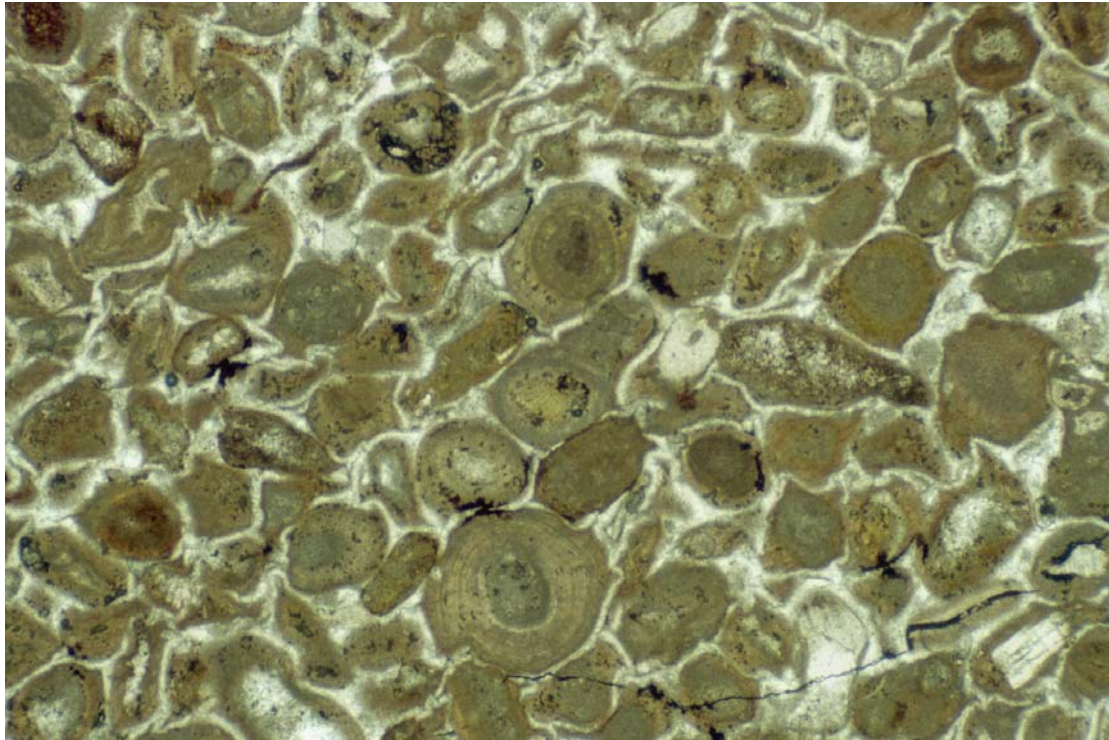
Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Areas of white space in some of the oolith cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: echinoderm; calcite replaced probable aragonite molluscs



Sample: 11

SF: 855

Item: scapped block

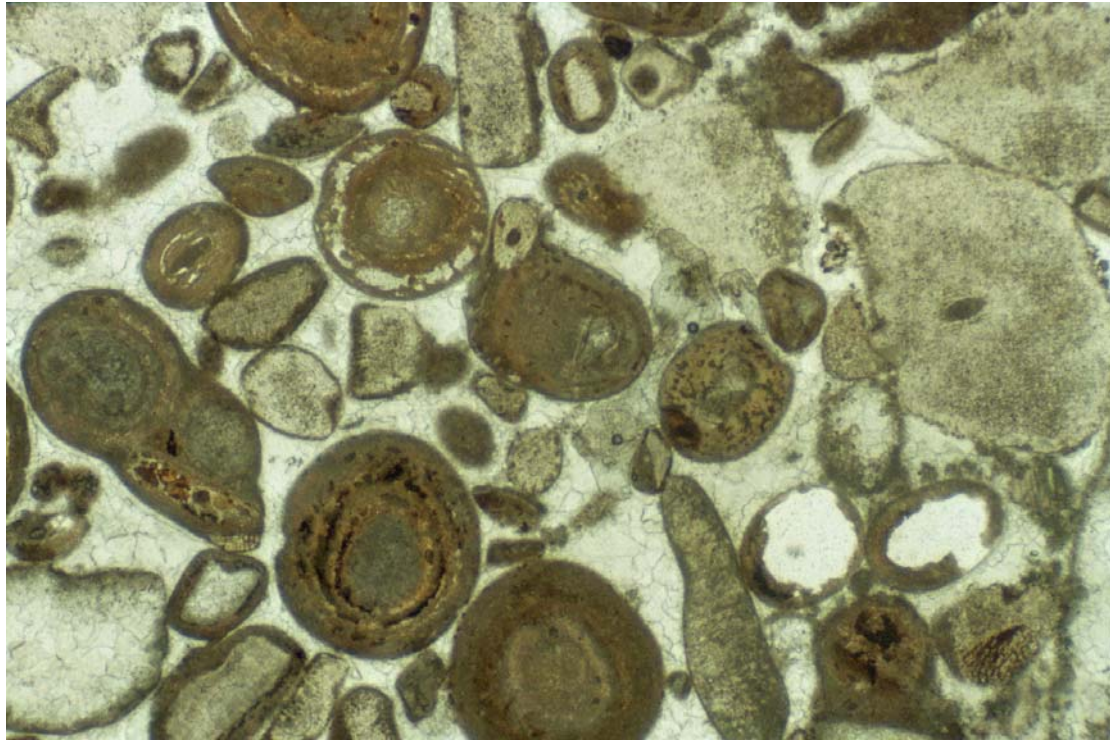
Width of View of Picture: 3.4 mm

Petrographic type: oolitic grainstone with drusy spar cement

Grain overcompaction: strongly overcompacted after 1st cement generation to produce fitted fabric and crushing of ooid cortices.

Areas of white space in some of the oolith cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: prismatic calcite molluscan shell fragment forms oolith nucleus in lower right corner



Sample: 12

SF: 731

Item: large block from behind roof fall; Ralph Allen's time

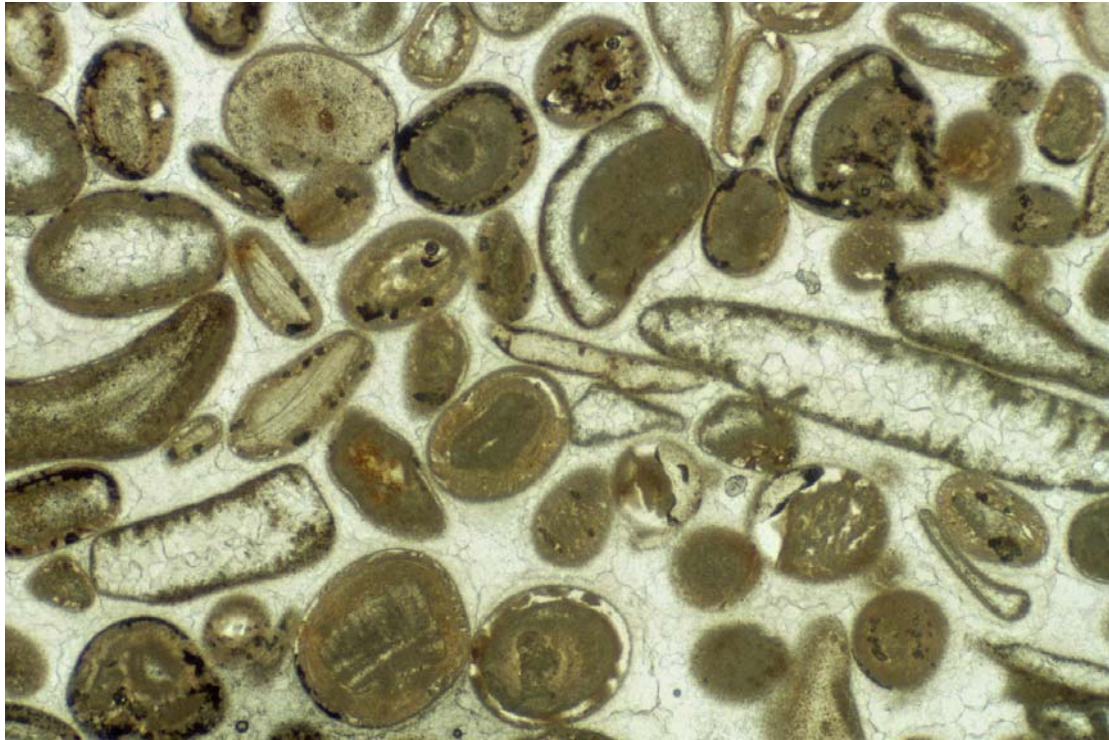
Width of View of Picture: 3.4 mm

Petrographic type: oolitic bioclastic grainstone with drusy spar cement and prominent echinoderm debris

Grain overcompaction: none

Areas of white space in some of the oolith cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: plentiful echinoderm fragments, probably unstalked crinoids; calcite-replaced probable mollusc grain in lower left corner.



Sample: 13

SF: 835

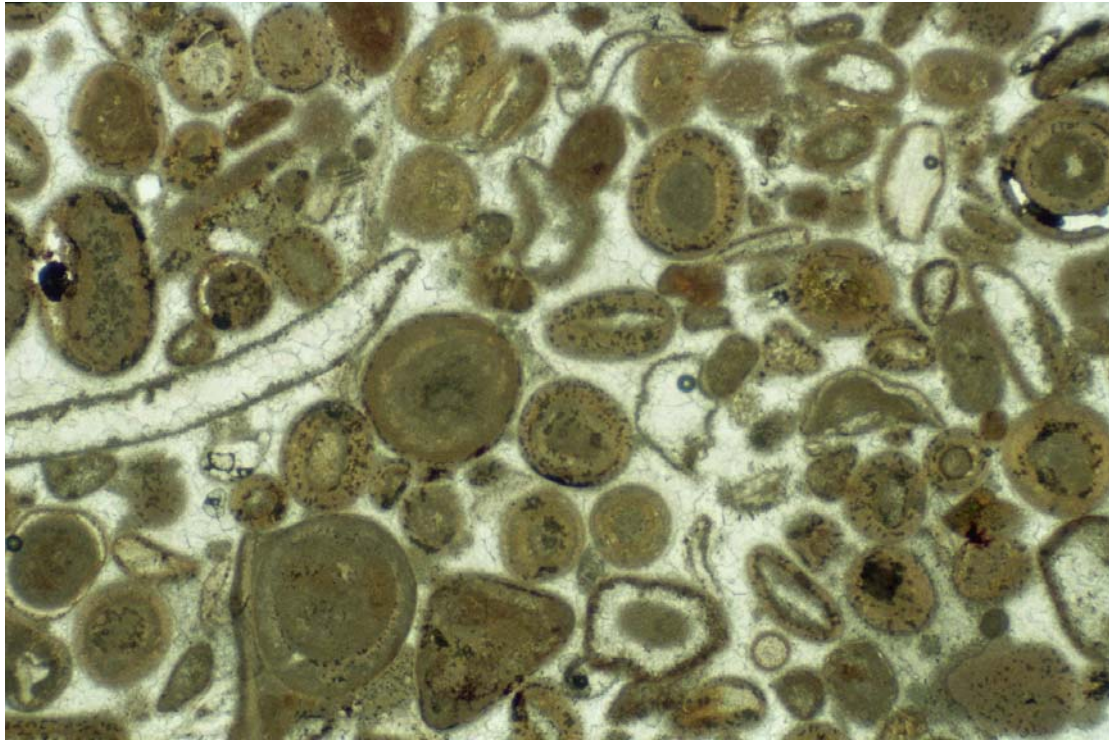
Item: roughed-out mullion

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: 2 large replaced probable mollusc fragments with well-developed micrite envelopes. Smaller central elongate grain may be punctate terebratulid brachiopod.



Sample: 14

SF: 670

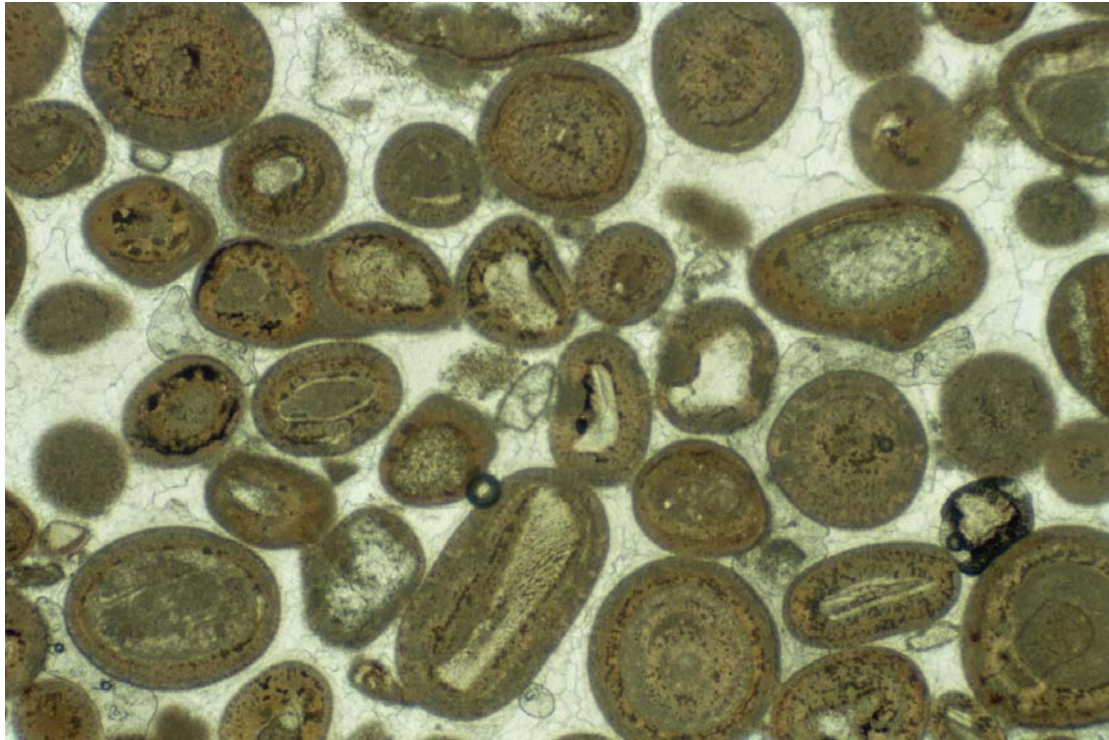
Item: block for crane bottom

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement. Traces of micrite locally between grains

Grain overcompaction: none

Distinguishable bioclasts: calcite-replaced probable mollusc fragments.



Sample: 15

SF: 139

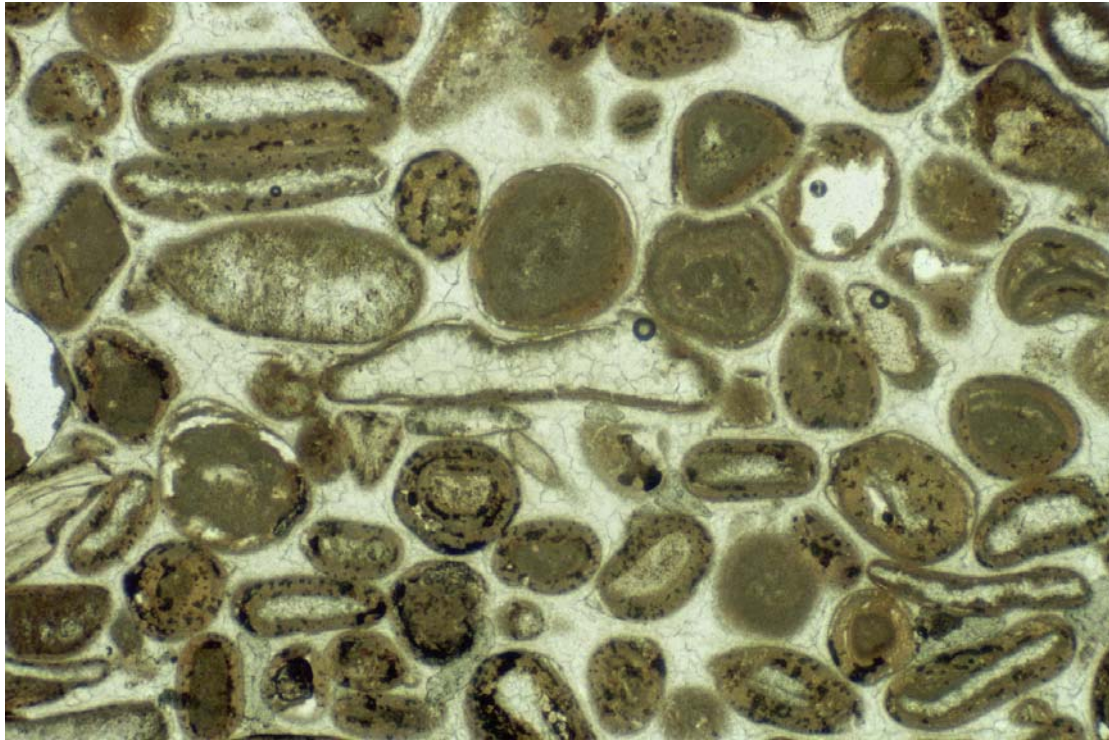
Item: not identified

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Distinguishable bioclasts: none.



Sample: 16

SF: 697

Item: part of lathe-turned stub

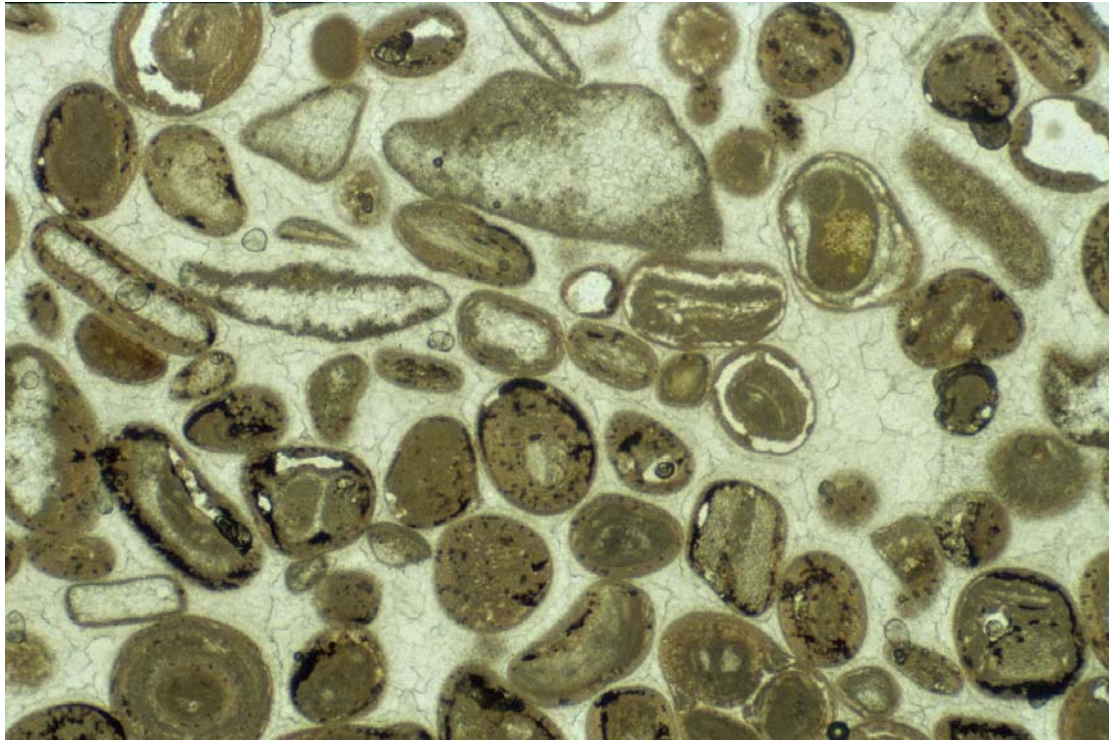
Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: moderate; some interpenetration, crushing of micrite envelopes, and spalling of superficial layers on ooliths.

Areas of white space in some of the oolith cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: some calcite-replaced probable mollusc fragments



Sample: 17

SF: 358

Item: waster from coping stone

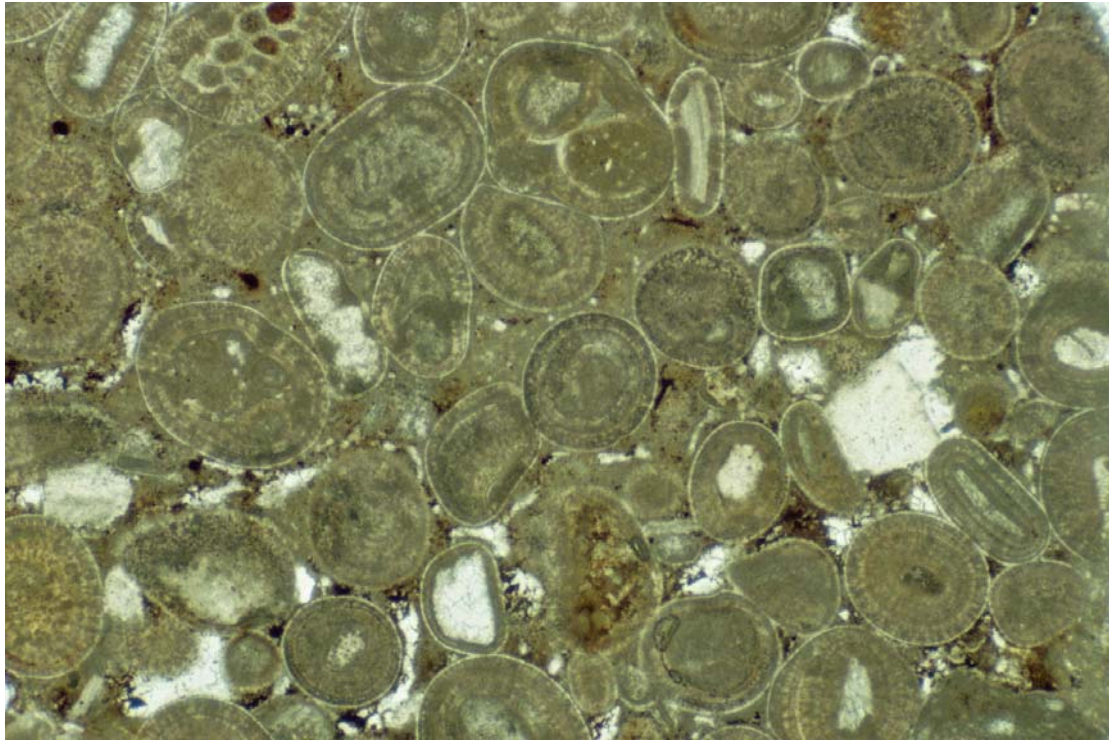
Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

Areas of white space in some of the oolith cortices are due to fracture of the grains during the section-making process.

Distinguishable bioclasts: some calcite-replaced probable mollusc fragments



Sample: 18

SF: none

Item: from core, 5 mm below hardground at top of Coombe Down Oolite

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with thin 1st generation isopachous calcite cement and vadose silt filling remaining intergranular pore space.

Grain overcompaction: none

Distinguishable bioclasts: bryozoan forming oolith nucleus top left; echinoderm with syntaxial overgrowth.

N.B. This slide is for comparison only. None of the artefacts has this petrography, and the worked stone clearly was taken further down into the Coombe Down Oolite.



Sample: 19

SF: none

Item: from core, 100 mm below hardground at top of Coombe Down Oolite

Width of View of Picture: 3.4 mm

Petrographic type: bioclastic oolitic grainstone with drusy spar cement

Grain overcompaction: none

