

Sample No LBSRS004

Location

661568E, 6761494N (GDA94 Z53)

Texture

Brecciated, highly weathered metasediment with CaCO₃ fracture fill.

Carbonate Grains

None

Siliciclastic Grains

25% Illite, 15% clay.

Voids

2% unfilled, 2% partially filled, 45% filled. Largely fractures.

Carbonate Mud

See below

Cements

30% carbonaceous mud, 5% microspar (zoned), 5% blocky, 5% fibrous, 5% micritic.

Other

5% euhedral gypsum in fracture fill, 1% goethite in crystal void (after sulphide?), tr. dendritic manganese oxide.

Comments

The presence of euhedral gypsum suggests that migrating waters were over-saturated with respect to sulphates. Sulphate concentrations most likely sourced from Bulldog Shale. Distribution of crystals looks geopetal. Deposition of carbonates in fractures initially a fine grained "muddy" precipitate that accumulated in fractures, followed by slower crystalline growth in voids. Textures in muds suggest phases of deposition. Presence of fibrous cements, thin microspar layers in otherwise empty voids and micritic void filling may be suggestive of burial in near surface environment and the influence of evaporative processes (?)

Classification

Bulldog shale

Interpretation

Highly brecciated and altered bulldog shale. Fractures are likely to have been a conduit for sulphate and carbonate-enriched groundwater.

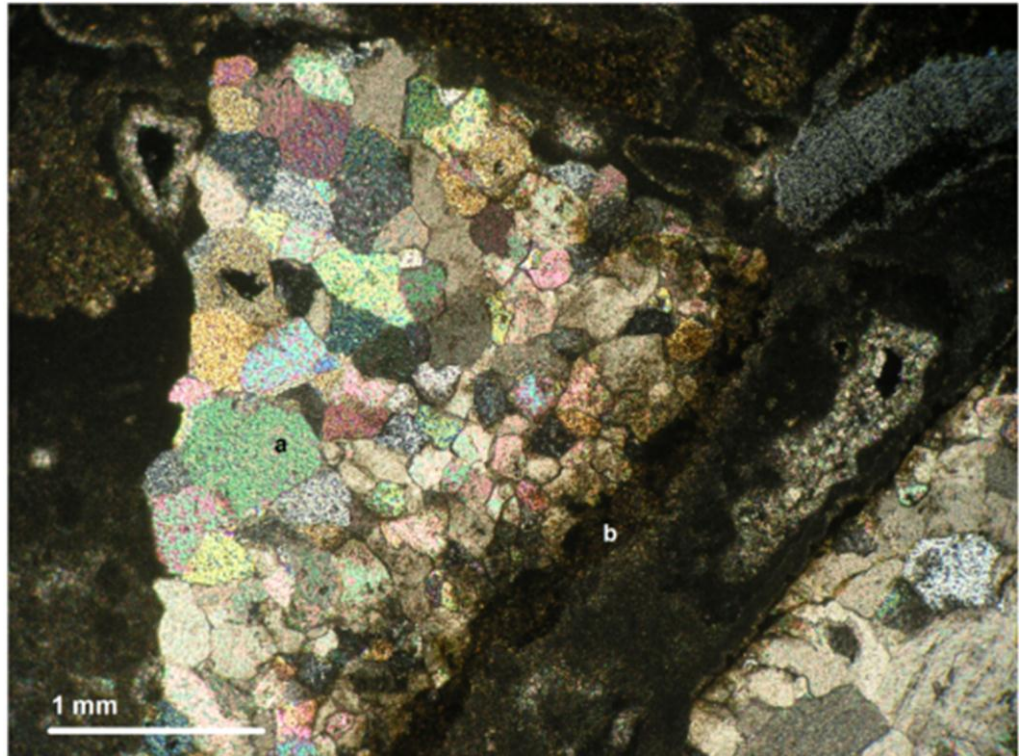


Photo 1: Large, possibly drusy blocky CaCO₃ cement (a) surrounded by goethite stained carbonate mud and carbonate mud fracture fill (b). Crossed polars.

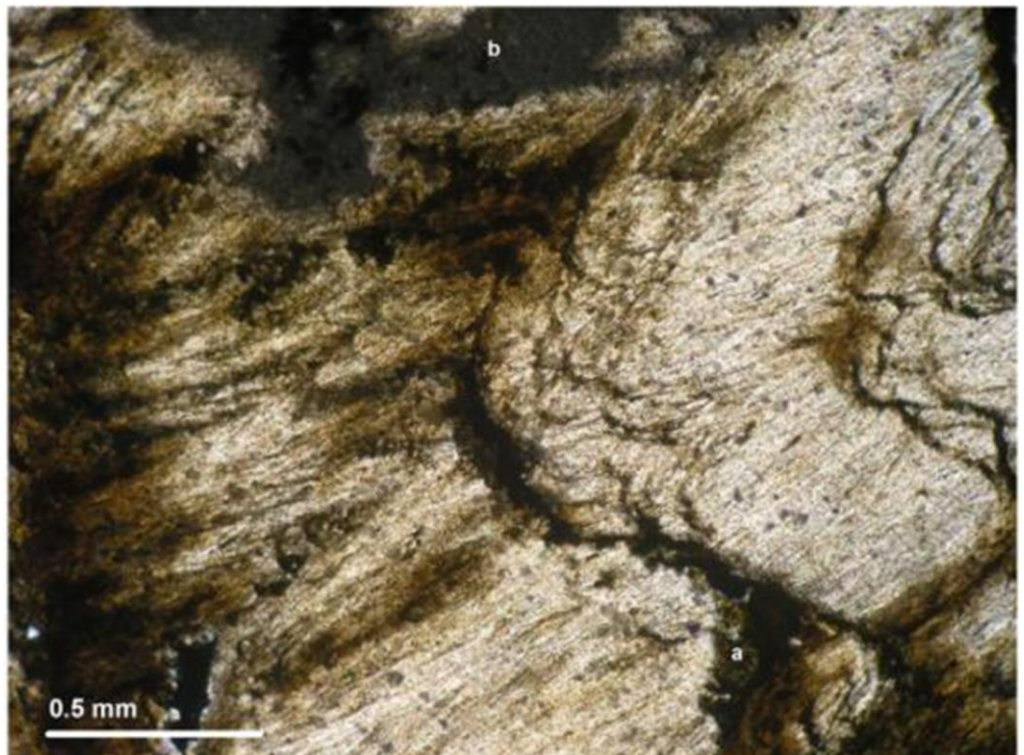


Photo 2: Illite texture within sample matrix. Goethite staining and small porphyroblastic cordierite (?) crystals present. Carbonate mud fracture fill at top of image (b). Crossed polars.



Photo 3: Euhedral gypsum crystals (a) in carbonate mud and micrite-fracture fill. Crystals show geopetal depositions, being deposited on the edge of the fracture. Illite matrix of shale evident at top of image (b). Crossed polars.

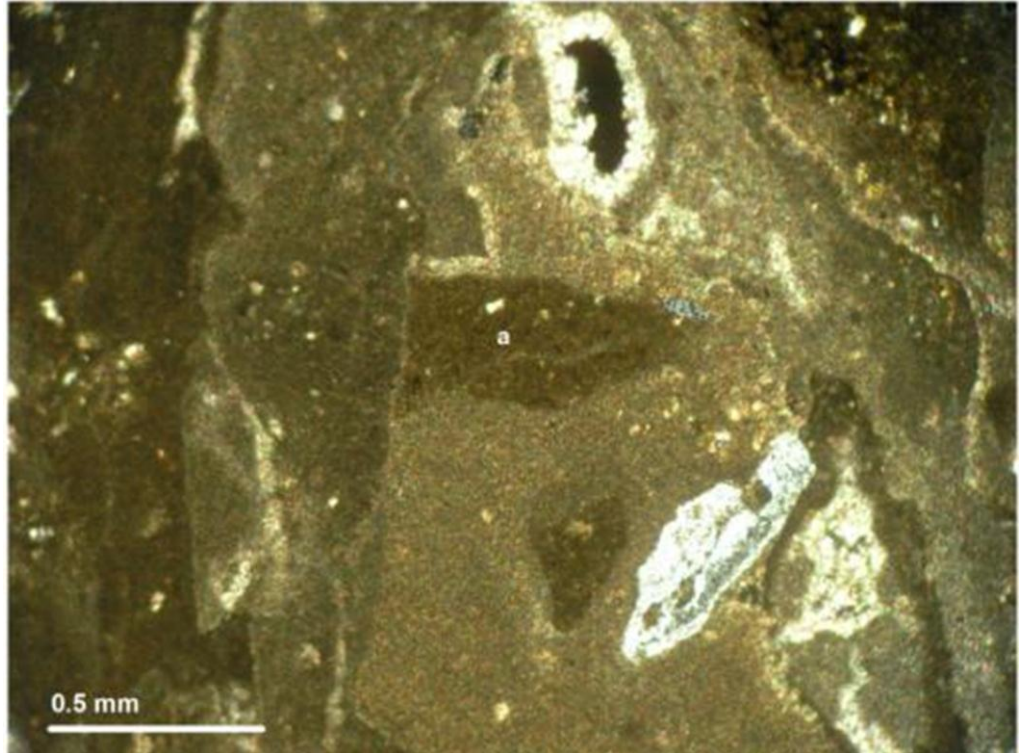


Photo 4: Carbonate mud fracture fill. Voids in mud either partially (top) or fully (bottom right) filled with microspar CaCO_3 cement. Gypsum crystals (bottom right, towards centre) also present. Discontinuities and clastic fragments (a) in carbonate mud suggest fracture filling happened in stages. Crossed polars.

Sample No LBSRS005

Location

661625E, 6761713N (GDA94 Z53)

Texture

Clotted and renalcid texture- possible recrystallisation of carbonate mud by dolomitisation? Laminations in both micrite and sparry cements evident.

Carbonate Grains

2% peloids, tr. lumps.

Siliciclastic Grains

Tr. quartz.

Voids

3% shrinkage fractures, 12% rounded fenestral. 2% unfilled, 7% partially filled 3% filled

Carbonate Mud

70%

Cements

2% microcrystalline, 2% micritic, 4% fibrous radiaxial, 3% granular, 1% meniscus. Complicated history of cementation evident. Pattern of microcrystalline/ granular followed by radiaxial fibrous and bladed cement infill. Bladed and fibrous cements sometimes display zonation. Some areas show pattern of micritic/ microcrystalline to sparry textures repeating. Final stages showed meniscus/ micritic cementation evidence of aerial exposure.

Other

1% manganese oxide within laminations and as dendritic precipitate.

Comments

Very similar in appearance to LBSRS002. Largely carbonaceous muds appear to be in stages of re-crystallisation, particularly in relation to indistinct boundaries between micritic matrix and cement infill. Despite this, microbial textures such as clotting and renalcid structures still evident. Late stage micrite and clastic void fill. Shrinkage structure late stage due to lack of cementation. Suggestive of eventual aerial exposure.

Classification

Microbial mudstone.

Interpretation

Very shallow, sparsely vegetated mud flat, low energy environment, lower tail.

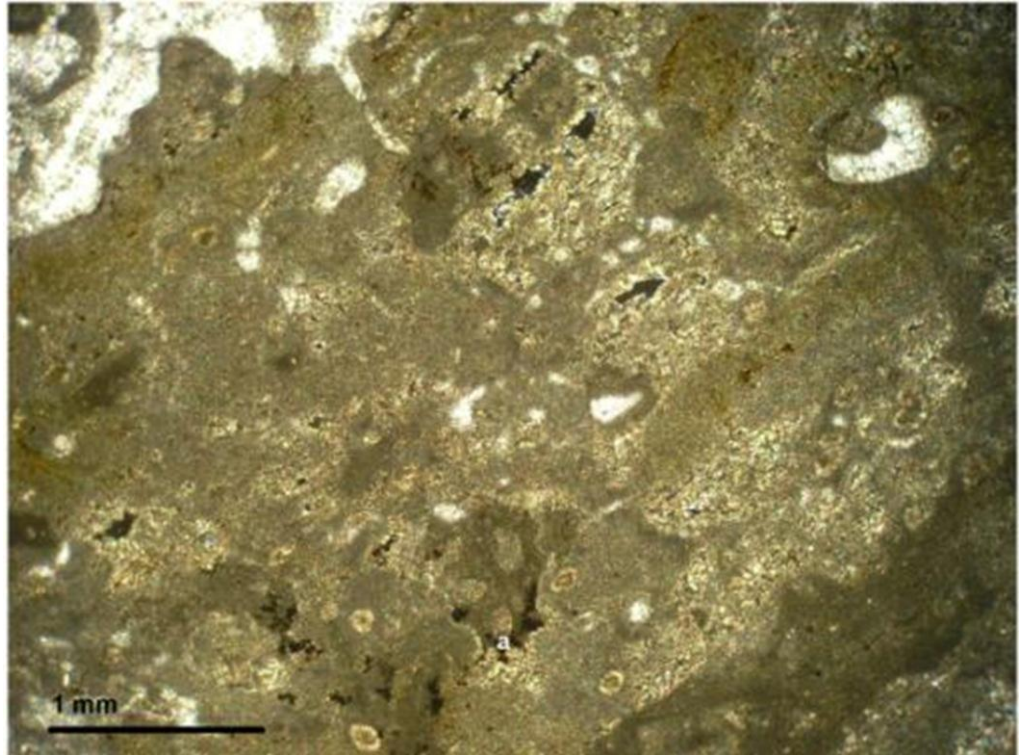


Photo 1: Clotted carbonate matrix of carbonate muds and microspar. Charophyte (?) castings are evident. Dendritic manganese oxide occupying areas that appear to be inter-granular voids. Crossed polars.

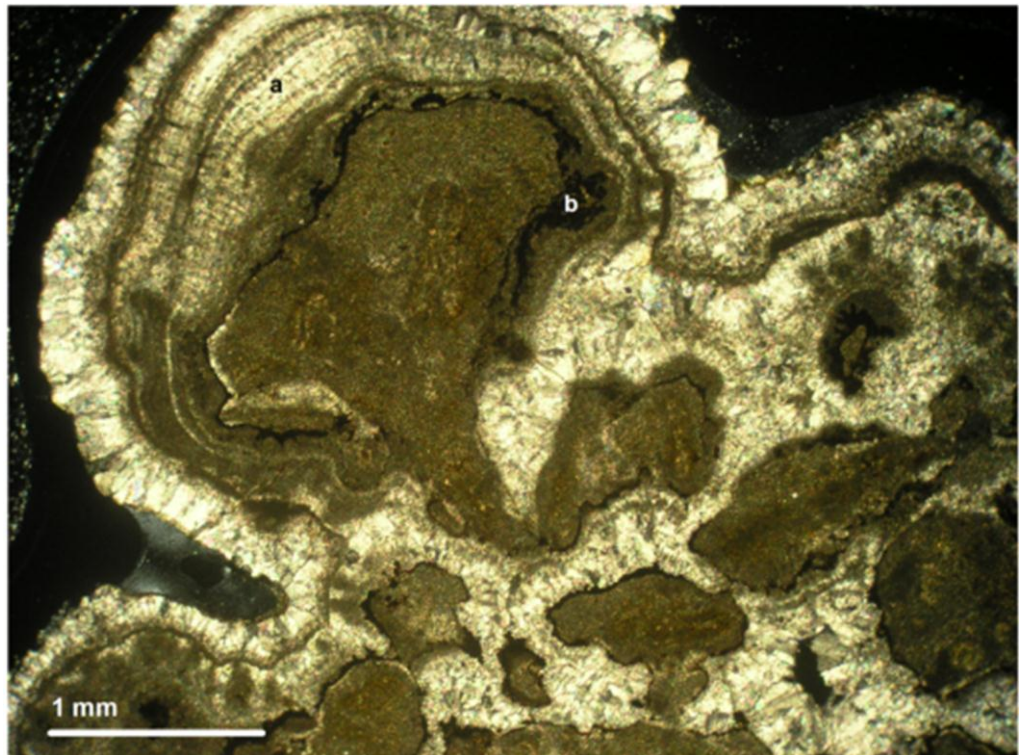


Photo 2: Bands of laminated radiaxial fibrous, micritic and bladed carbonate cement (a) coating "shrub-like" microbial carbonate (b). Sample appears botryoidal in hand specimen. Crossed polars.

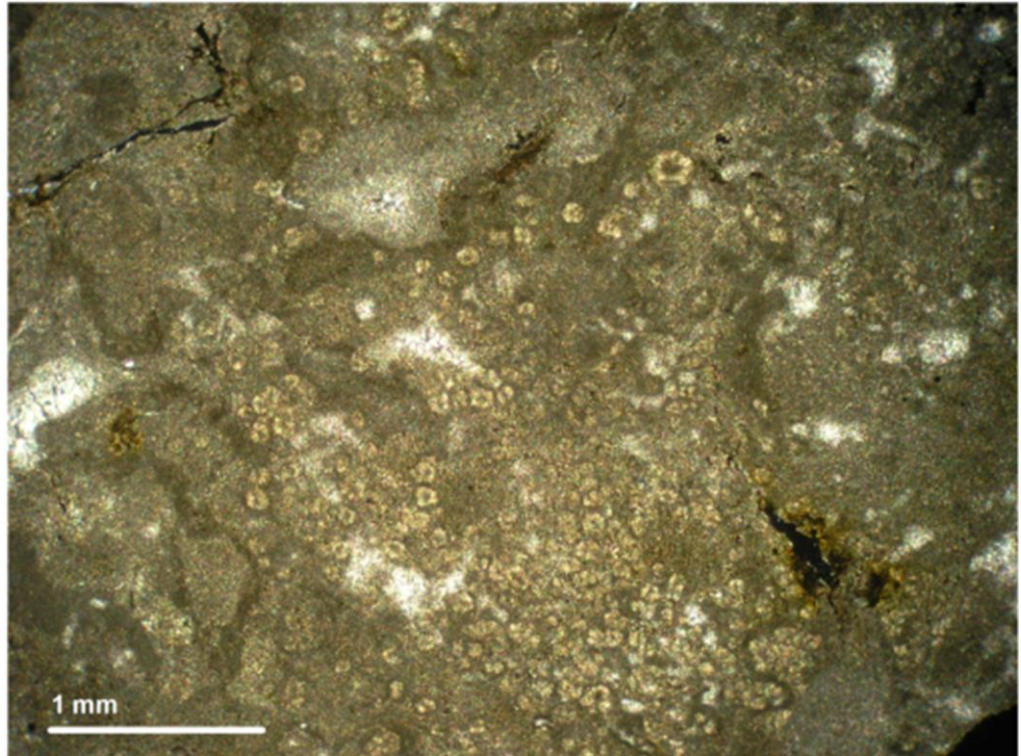


Photo 3: Renalcid (?) texture within clotted carbonate matrix. Circular textural features appear composed of more crystalline micrite or microspar compared to matrix material. Fenestral voids filled with microcrystalline cement. Crossed polars.

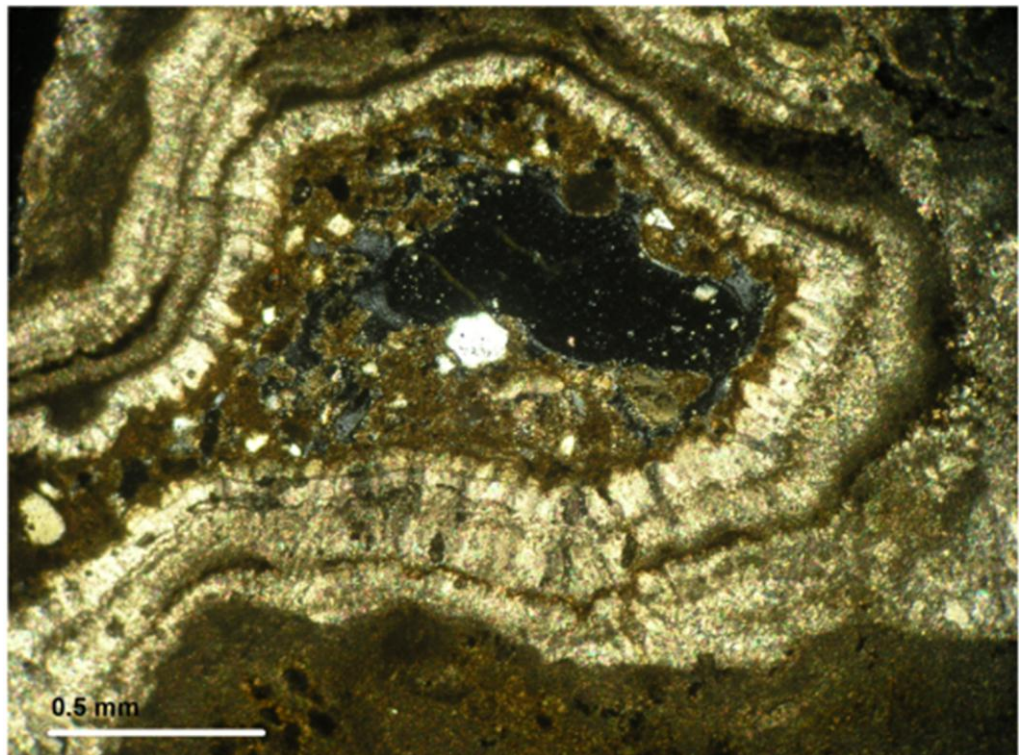


Photo 4: Laminated bands of microcrystalline, micritic radiaxial fibrous and bladed carbonate cement in inter-particle (?) void. Final void fill consists of carbonate mud with high siliciclastic content. Crossed polars.

Sample No LBSRS007

Location

661670E, 6761618N (GDA94, Z53)

Carbonate Grains

5% oncoids, 2% peloids, 1% clasts, 1% bioclasts.

Siliciclastic Grains

Tr. quartz grains.

Voids

5% fenestral (thrombolytic), 1% moldic (thalli of cyanobacteria).

Carbonate Mud

70% incorporated into microbial structure (Shrub textures, oncoidal textures).

Cements

5% microcrystalline, 1% bladed, 1% granular fenestral void fills.

Other

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Comments

Recently deposited microbial tufa in framestone formed in tail of spring. Lack of cementation may indicate lack of evaporation, or simply may indicate recent age of sample.

Classification

Microbial mudstone.

Interpretation

Microbially mediated carbonate in tail section on framestone.

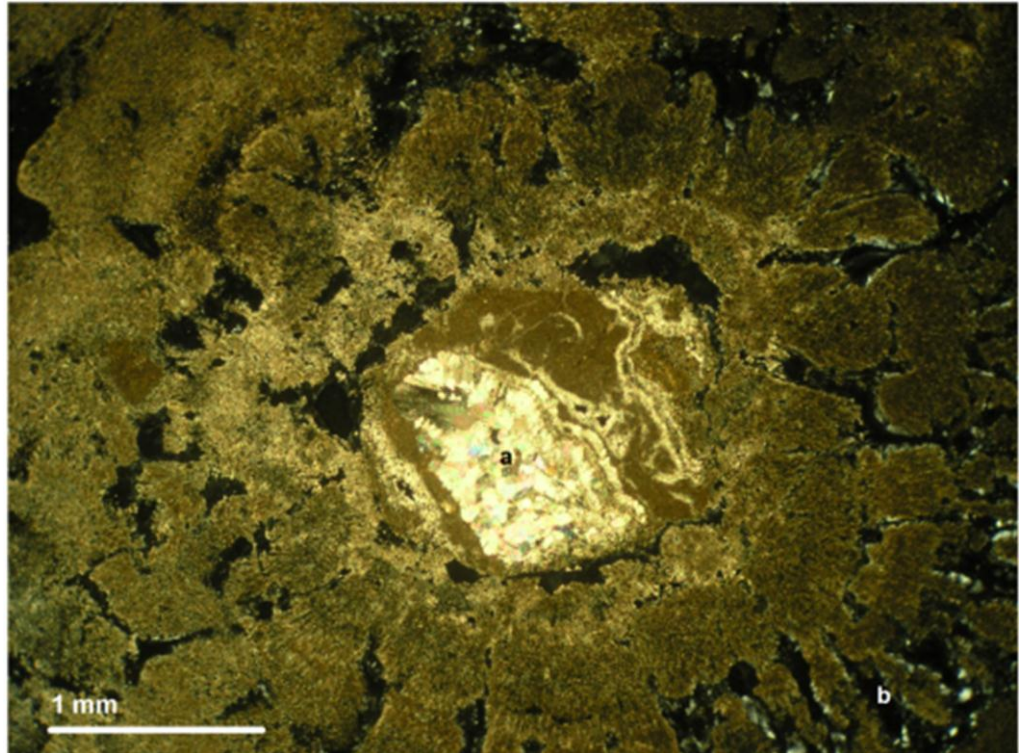


Photo 1: Porostromate oncoide; (a) note radiating fenestrae (b) that define the oncoide structure. The original nucleus of oncoide (a) appears to be a broken tufa fragment of micritic and sparry granular cement. Crossed polars.

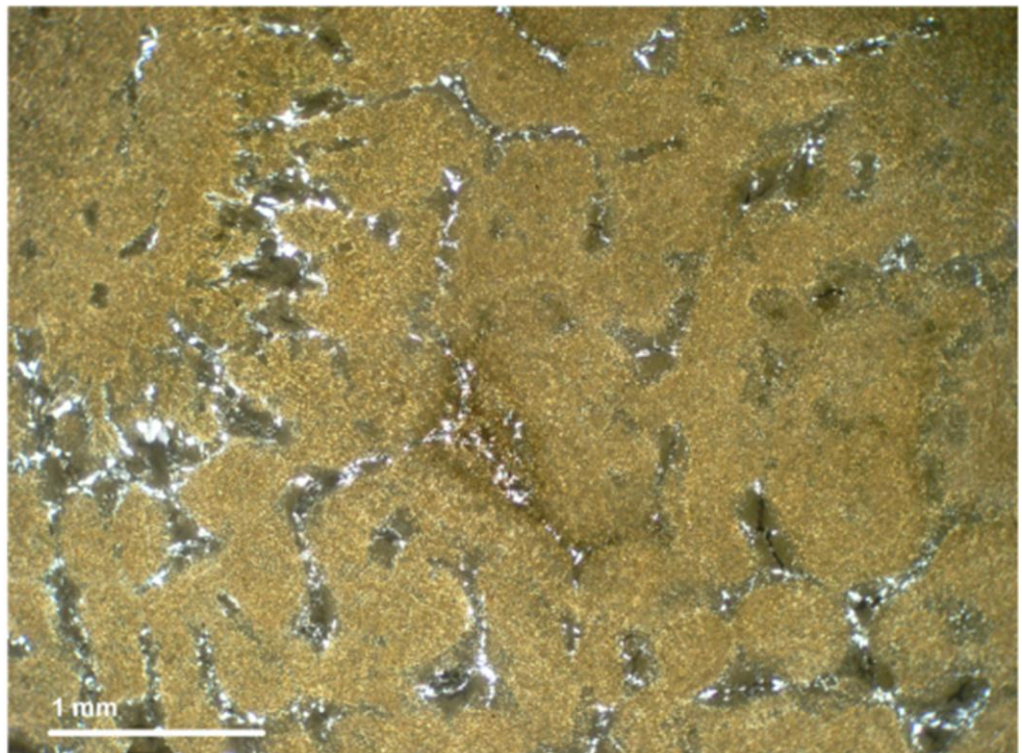


Photo 2: General micritic matrix and fenestral (thrombolitic) texture. Crossed polars.

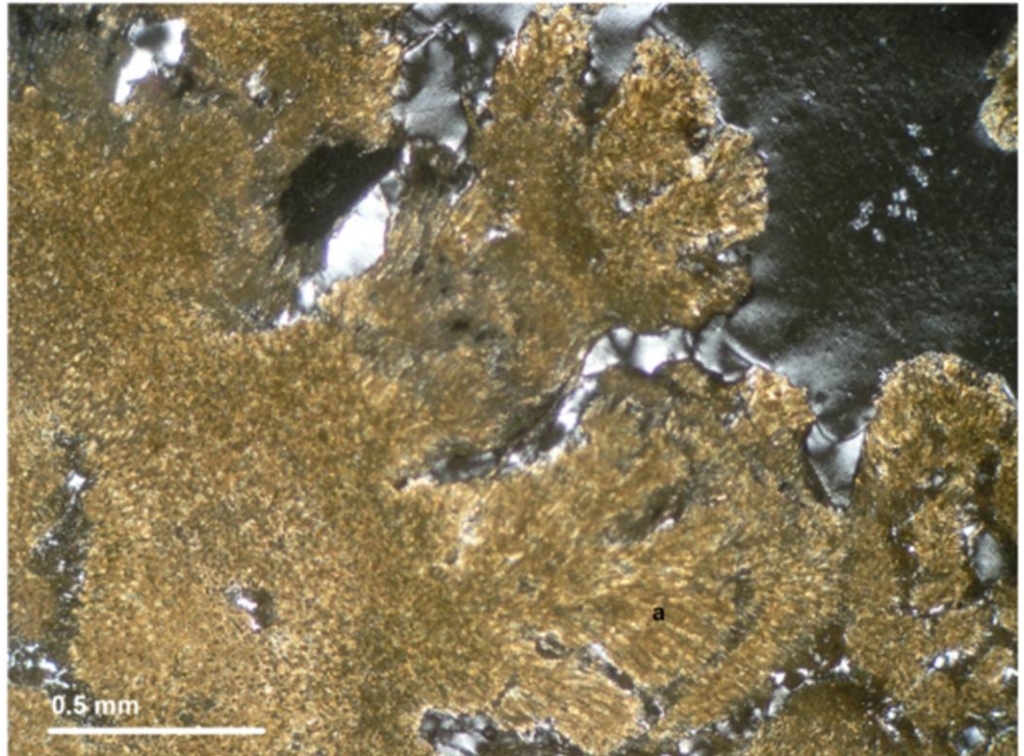


Photo 3: Microbial shrub textures in micritic matrix. Appears similar to the form-genus *Rivularia sp.* Fenestra appear to be chambers for thalli. Crossed polars.

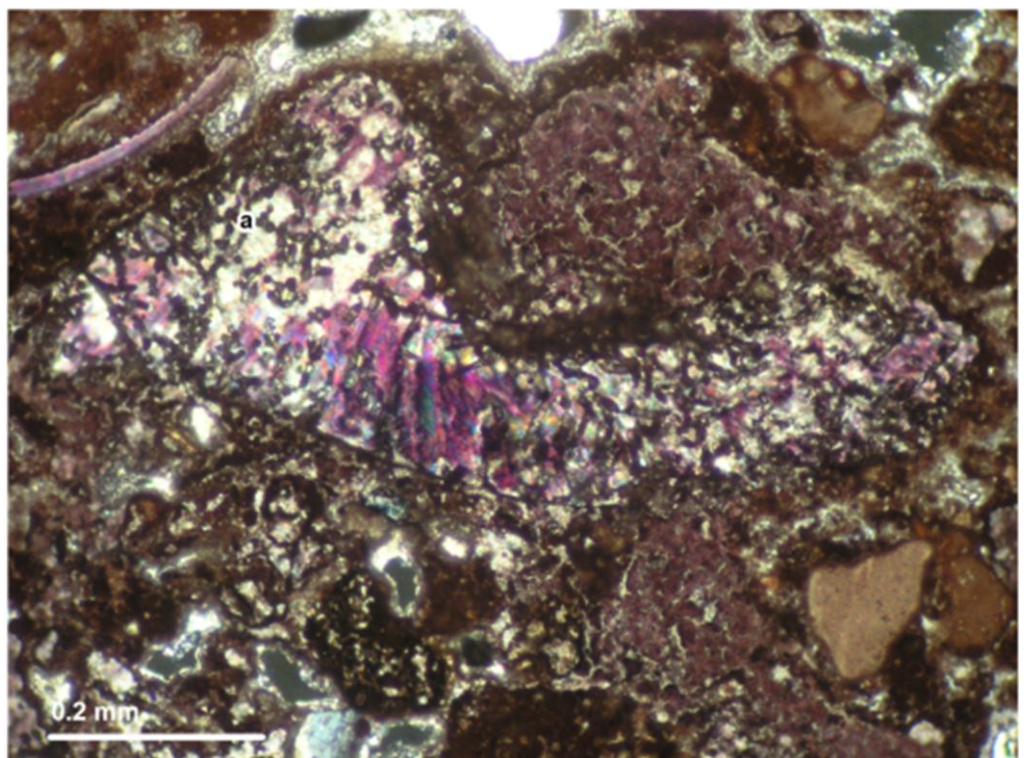


Photo 4: Ostracod (?) fragment replaced with ferroan calcite (mauve) and dolomite (unstained) cement. Evidence of microbial boring activity from microbes. Note dark coloured cross cutting bores emanating from the edge of the clast. Crossed polars.

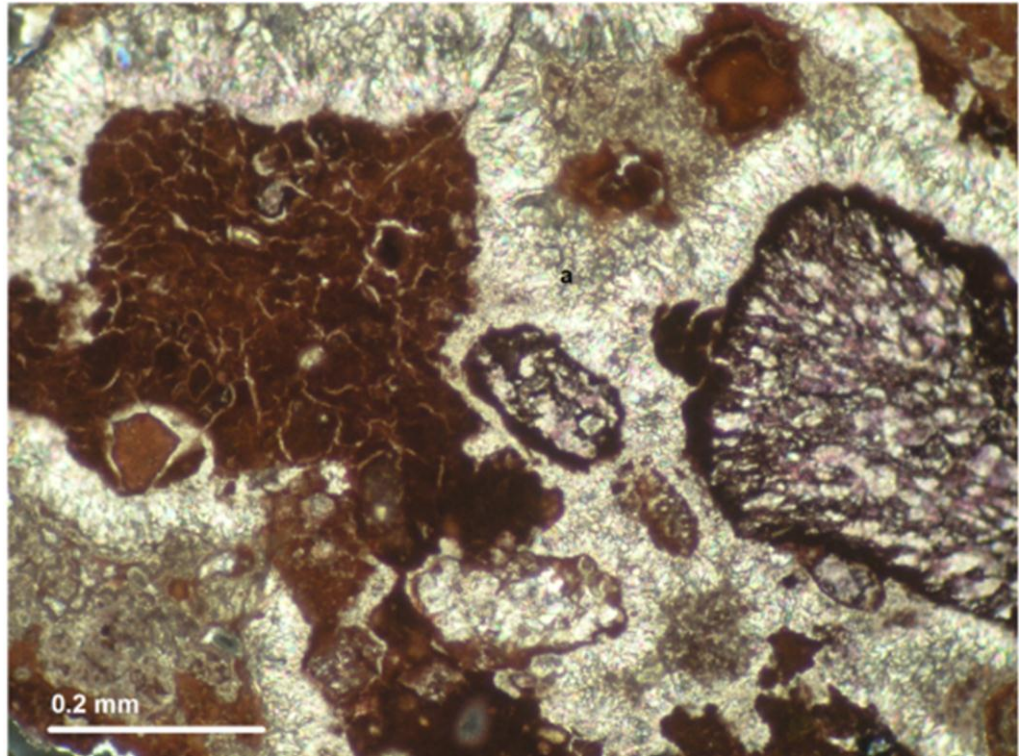


Photo 5: Photomicrograph displaying cross-section of carbonate types and associated textures.
Reddish brown is clotted micritic carbonate clasts or matrix material. Patchy mauvish pink components are porostromate microbial bioclasts composed of ferroan calcite, dolomite and micrite.
Unstained carbonates (dolomite) are composed of isopachous microspar cement. Plane light.

Sample No LBSRS008

Location

661716E, 6761750N (GDA94, Z53)

Texture

Highly altered fine grained carbonate. Broad horizontal desiccation fractionation through sample. Micritic textures appear shrub-like in parts – possible microbial precursor.

Carbonate Grains

5% lumps, 5% calcareous clasts.

Siliciclastic Grains

5% quartz silt, tr. zircon.

Voids

15% fenestral, 10% desiccation fracturing, 10% partially filled, 14% filled, 1% unfilled.

Carbonate Mud

50% micritic matrix, neomorphic processes appear to have converted a large proportion to microspar.

Cements

15% laminated radiaxial fibrous, 5% late stage micritic, 15% microspar.

Other

Tr. dendritic manganese oxide.

Comments

Rock has complicated diagenetic history. Extensive void fill appears to have occurred after or during rock desiccation (shrinkage cracks?). This was followed by dissolution and deposition of micritic void fill (possible burial). If void not completely filled, a final very thin layer of microspar cement follows. Neomorphism of original micritic matrix appears advanced, although original depositional textures still evident in places. No fossils found.

Classification

Microbial cementstone.

Interpretation

Ancient spring tail environment which has undergone calcretisation, burial and exhumation.

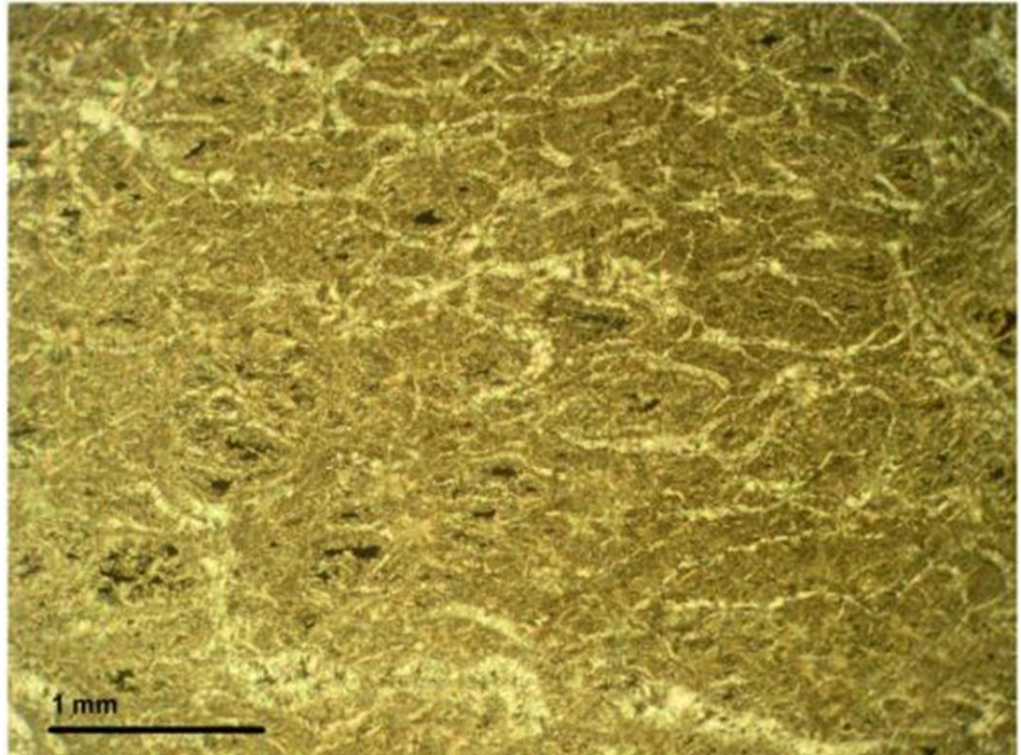


Photo 1: Fine desiccation fracturing filled with microspar cement in generally micritic/microspar matrix. Crossed polars.

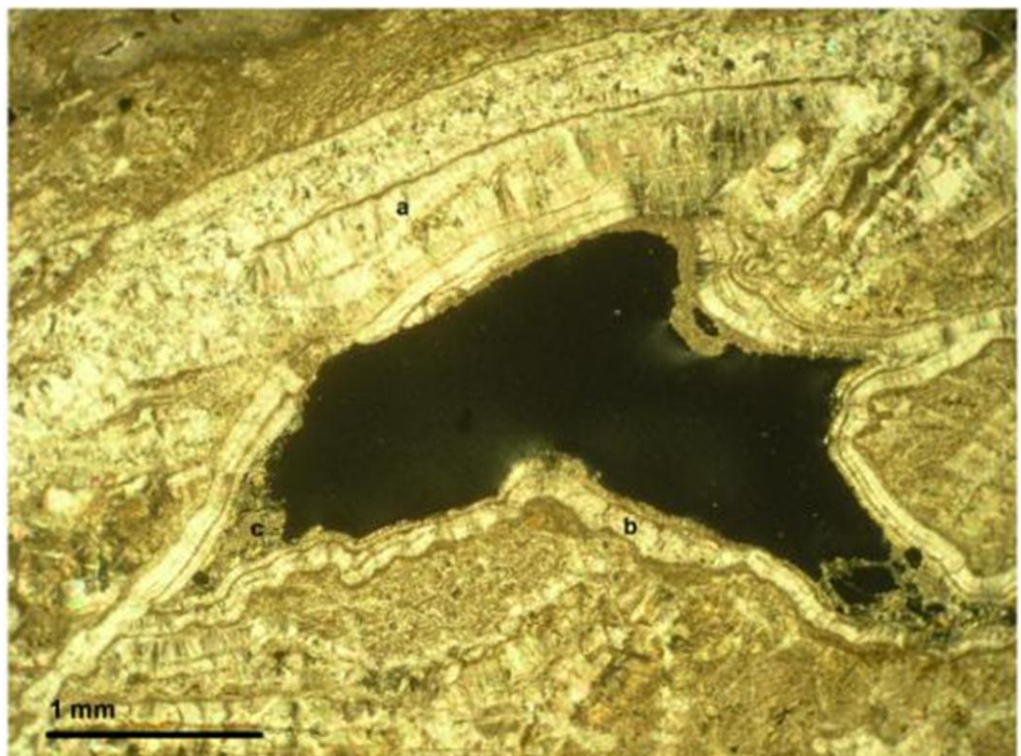


Photo 2: Void with multi-stage history. Original laminated radiaxial fibrous cement (a) has been partially dissolved, with the void filled with a thinner layer of laminated radiaxial fibrous cement (b). This in turn has been partially dissolved and the void filled partly with micrite (c). Crossed polars.

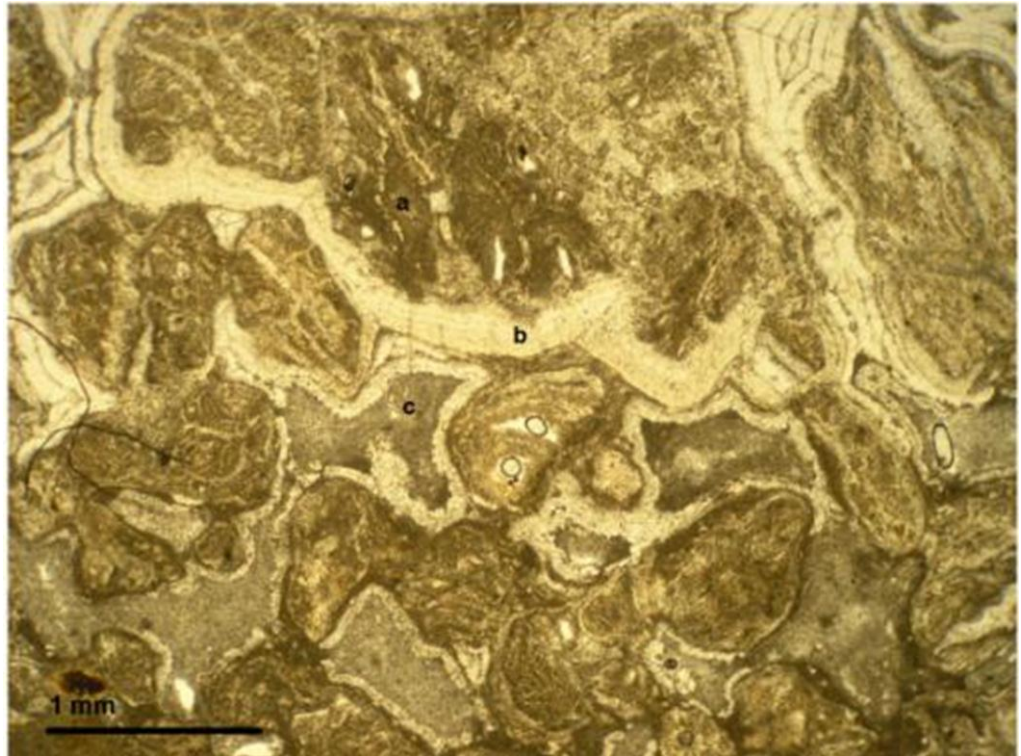


Photo 3: What appear to be inter-particle voids of intra-clastic carbonate and lumps (example at a) partially filled with laminated radiaxial fibrous cement (b) before being completely filled with micrite (c). Plane light.

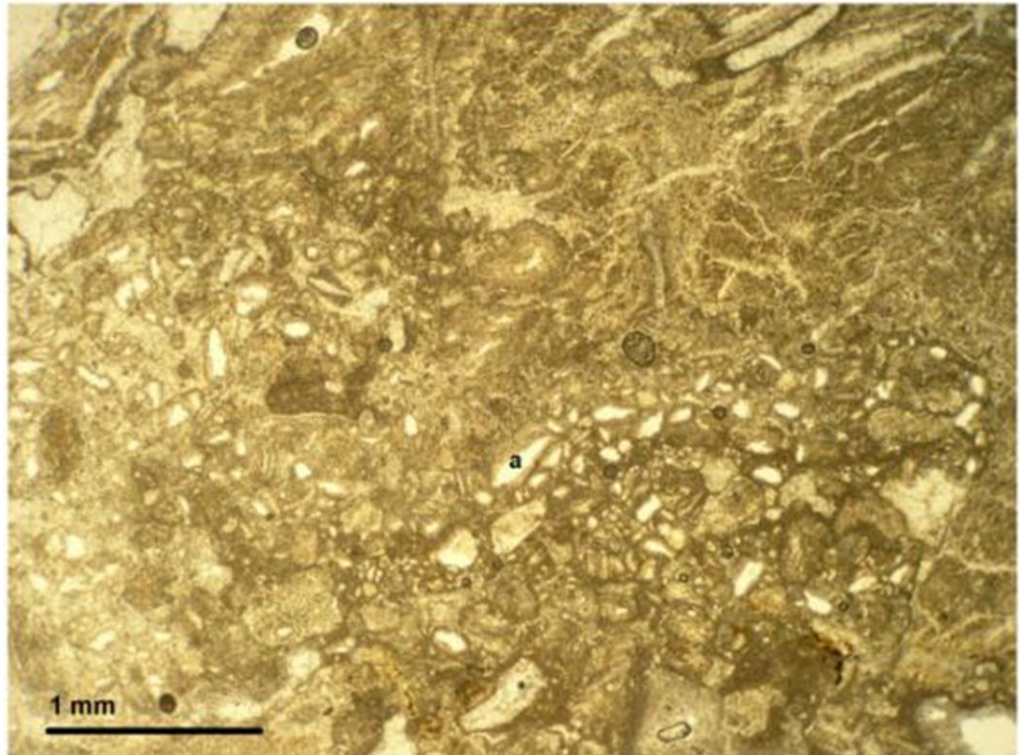


Photo 4: Lattice like void development (a) in a fabric varying between desiccated fracturing and detrital. Possible clotted texture in places. Plane light.

Sample No LBSRS009

Location

661716E, 6761618N (GDA94, Z53)

Texture

Clotted micritic matrix amongst altered carbonaceous clasts. Neomorphic alteration has converted much of the matrix to microspar.

Carbonate Grains

10% amorphous calcareous clasts, 1% peloids.

Siliciclastic Grains

Quartz grains 8% (in late stage micritic void fill)

Voids

15% fenestral, fracture 5%. 10% filled, 7% partially filled, 3% unfilled.

Carbonate Mud

51% (micrite/microspar matrix).

Cements

20% microspar, 5% meniscus, 5% micritic.

Other

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Comments

Rock has complicated diagenetic history. Microbial texture still evident despite diagenesis – mainly through fabric and voids. Inter-granular cementation is largely microspar. Amorphous carbonate clasts are rounded and goethite stained. Fractures are partially to completely filled with microspar cement. Occasional thin lamination of micrite cement. Late stage micrite fills voids after spar cement. Unfilled voids and some particles have thin layer of micrite/microspar cement. Neomorphism of original micritic matrix appears advanced, although original depositional textures still evident in places. No fossils found.

Classification

Microbial clastic cementstone.

Interpretation

Ancient spring tail environment which has undergone calcretisation and burial.

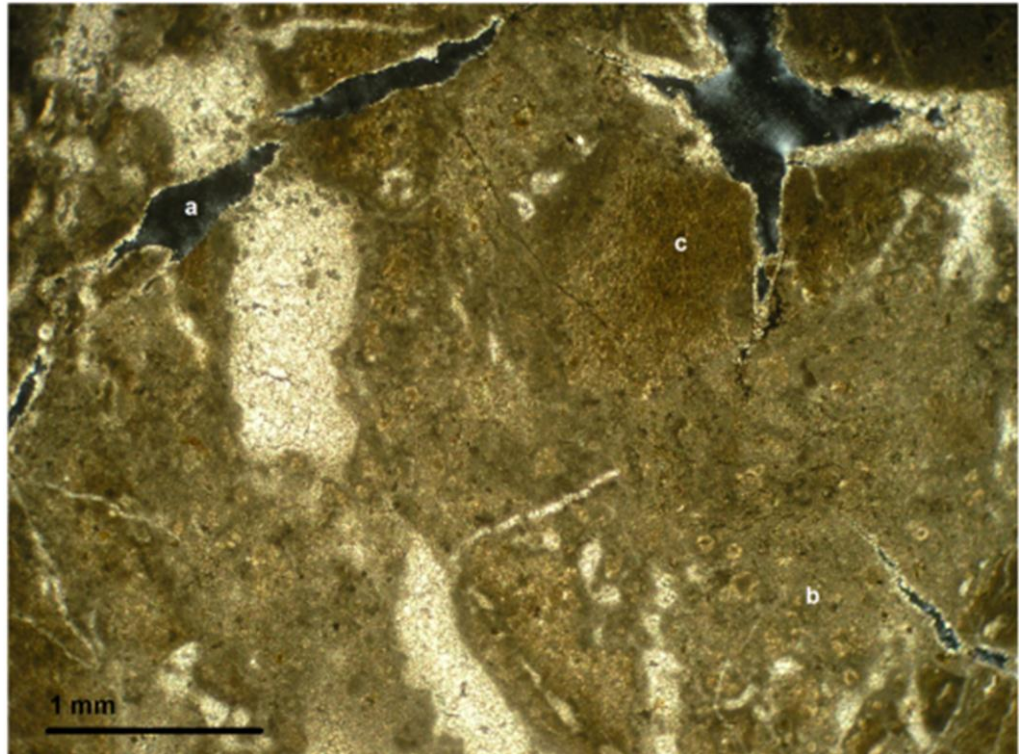


Photo 1: Desiccation fracturing (a) evident in micritic matrix which shows evidence for microbial activity with clotted and renalcid textures (b) and calcareous clasts (c). Fenestral voids totally filled and fracturing partially filled with microspar cement Crossed polars.

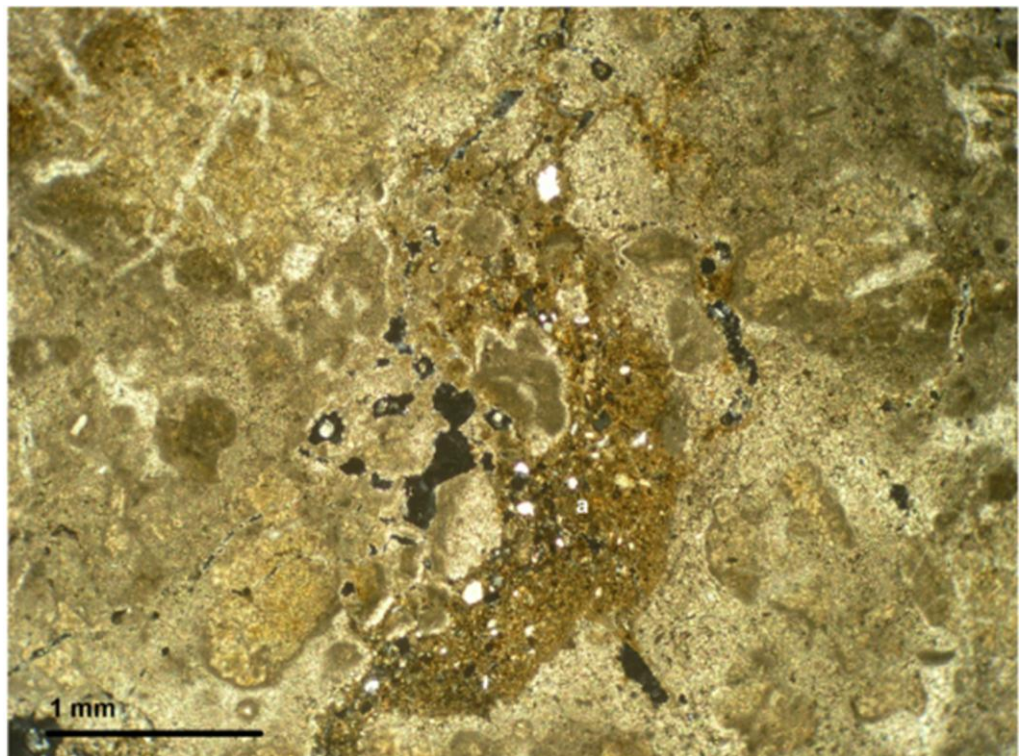


Photo 2: Late stage micrite and detrital quartz fenestral (?) void fill (a). Rest of void filled earlier by micrite /microspar. Carbonate lumps and peloids give micritic matrix surrounding the void a clotted appearance in part. Crossed polars.

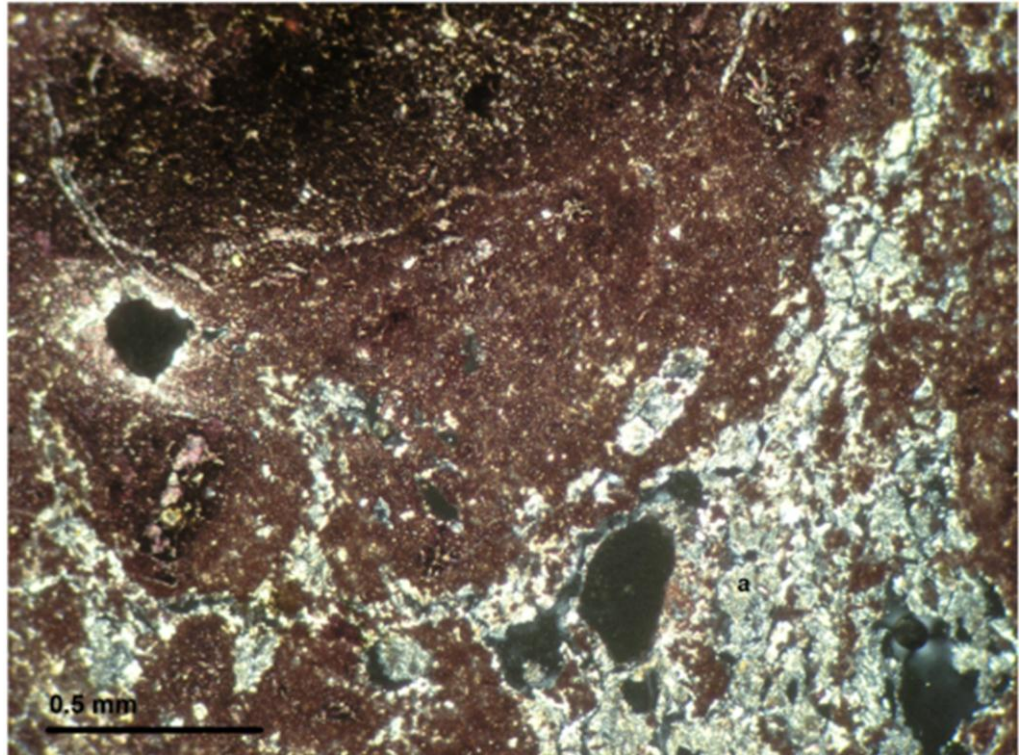


Photo 3: Micritic matrix composed of reddish brown material partly replaced with very fine grained, non-planar unstained dolomite (a). Note heterogeneous distribution of dolomite, with distribution centered, but not wholly confined to a possible fracture void. Crossed polars.

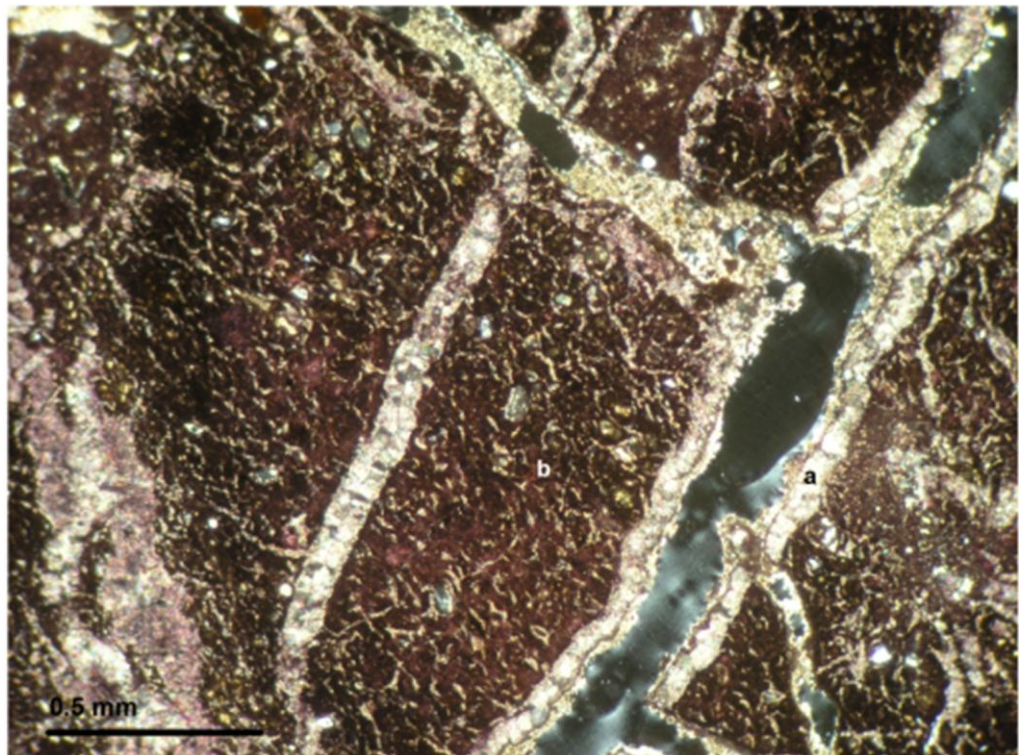


Photo 4: Fractures partially filled by unstained dolomitic cement (a). Micritic matrix stained reddish brown and has a felted texture (b). Crossed polars.

Sample No LBSRS0010

Location

661645E, 6761685N (GDA94, Z53)

Texture

Vuggy calcareous rock with thick, anastomosing (lattice-like) sparry cement and fine grained micritic and siliciclastic (?) groundmass. Parts of the groundmass appear clotted, others ropey (sericitic)

Carbonate Grains

5% lumps, 5% peloids.

Siliciclastic Grains

Tr. quartz sand, 10% Sericite (?) (Replaced by carbonate).

Voids

40% channel, 39% filled, 1% partially filled.

Carbonate Mud

40% micritic matrix, neomorphic alteration processes appear to have partially converted matrix to microspar

Cements

20% laminated radiaxial fibrous, 10% laminated, 5% micritic, 3% microspar, 2% granular

Other

trace goethite

Comments

Rock appears to be partially formed by fractured Bulldog Shale. Complex diagenetic history that has led to a significant portion of the sample to be composed of cements. Alternating layers of laminated and fibrous laminated noted.

Classification

Microbial sparstone.

Interpretation

Spring tail environment near contact with Cretaceous basement material.

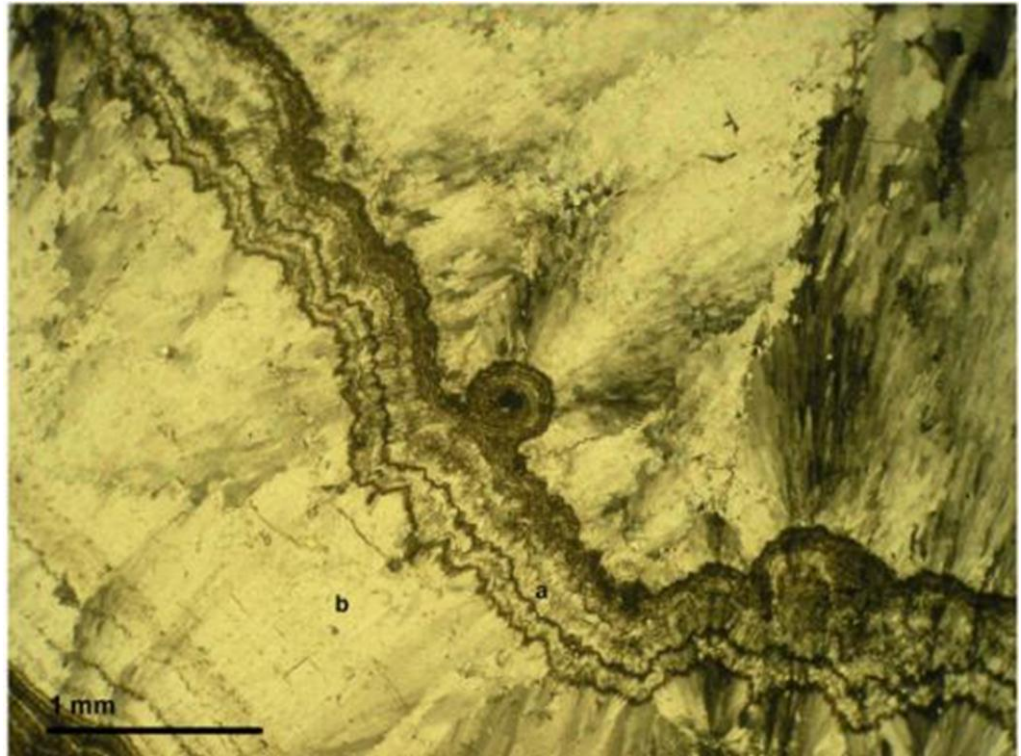


Photo 1: Laminated and radiaxial fibrous spar within large anastomosing” lattice-like” fracture fill. Laminae appear microbial with arborescent cement overgrowths. Crossed polars.

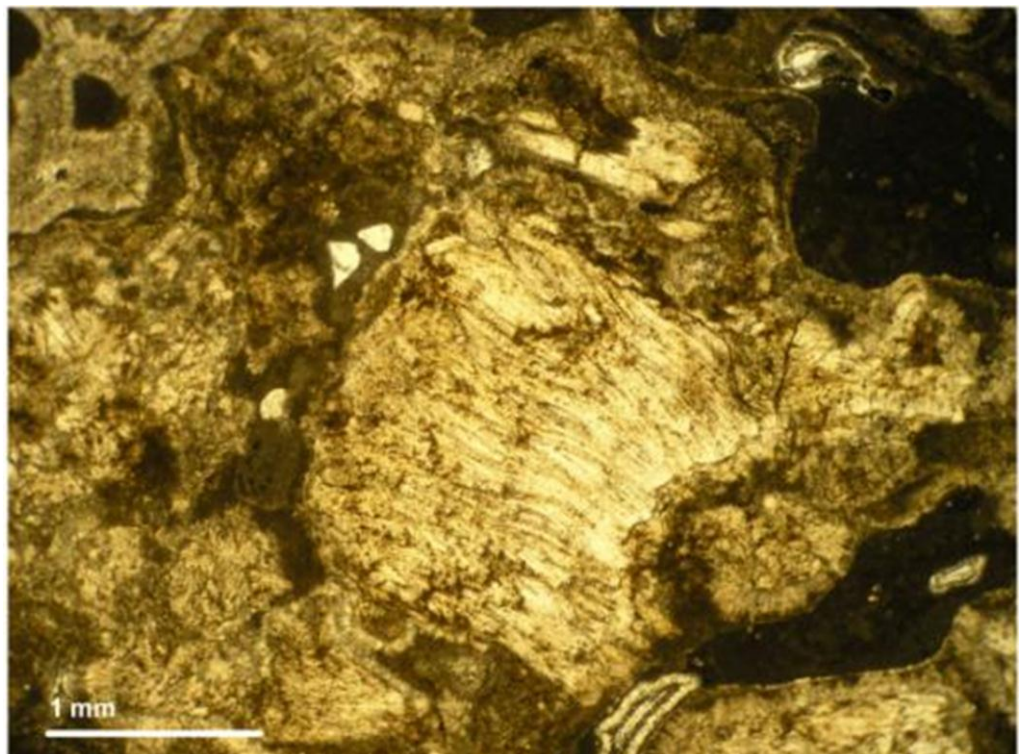


Photo 2: “Ropey” texture within carbonate. Plane light.

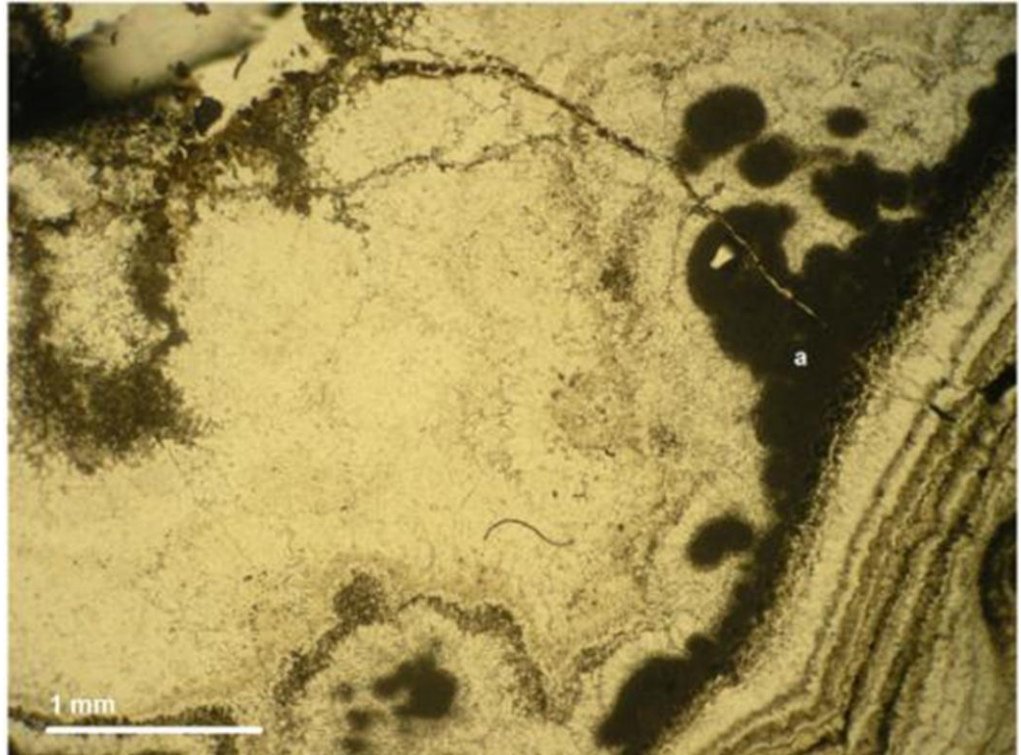


Photo 3: Peloidal void fill (a) between thinner bands of laminated-microbial and fibrous sparry cementation. Plane light.

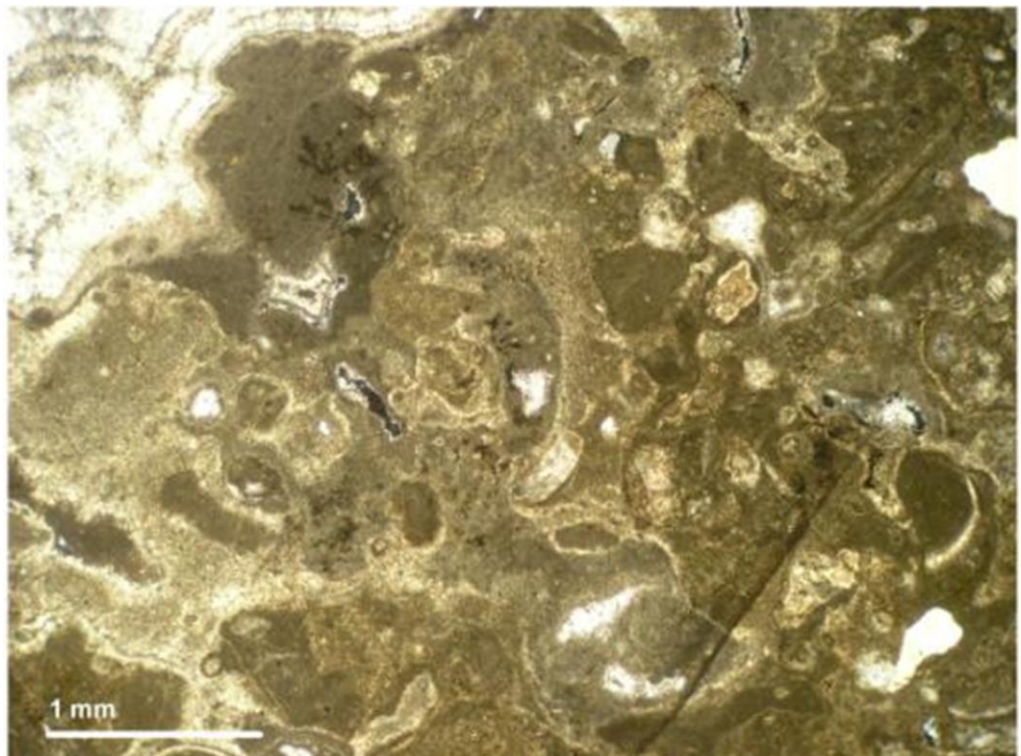


Photo 4: Generally clotted micritic/microspar matrix, but with evidence of several episodes of deposition/ inter-particle void fill. Crossed polars.

Sample No LBSRS012

Location

661629E, 6761599N (GDA94, Z53)

Texture

Peloidal and microspar matrix with pisoids and fenestral voids. Neomorphic alteration of original micritic matrix material has converted much of matrix material to microspar.

Carbonate Grains

25% pisoids/ooids, 15% peloids, 4% lumps, tr. mollusc fossils.

Siliciclastic Grains

Tr. quartz grains.

Voids

35% Fenestral, 15% inter-granular, 1% moldic, 35% partially filled, 16% unfilled.

Carbonate Mud

5% void fill.

Cements

10% radiaxial fibrous, 15% microspar (inc. meniscus), 10% micritic, tr. granular.

Other

Tr. zircon.

Comments

Rock primarily composed of root and reed castings. Inter-cast areas filled with pelitic material, irregularly shaped peloids or flattened ooids. Radiaxial fibrous cement composes castings. Voids lined with microspar or micritic cement. Last stage void fill composed of micritic matrix material (burial?). Neomorphic alteration has converted much of the original micritic matrix material to microspar.

Classification

Fenestral packstone.

Interpretation

Ancient vegetated shallow tail environment. Initial precipitation in subaqueous environment followed by cementation and alteration in vadose zone environment.

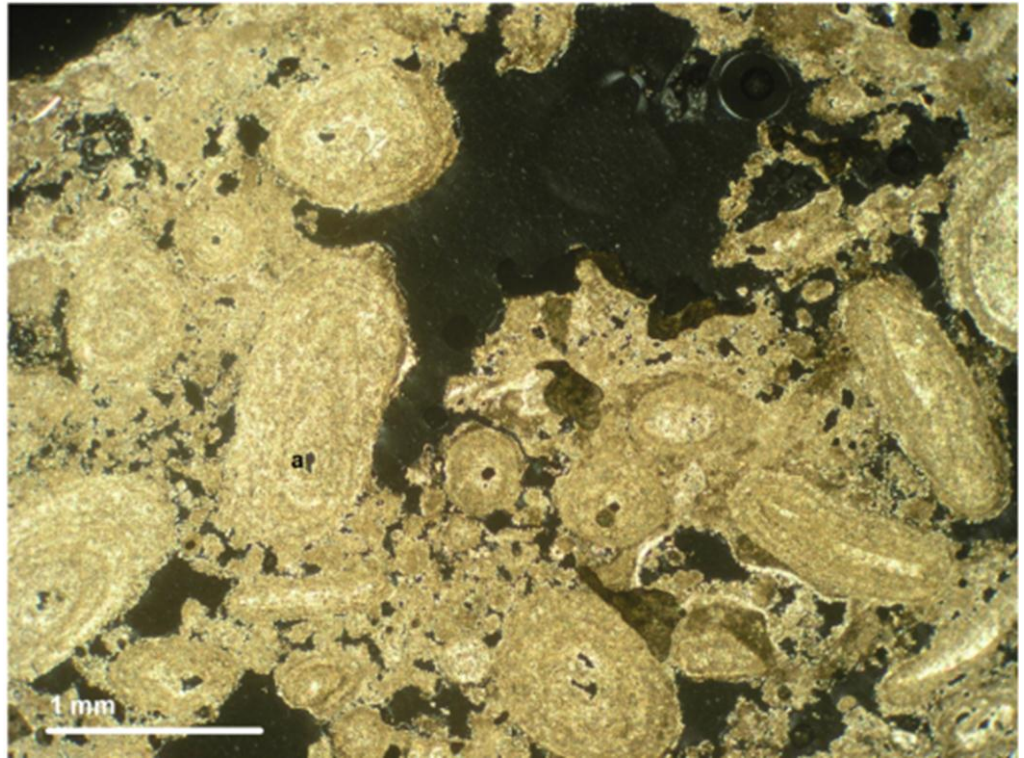


Photo 1: Concentric deposition of carbonate around biotic matter leads to the development of ovoid-shaped ooids. Voids at center of each ooid (example at a) formerly occupied by a nucleus, probably vegetative in composition. Micritic matrix partly altered to microspar. Crossed polars.

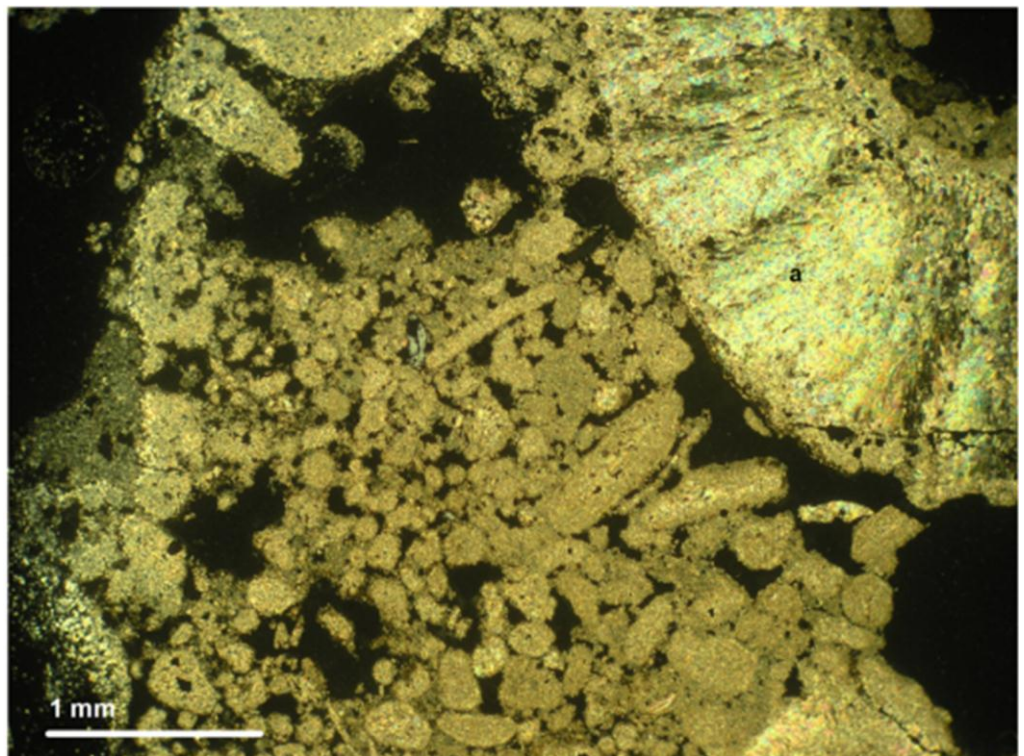


Photo 2: Example of ooids. Radiaxial fibrous carbonate in top right of image (a) is part of a reed casting. Crossed polars.

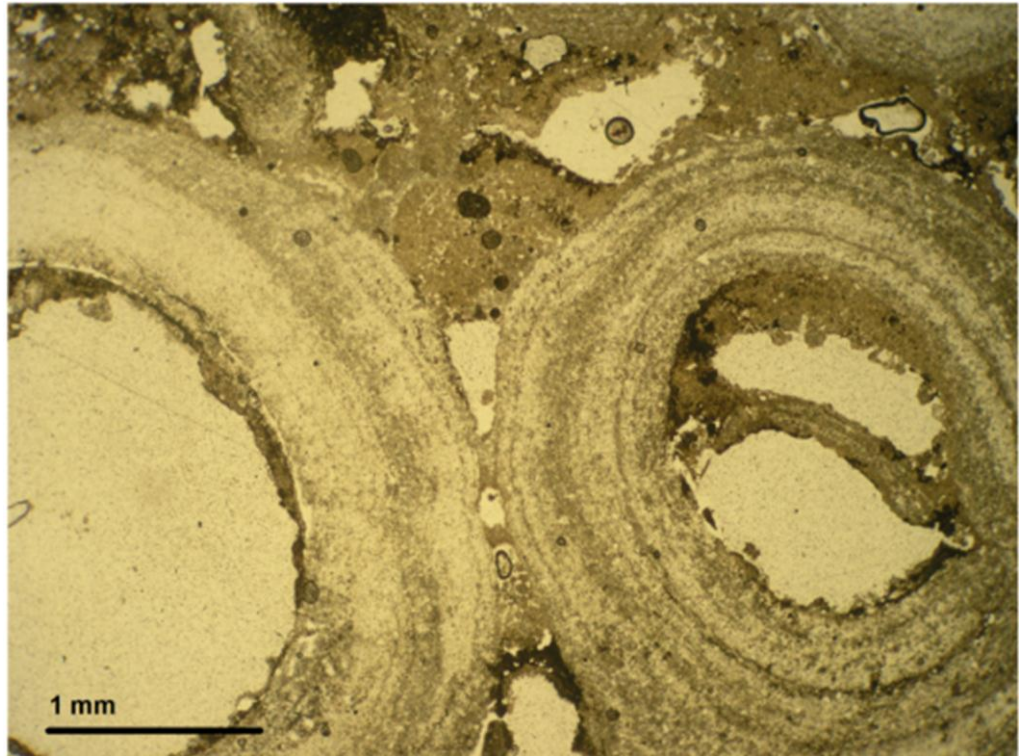


Photo 3: Larger reed castings composed of radial fibrous spar, partially filled with micrite. Plane light.

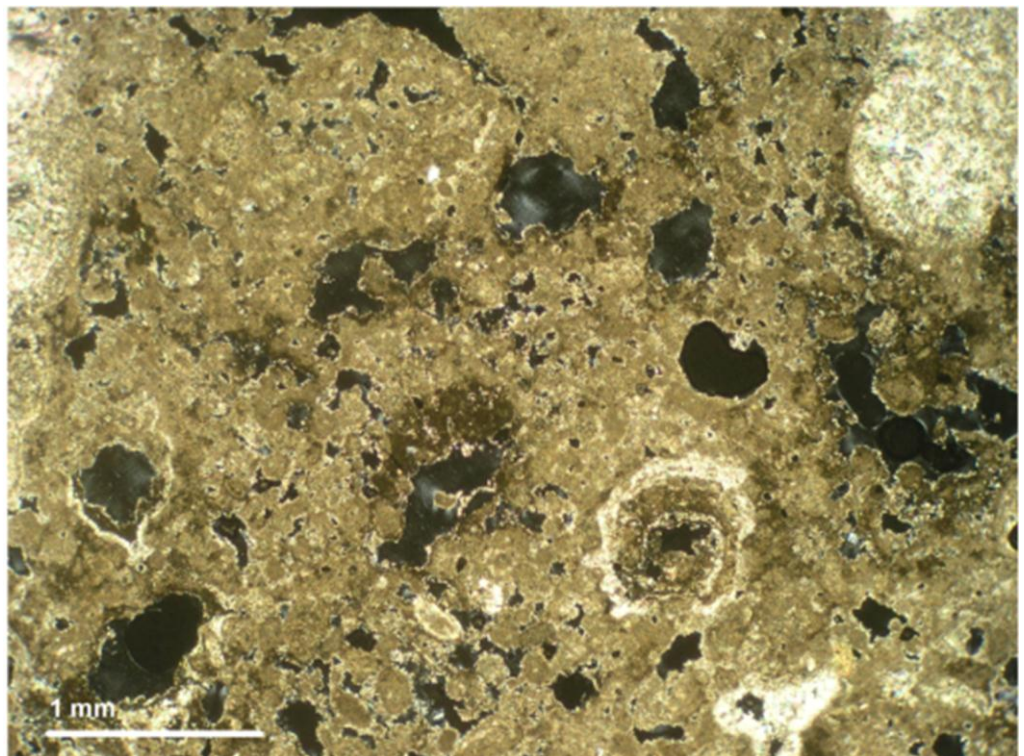


Photo 4: Peloidal and ooidal matrix composed of micrite. Meniscus cement is also evident between particles. Crossed polars.

Slide Descriptions for samples collected at Warburton Springs

Sample No WSRS001

Location

662355E, 6760458N (GDA94, Zone 53)

Texture

Very vuggy limestone. Clotted micritic matrix. Void are both fenestral and bridging

Carbonate Grains

10% peloids, 1% ooids, 5% lumps, 1% bioclasts (gastropods, ostracods, bivalves).

Siliciclastic Grains

2% Quartz sand.

Voids

18% fenestral, 2% intra-granular (bioclasts). Unfilled 15% partially filled 5%

Carbonate Mud

43%

Cements

5% micritic (geopetal), 5% microspar, 2% meniscus, 1% granular, 5% cloudy radiaxial fibrous.

Other

Tr. goethite

Comments

Hollow centres of a number of ooids are probably indicative of vegetation providing the nucleus point. Micritic and meniscus cement indicative of rapid crystallisation, possibly due to evaporation in a sub-aerial zone.

Classification

Fenestral microbial grainstone.

Interpretation

Vegetated swamp or pool environment.

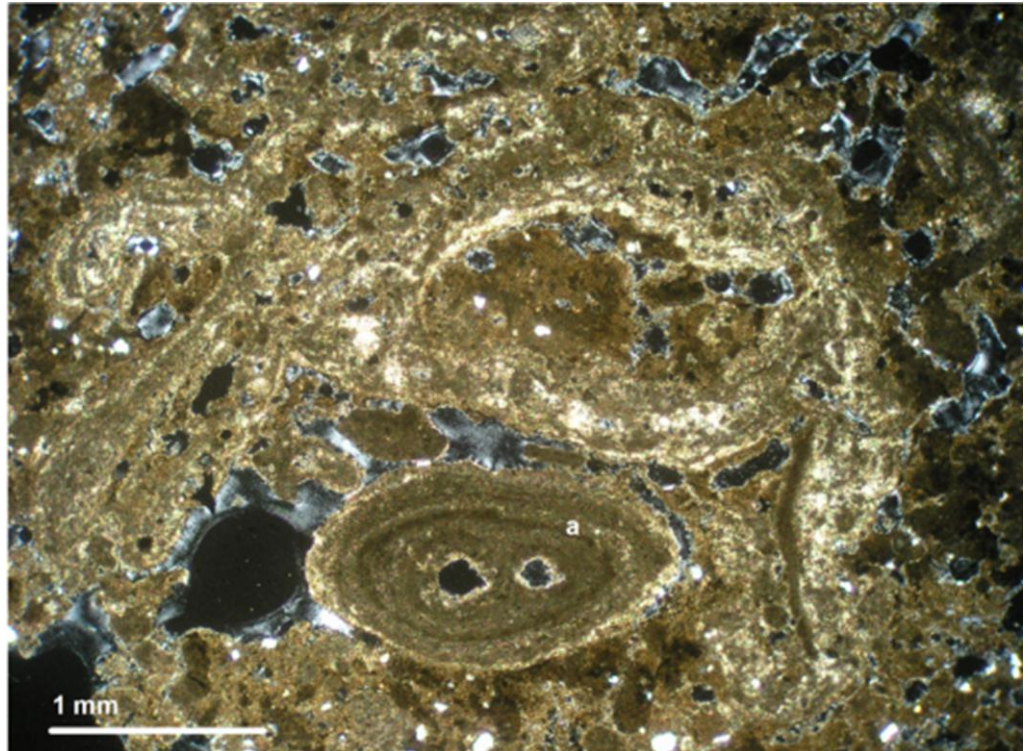


Photo 1: Ooid (a) with hollow centre within clotted/ peloidal matrix. Crossed polars.

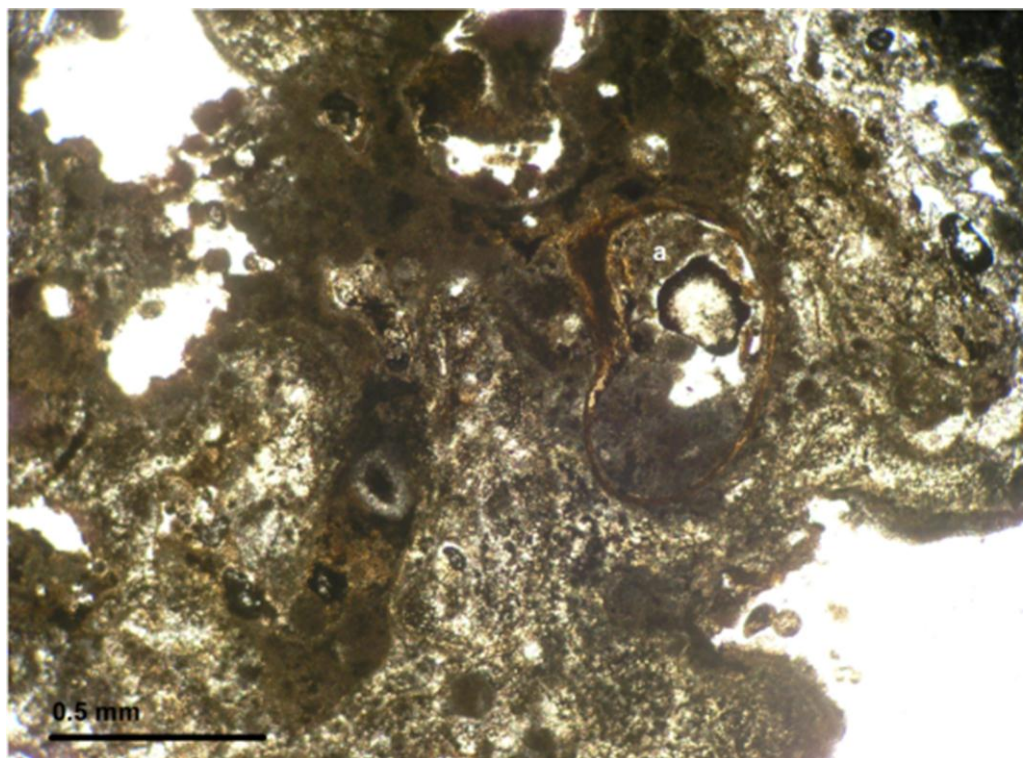


Photo 2: Ostracod fossil (a) with partial void infill of micrite and carbonaceous mud. Plan light.

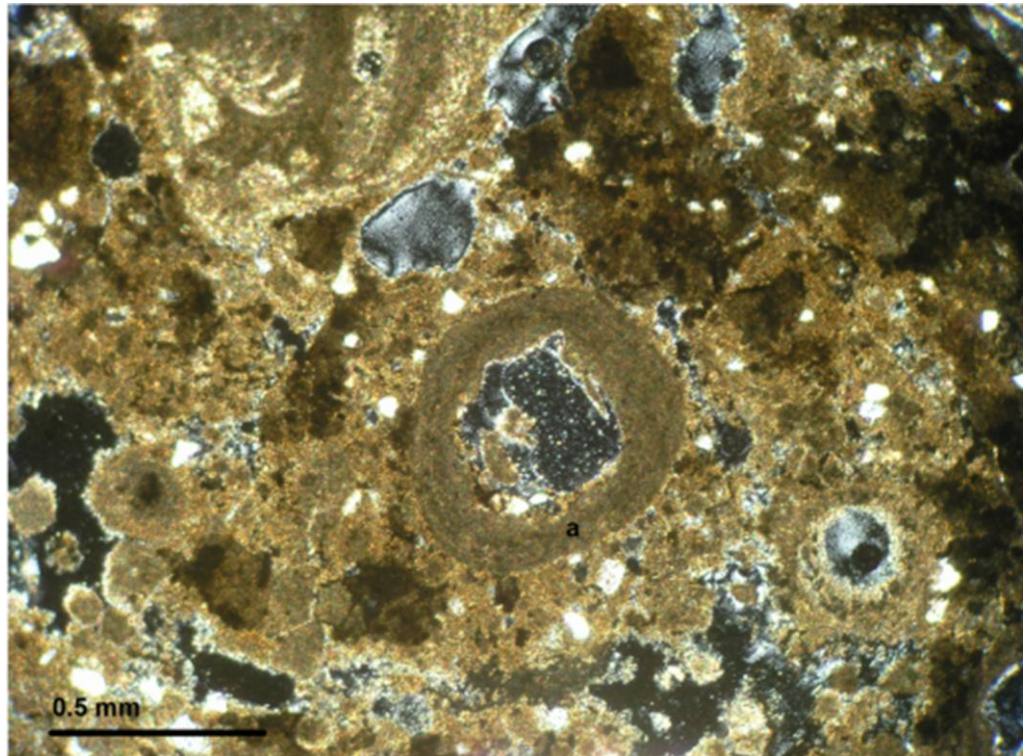


Photo 3: Possible Charophyte casting (a) within clotted and peloidal matrix. Crossed polars.

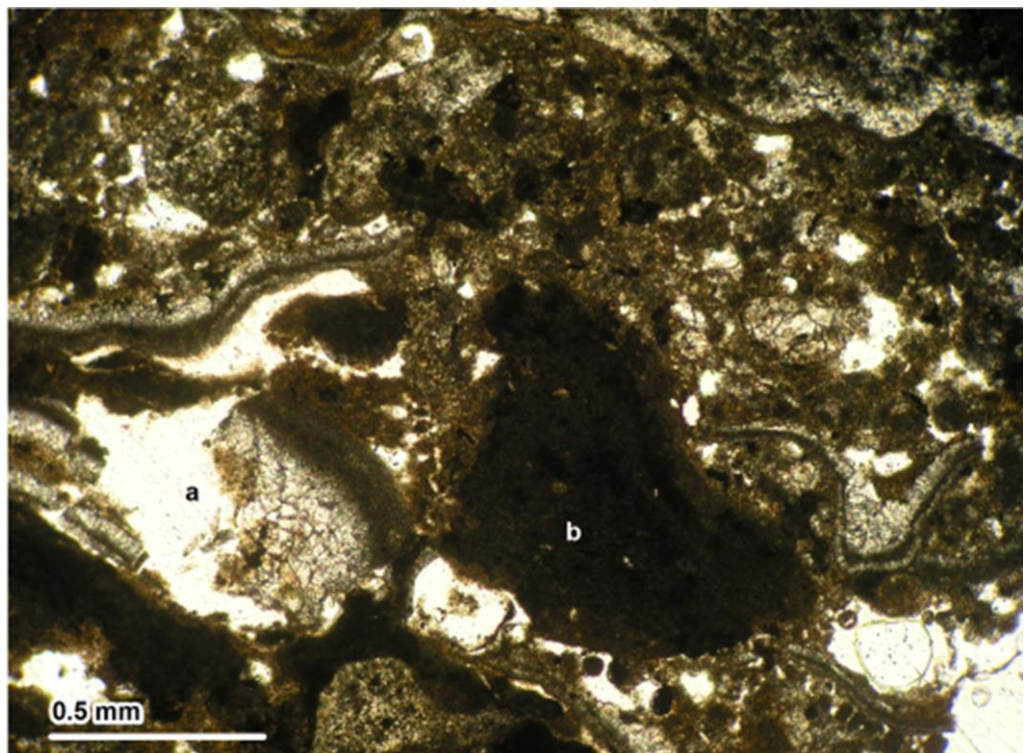


Photo 4: Geopetal void fill of micritic and granular cement to left (a). Lump or carbonaceous clastic in centre (b). Peloidal/ clotted texture. Plane light.

Sample No WSRS002

Location

662359E, 6760472N (GDA94, Zone 53)

Texture

Vuggy limestone with fine grained carbonate mud matrix. A combination of clotted (possible renaloid texture) and microbial carbonaceous mud and clastic deposition.

Carbonate Grains

5% peloids, 4% lumps, 1% bioclasts (ostracods, charophytes, gastropods), 1% oncoids (?).

Siliciclastic Grains

1% quartz sand.

Voids

25% fenestral and botryoidal, 1% intra-particle (1%). 10% unfilled, 10% partially filled (geopetal) 10%, 5% filled.

Carbonate Mud

52%

Cements

5% micritic, 1% meniscus, 3% microcrystalline (geopetal), 2% radial fibrous and granular.

Other

Tr. goethite

Comments

Laminated botryoidal texture may be indicative of microbial influence. Complicated diagenetic history, with microcrystalline cementation followed by granular/ fibrous cementation and then micrite void filling – may be indicative of increased burial over time.

Classification

Microbial wackestone.

Interpretation

Vegetated pool or swamp environment that has progressively been buried.

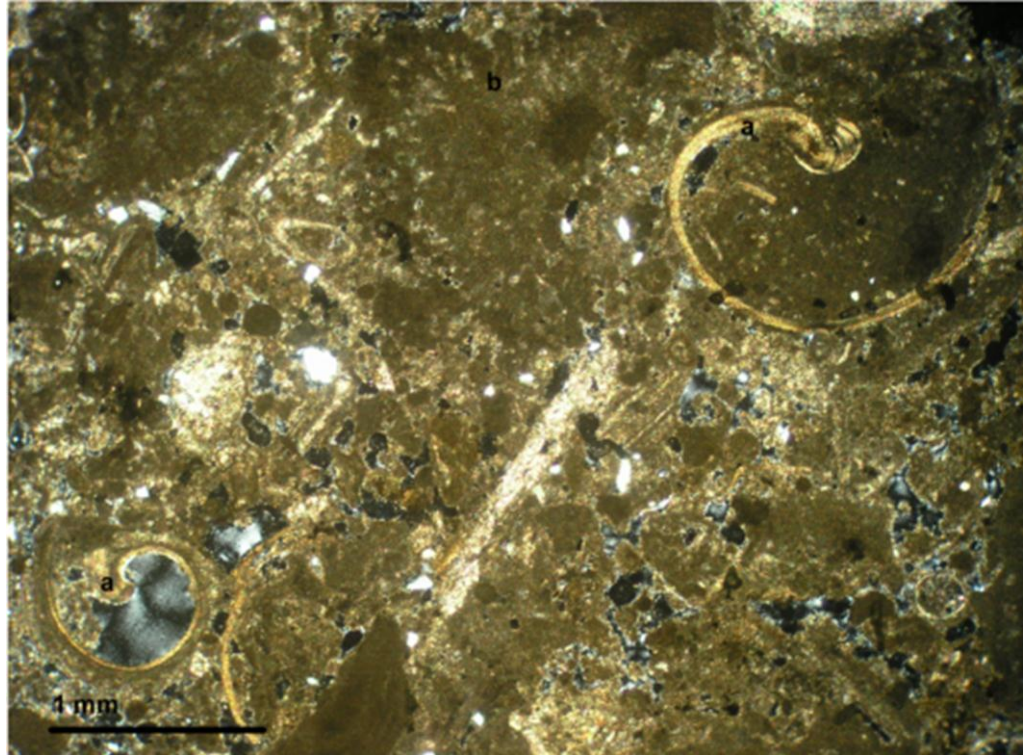


Photo 1: Gastropod fossils (a) with geopetal matrix material infill within a peloidal and “lumpy” carbonate mud matrix. Micritic (meniscus) cement fills some inter-particle voids. Other voids unfilled. Small fenestra at top of image is evidence for microbial activity. Crossed polars.

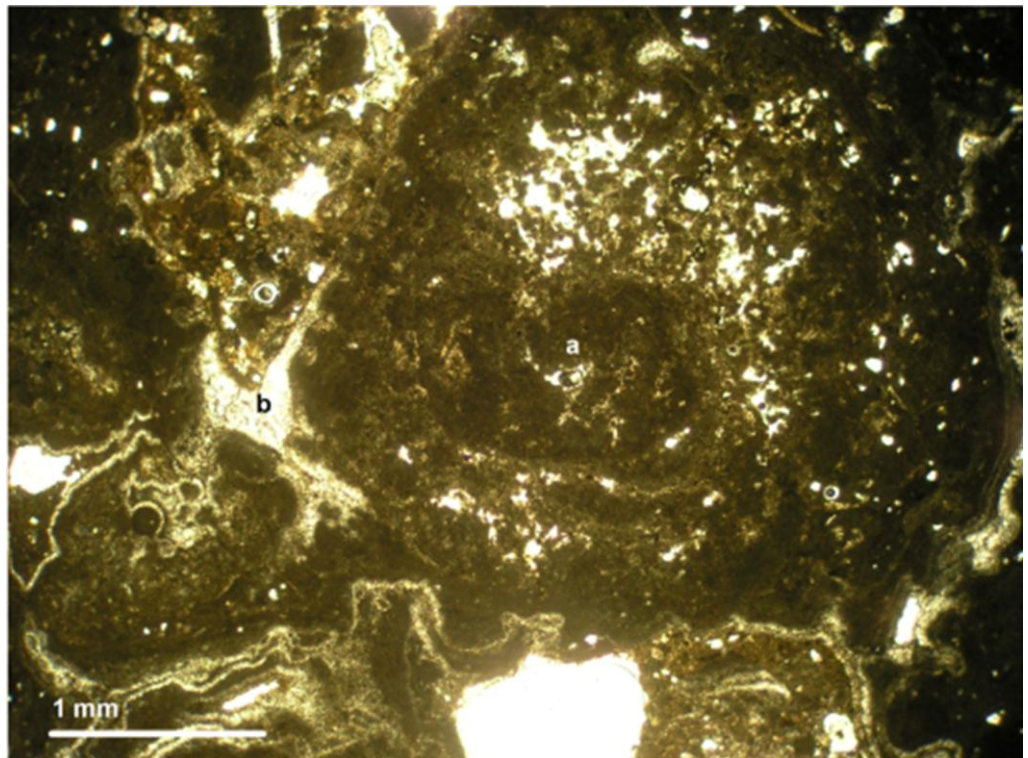


Photo 2: Possible oncooid (a) with fenestra partially filled with micritic cement. Voids surrounding oncooid filled with thin film of microcrystalline carbonate cement (b) and micrite. Centres of larger voids filled with matrix material. Plane light.

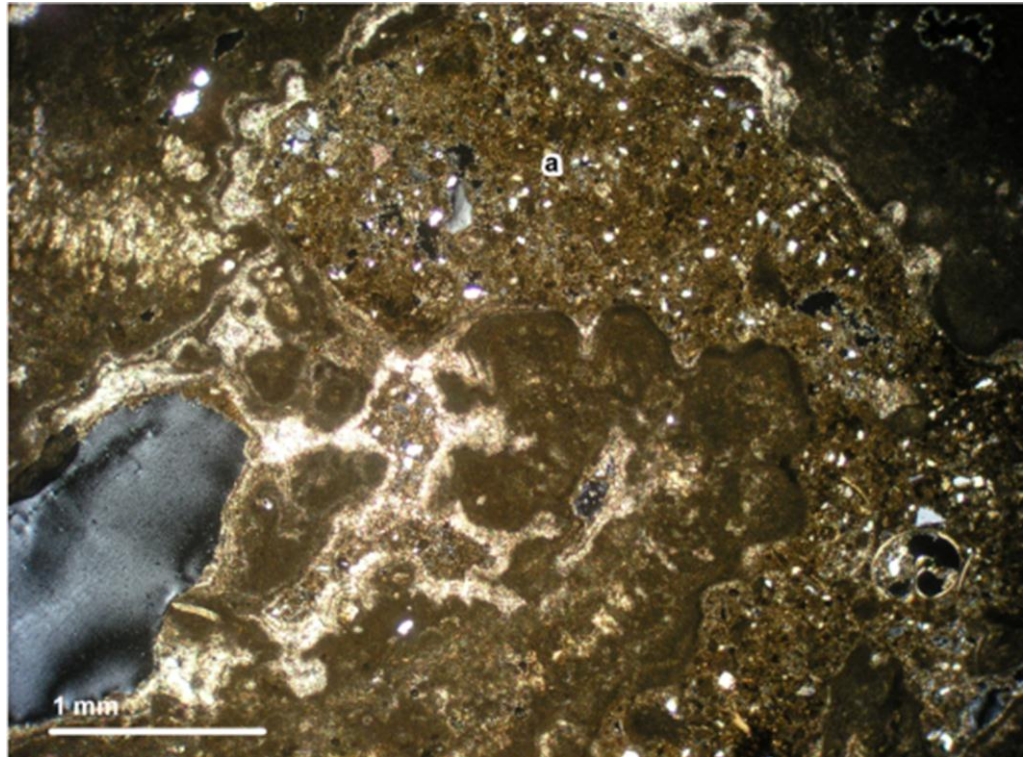


Photo 3: Shrub-like textures and fenestra formed under microbial (cyanobacteria) influence. Fenestra filled with microcrystalline and radiaxial fibrous cement and geopetal micrite. Larger void at top of image (a) filled with matrix material. Crossed polars.

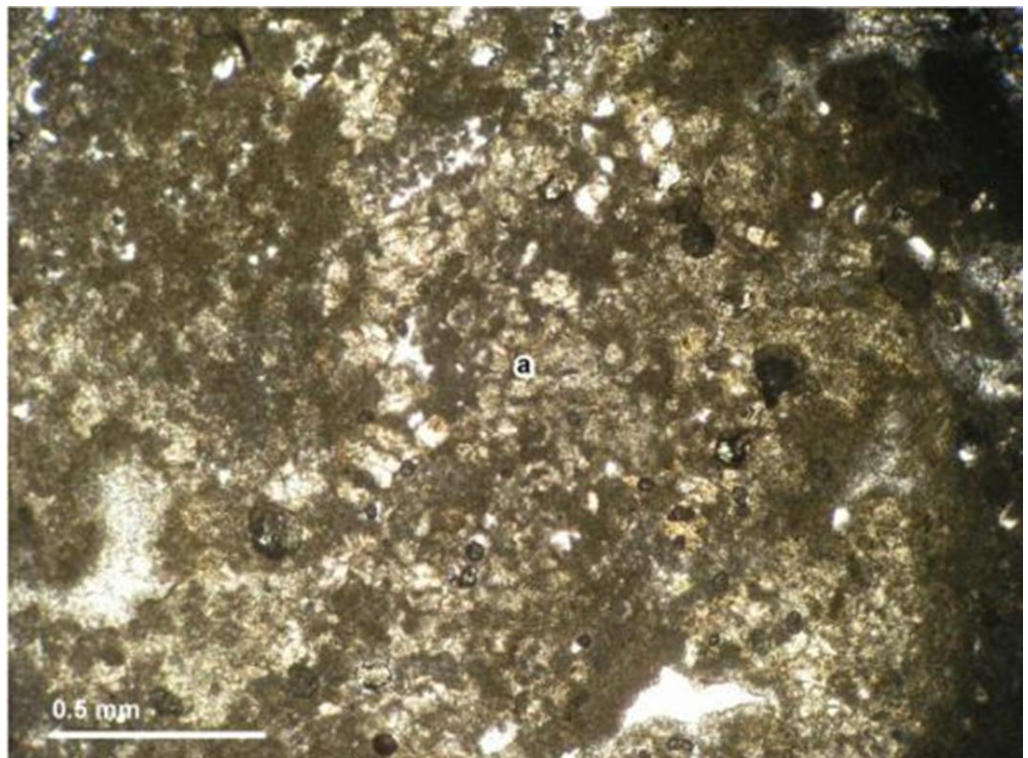


Photo 4: "Clotted" possible renalcid texture (a). Matrix composed of micrite, carbonaceous mud and some microspar (?). Plane light.

Sample No WSRS003

Location

662359E, 6760472N (GDA94, Zone 53)

Texture

Very vuggy limestone. Clotted micritic matrix. Void are both fenestral and bridging

Carbonate Grains

5% peloids, 10% ooids, 5% lumps, 1% bioclasts (ostracods?)

Siliciclastic Grains

Tr. quartz sand.

Voids

40% fenestral. 35% unfilled, 5% partially filled.

Carbonate Mud

33%

Cements

2% micritic (geopetal), 2% meniscus, 1% granular, 1% cloudy radiaxial fibrous.

Other

Tr. goethite.

Comments

Hollow centres of a number of ooids are probably indicative of vegetation providing the nucleus point. Micritic and meniscus cement indicative of rapid crystallisation, possibly due to evaporation in a sub-aerial zone.

Classification

Fenestral ooidal grainstone.

Interpretation

Vegetated swamp or pool environment close to vent.

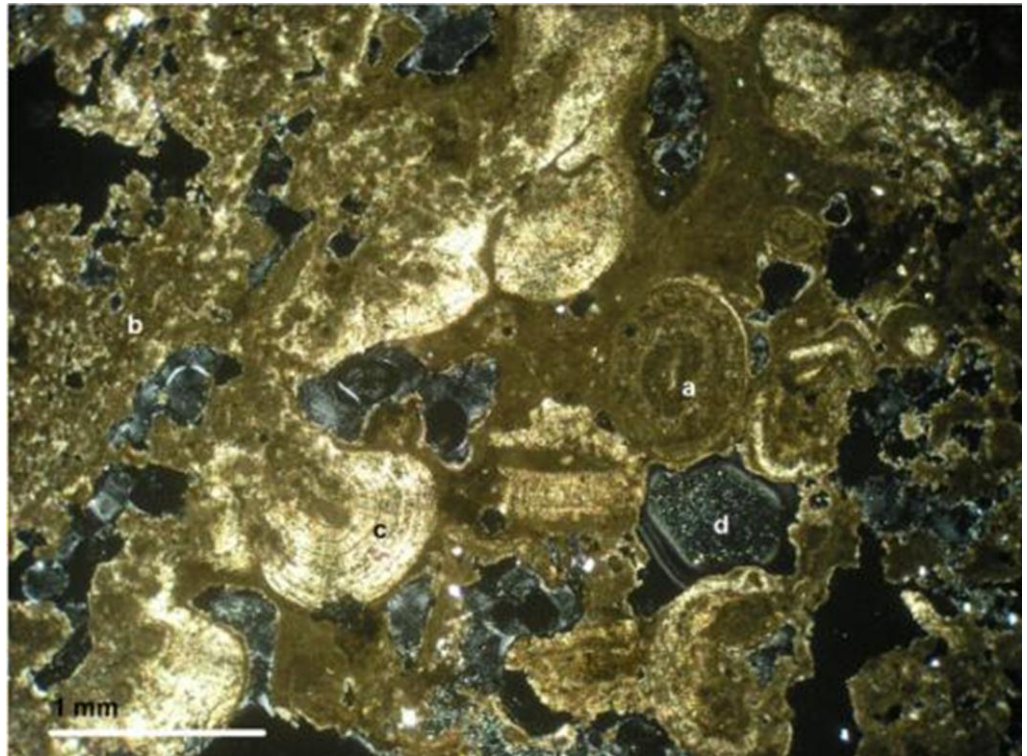


Photo 1: Ooids (a) and peloids (b) with carbonaceous mud infill. Cloudy radiaxial fibrous cement growth in shrub-like form (c) is also observable. A large number of primary cavities (d) are evident. Cross polars.

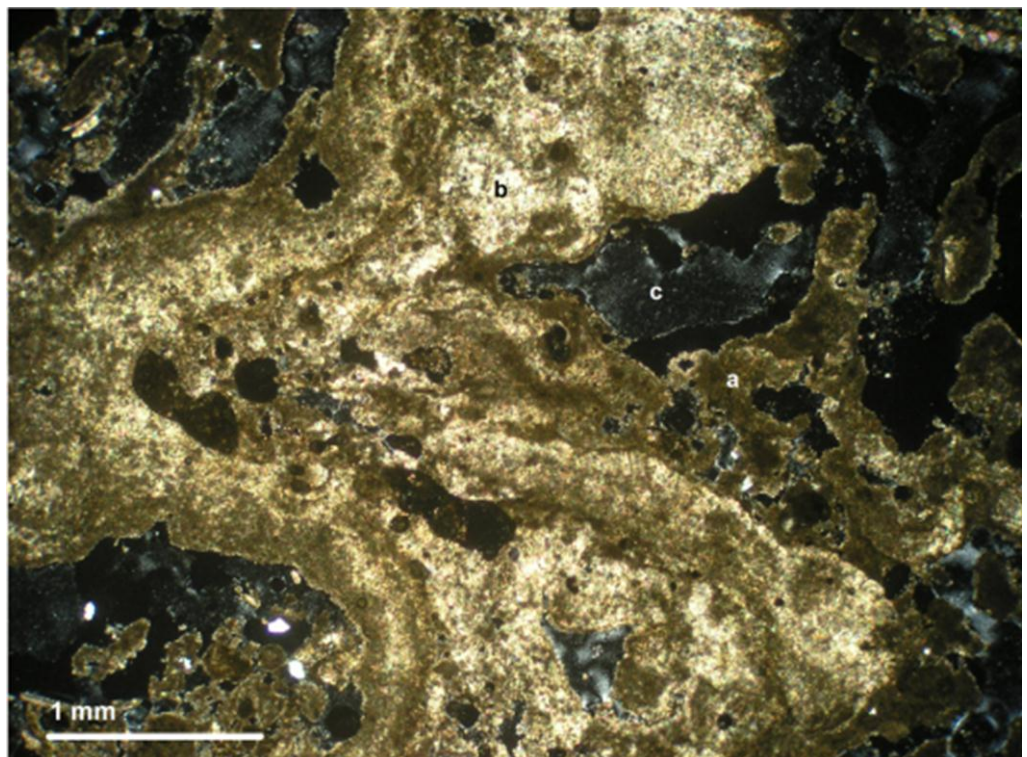


Photo 2: micritic and microcrystalline matrix textures and primary fenestral voids. Crossed polars.

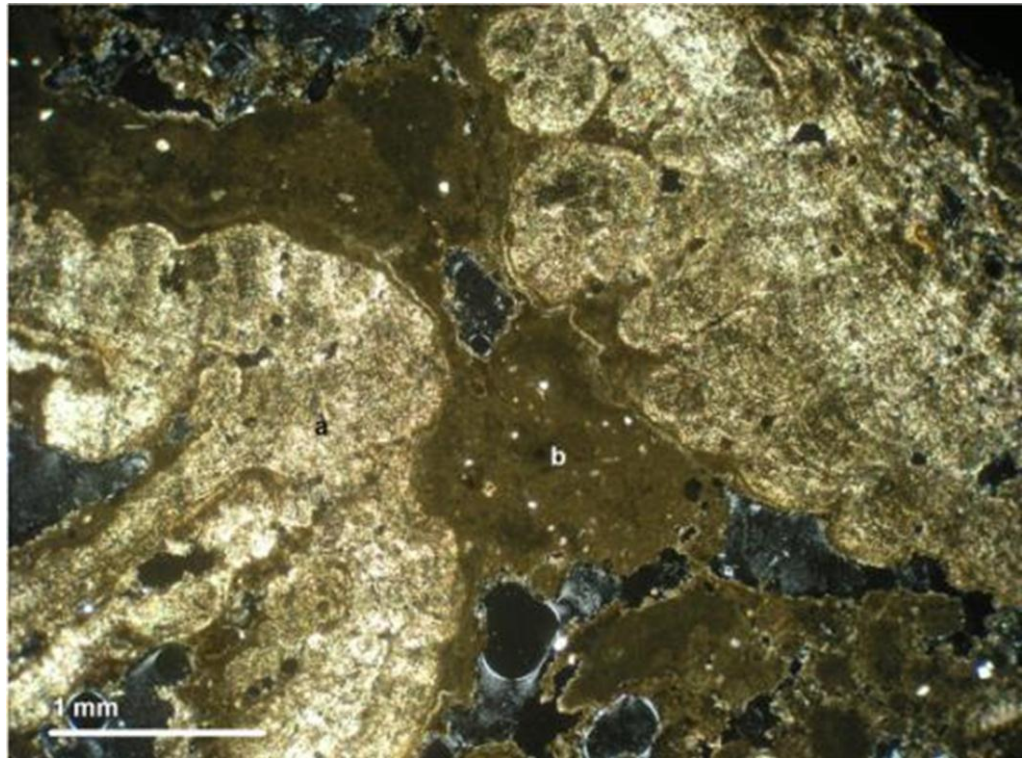


Photo 3: Cloudy radiaxial fibrous cements (a) forming a shrub-like texture. Carbonaceous mud fill (b) at later stage. Cross polars.

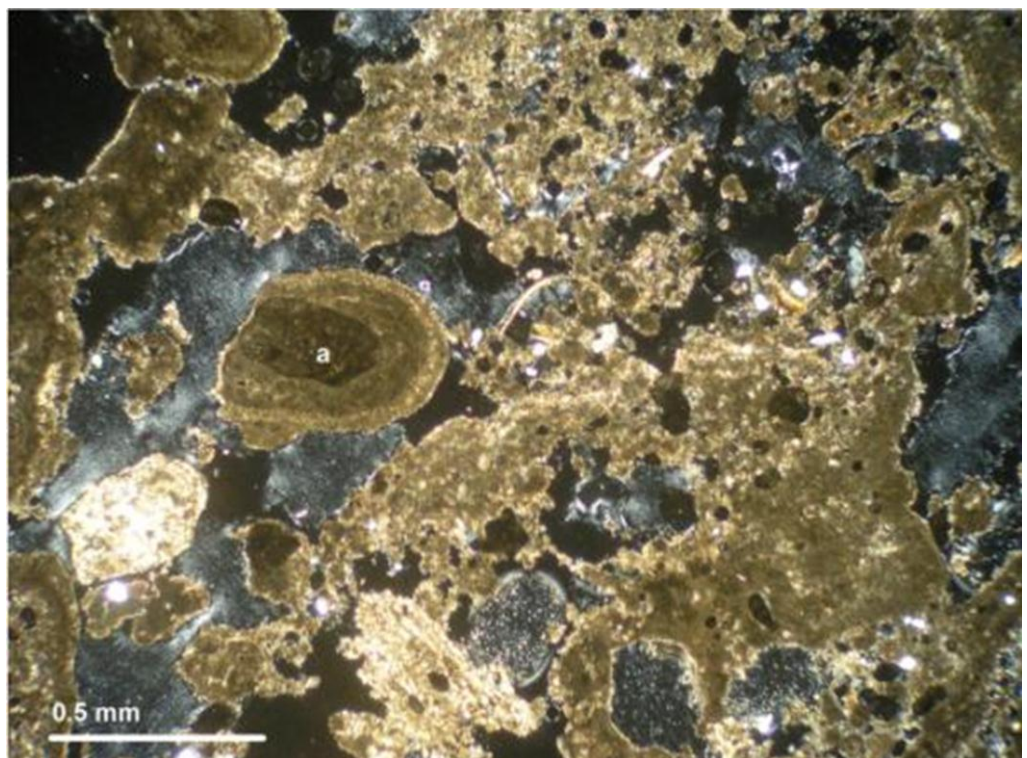


Photo 4: Broken ooid (a) near centre left of image. Peloidal and carbonaceous mud matrix. Large percentage of primary voids. Crossed polars.

Sample No WSRS004

Location

662379E, 6760363N (GDA94, Zone 53)

Texture

Fine grained massive marly limestone. Fine grained "blotchy" (clotted? Not peloidal) micritic and clayey matrix.

Carbonate Grains

3% calcareous clasts, 3% lumps

Siliciclastic Grains

5% quartz sand, 10% phyllosilicate clay (kaolinite)

Voids

10% fracturing and irregular rounded (possibly fenestral). A number of almost circular voids, variously filled with cement, may be burrows or castings. Later void fillings appear geopetal. 4% unfilled, 4% partially filled, 2% filled. Unfilled voids may be attributable to dissolution.

Carbonate Mud

60%

Cements

2% microcrystalline, 2% micritic, 1% granular, 1% bladed, tr. meniscus

Other

3% goethite (matrix).

Comments

Void filling usually begins with micritic and or microspar cement, followed by infilling with bladed and then granular cement. This may reflect increased burial over time. "Blotchy" pattern may be a result of replacement of original pedogenic matrix with a micritic one.

Classification

Goethitic wackestone

Interpretation

Pedogenic carbonate horizon within (relict?) vadose zone