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Data Repository

Table 1 – Localities		
Locality name	*Longitude*	*Latitude*
Site 1: Driedoornvlagte	16° 39' 50.57" E	23° 51' 36.83" S
Site 2: Omkyk	16°13'45.00"E	24°48'19.00"S

Table DR1. Names of localities and co-ordinates.

Geological Background

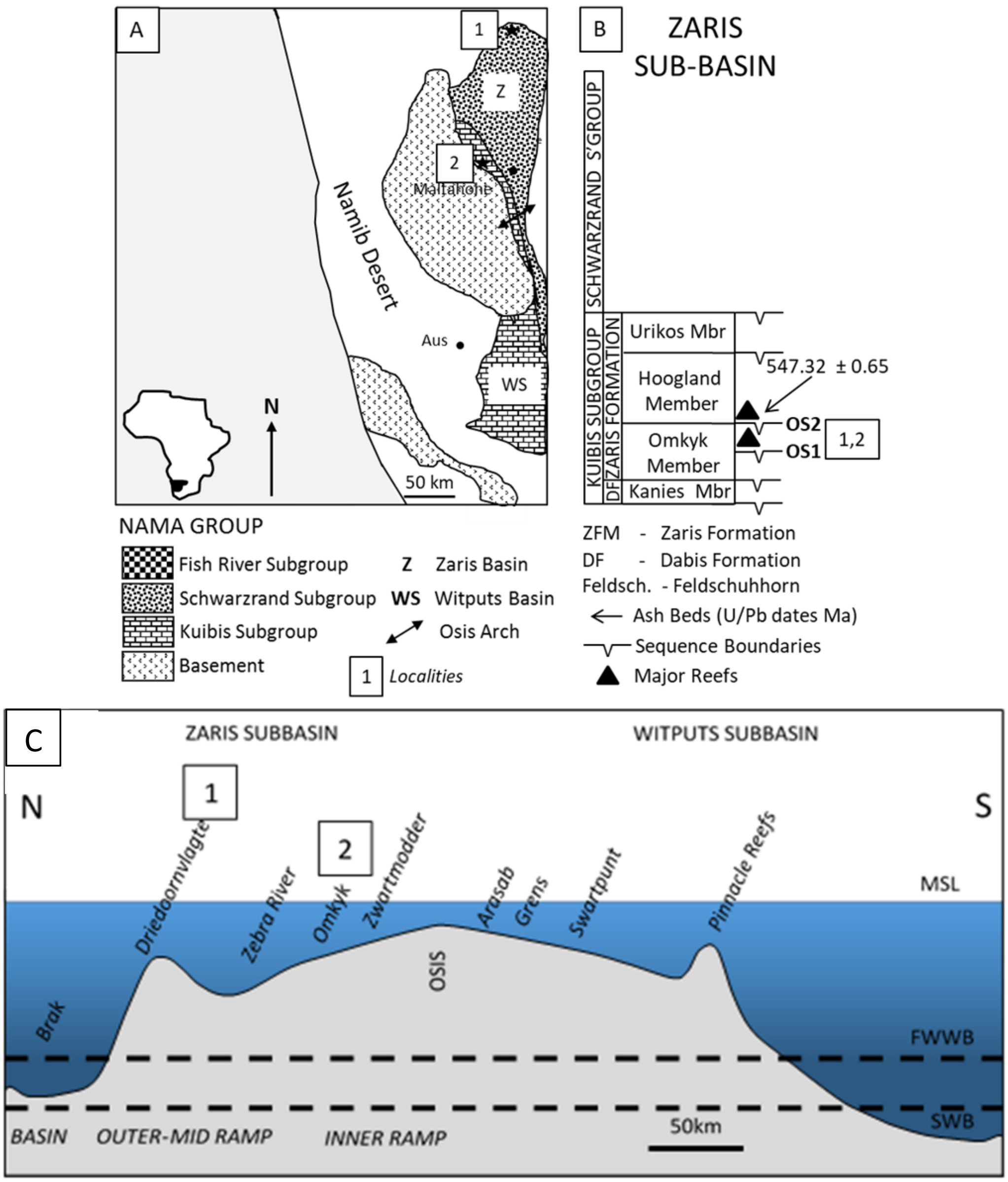


Figure DR1. Geological setting of the Nama Group and sampling localities, 1: Dreidoornvlagte, 2: Omkyk. A: Geological map of the Nama Basin. B: Stratigraphy of the Zaris Subbasin. OS1 and OS2 indicate the Lower Omkyk Member and the Upper Omkyk Member, respectively. C: Schematic of the paleogeography of the Nama Subbasins. Modified from Wood et al. (2015).

Geological locality information: Modified from Wood et al. (2015).

1) **Dreidoornvlagte**

At Driedoornvlagte the succession covers ~ 47 m of Kanies Member, followed by ~ 60 m Lower Omkyk Member and over 380 m Upper Omkyk Member. The Driedoornvlagte reef is a large pinnacle reef complex, 7 km long and over 250 m high, that accumulated in a mid-ramp setting during the TST of the Upper Omkyk, with markedly increased accommodation space associated with a deeper-water setting compared to Zebra River.

The reef is predominantly composed of thrombolitic limestones and grainstones, with minor dolomitization. Calcified metazoan fossils are found throughout the complex, but are particularly abundant towards the top of the section. Here, reef-building *Cloudina hartmannae* and smaller C. riemkeae are found, as well as cryptic *C. riemkeae* within thrombolitic reefs. *Namacalathus* occurs intergrown with *C. riemkeae*, as monospecific aggregations, and also grew in crypts. *Namapoikia* is present occupying fissures within thrombolite reefs.

2) Farm Omkyk

The Omkyk Site consists of ~73 m Lower Omkyk Member and ~30 m Upper Omkyk Member. This is a mid-ramp site, with strata consisting of green shales sandstones, passing into grainstones and thrombolites, then packstones and wackestones.. Re-sedimented carbonate beds and storm beds typify the lower part of the succession, then shallows upward to tidally influenced limestone grainstones with limited thrombolites and abundant *Cloudina hartmannae* and *Namacalathus* in the upper part. Some shoaling cycles contain evidence for deposition in supra- to inter-tidal conditions, which may have been subjected to exposure and evaporitic conditions. There are horizons of abundant calcified metazoans in the Upper Omkyk Member late Transgressive System Transect only.

Methods

During serial sectioning cloudinomorph specimens were ground in increments of 10 µm, 1.23 mm in total, (Fig. DR2 and DR3) or 25 µm, 1.25 mm in total, (Fig. DR4) using a Buehler Petrothin thin sectioning system. Three vertical holes in each sample to aid alignment of the images, which were imaged using a binocular microscope (300 dpi; 19 x 19 to 31 x 31 µm pixel size) and a Canoscan Lide 210 flatbed scanner at (4800 dpi; 53 x 53 to 39 x 39 µm pixel size). Before imaging each sample was ground until flat. After alignment images were either segmented manually or through binarising each section with the contrast settings of each scan replicating the original image. Background noise was removed manually. The processed images were imported as a virtual stack into Avizo 9 software to create 3D models composed of between 50-123 2D images and smoothed to reduce noise. Cloudinomorph walls and the open cavity were manually segmented separately (Fig. DR5). Smoothing thresholds were used to reduce noise within the model by constant reference to features in the original scans, so as not to remove key features such as branches or attachments. Highly polished thin sections were imaged by standard petrographic and cathodoluminesence microscopy.

ImageJ software was used to measure internal cement thickness within cloudinomorphs from polished sections, and to quantify cloudinomorph specimen dimensions from bedding planes. ImageJ was also used to measure the dimensions of the cloudinomorph tubes in increments on both the bedding surface and in the models. Measurements were taken perpendicular to the central line of the tube at 0.5 increments in the model, and 1 mm increments on the bedding plane surface. Only the major axis of each tube was measured in increments in each 3D model, as the necessary removal of material to produce a flat surface rendered minor axes measurememts meaningless.

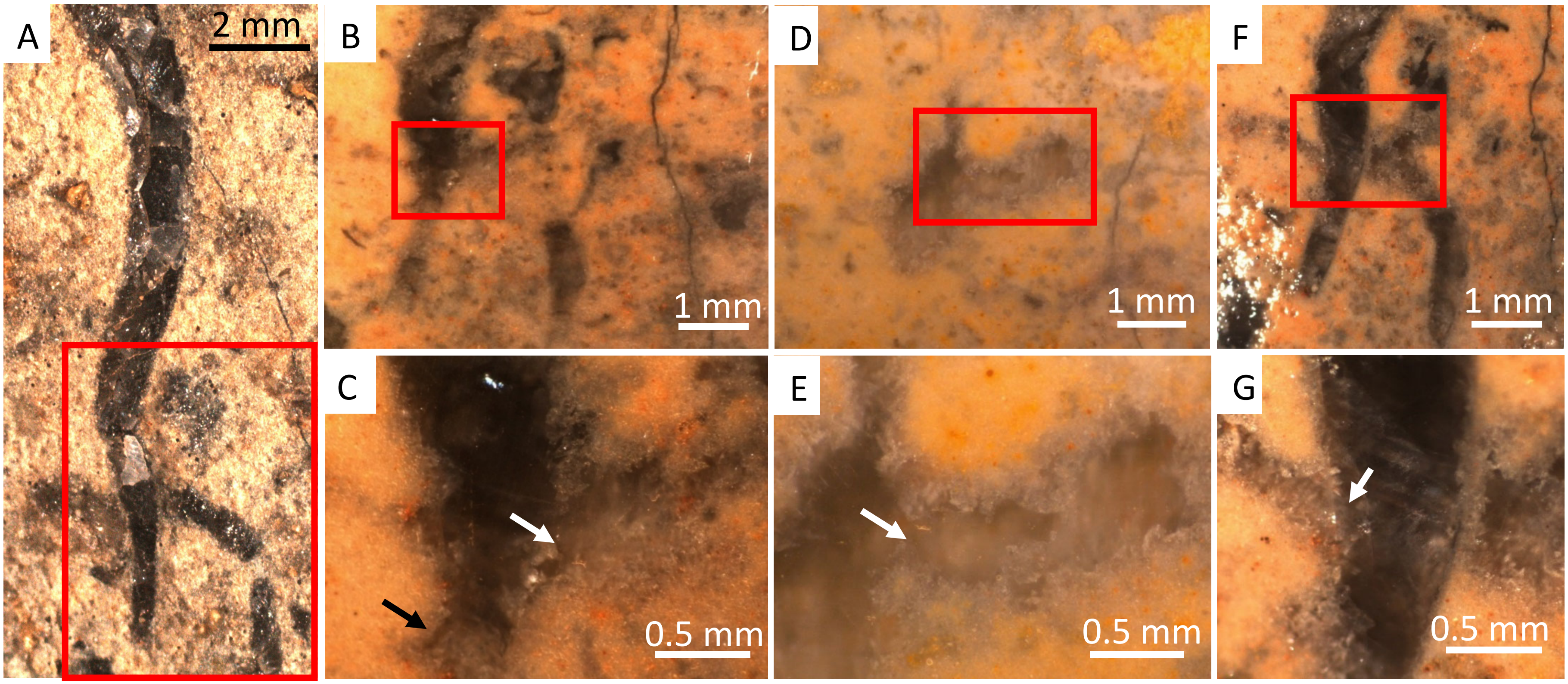


Figure DR2: Evidence of budding in cloudinomorphs from the Nama Group. A: Potential branching cloudinomorph on bedding surface, with branching highlighted. B: Polished surface of branching cloudinomorph. C: inset of B, with white arrow showing no wall between parent and daughter tube, indicating that they share one cavity. Black arrow indicates isopachous cement. D: Polished surface of branching cloudinomorph. E: inset of D, with white arrow in sparry calcite showing no wall between parent and daughter tube, indicating that they share one cavity. F: Polished surface of branching cloudinomorph. G: inset of F, parent and daughter tube do not share the same cavity as isopachous cements forms against parental wall (red arrow).

Multiple branching cloudinomorph model

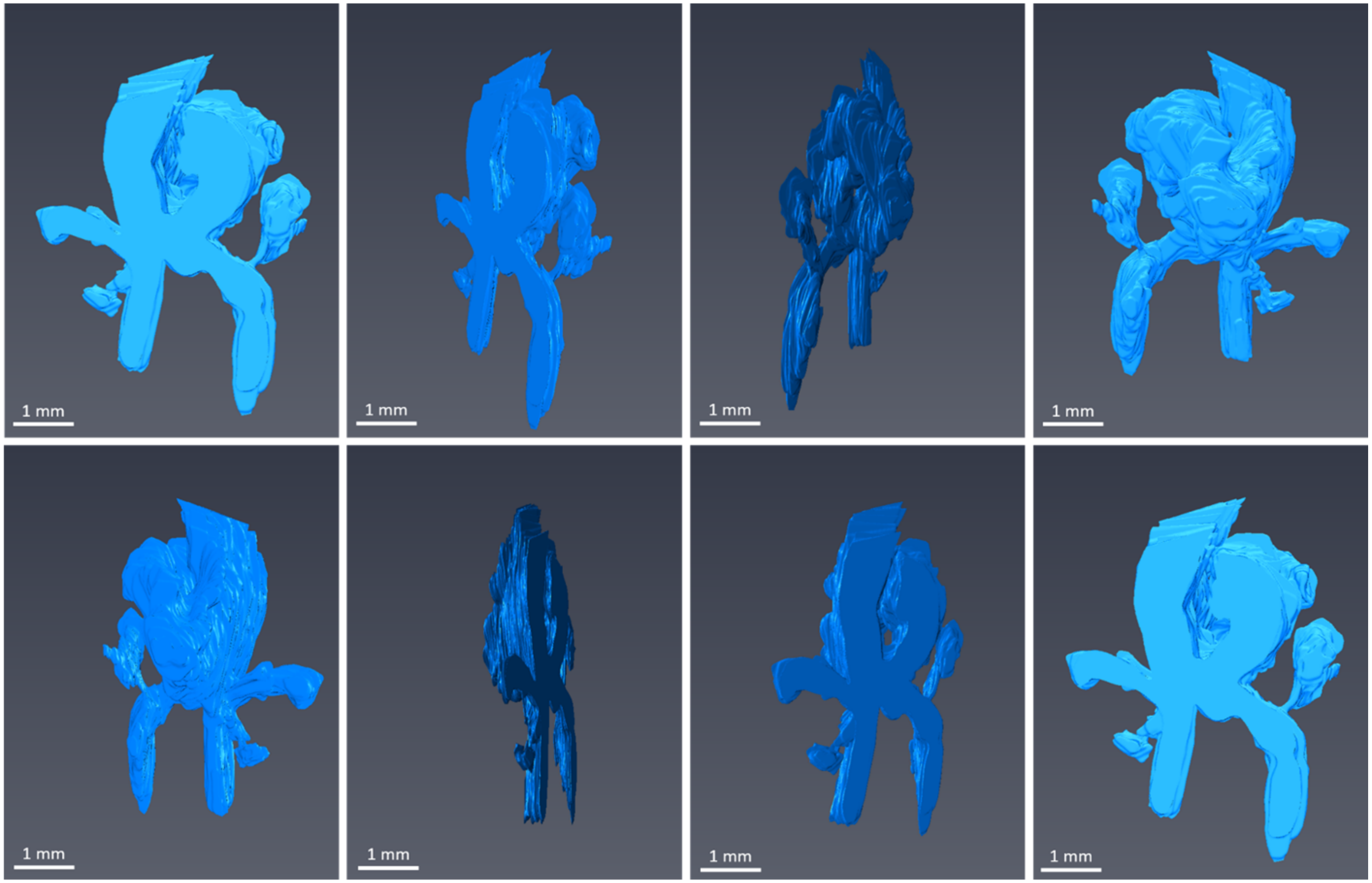


Figure DR3: Image stack of different orientations of the multiple branching cloudinomorph model.

Cloudinomorph and *Namacalathus* attachment model

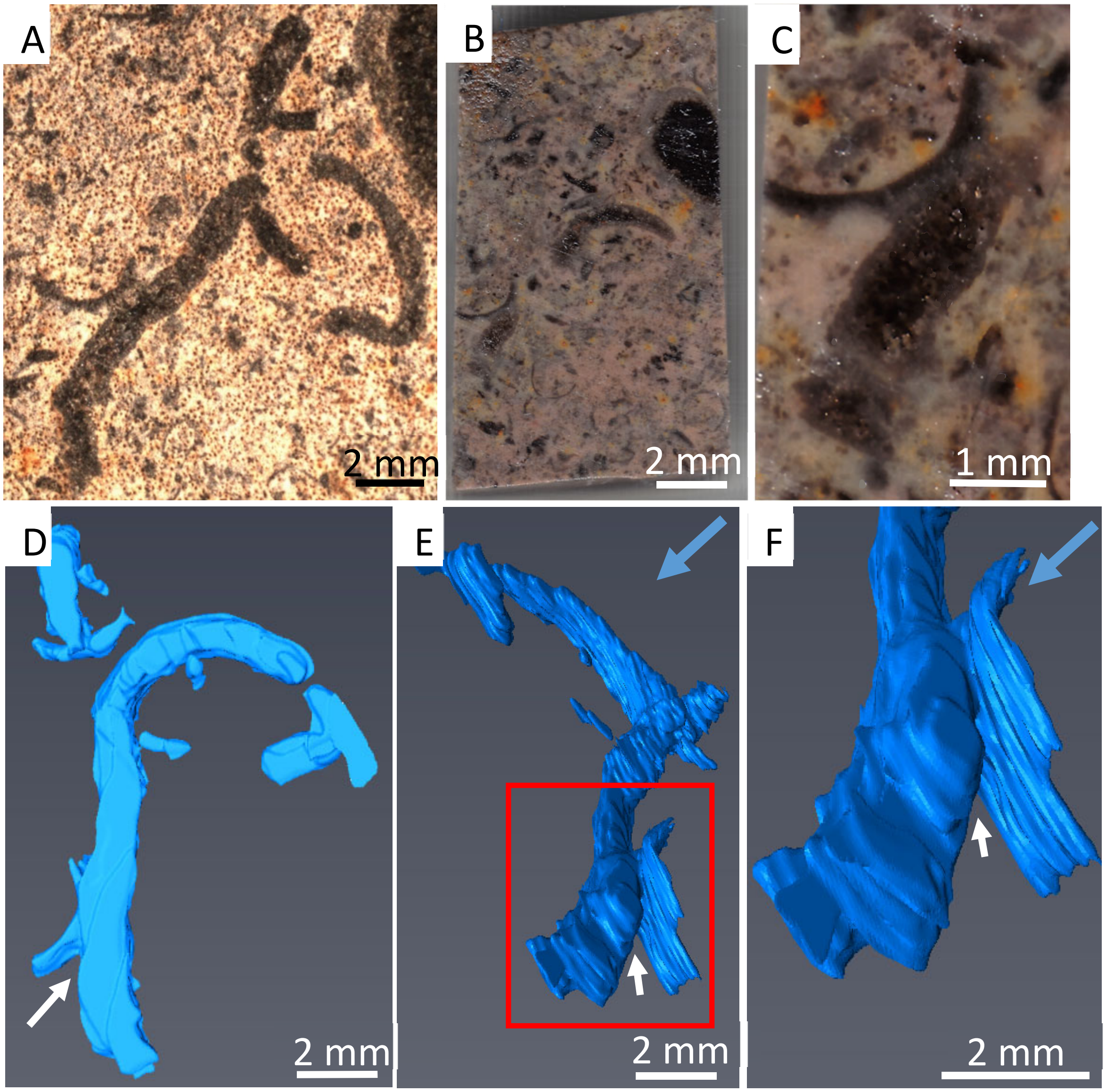
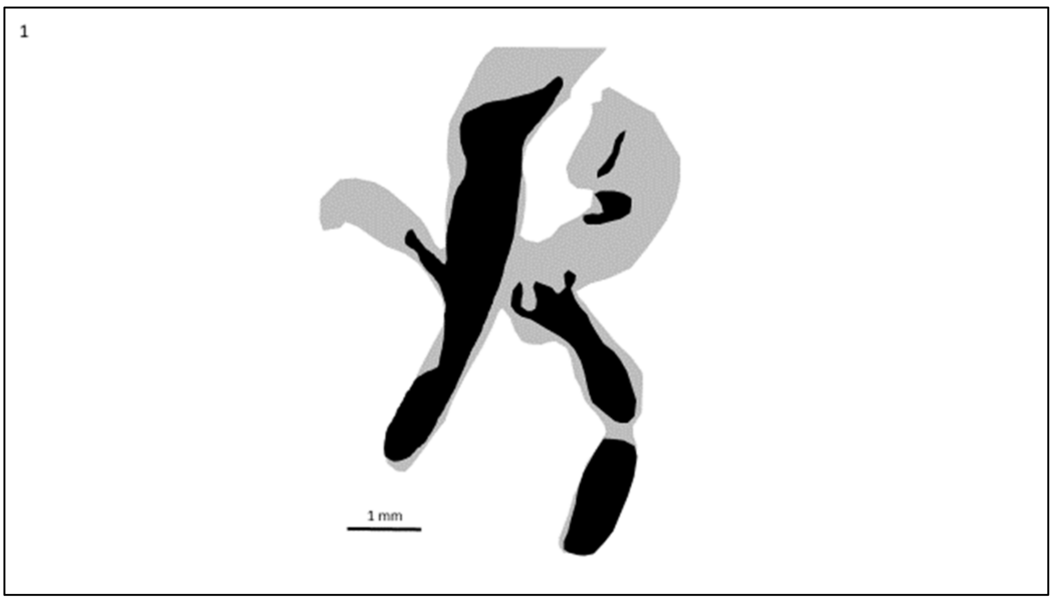
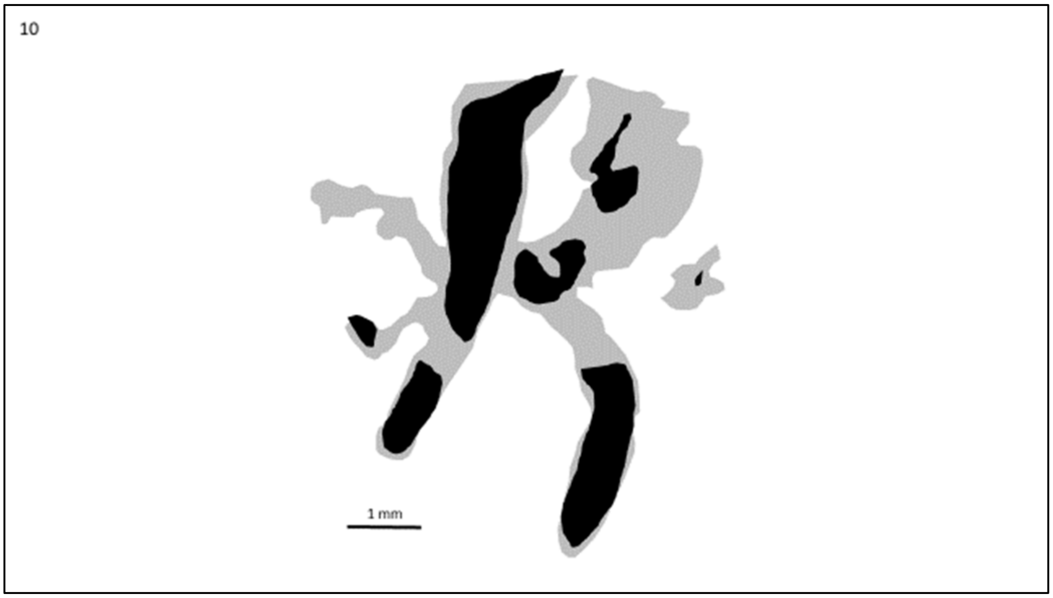


Figure DR4: Cloudinomorph cemented to Namacalathus cup. A: Potential branching cloudinomorph from bedding surface. B: Serial sectioned cloudinomorph showing cementation upon Namacalathus. C: Inset of B showing extratubular structure present between the cloudinomorph and the Namacalathus cup (arrowed). D: 3D model of a cloudinomorph attached to Namacalathus (11.7 x 7.6 x 1.475 mm). This has a smoothing extent of 3.86%. E: Rotated 3D model orientated to cementation *surface, blue arrow indicating way up. F: inset of E, 3D model of attachment between the cloudinomorph and Namacalathus, blue arrow indicating way up..*

Segmentation of cloudinomorph wall and open cavity

Segmentation of the cloudinomorph wall and the open cavity, as highlighted by the sparry calcite, were segmented separately when creating the multiple branching cloudinomorph model (Fig. DR 5), as using the binocular microscope to capture the images during serial section aided in the distinction between the isopachous crust and the sparry calcite on polished surface in hand specimen.

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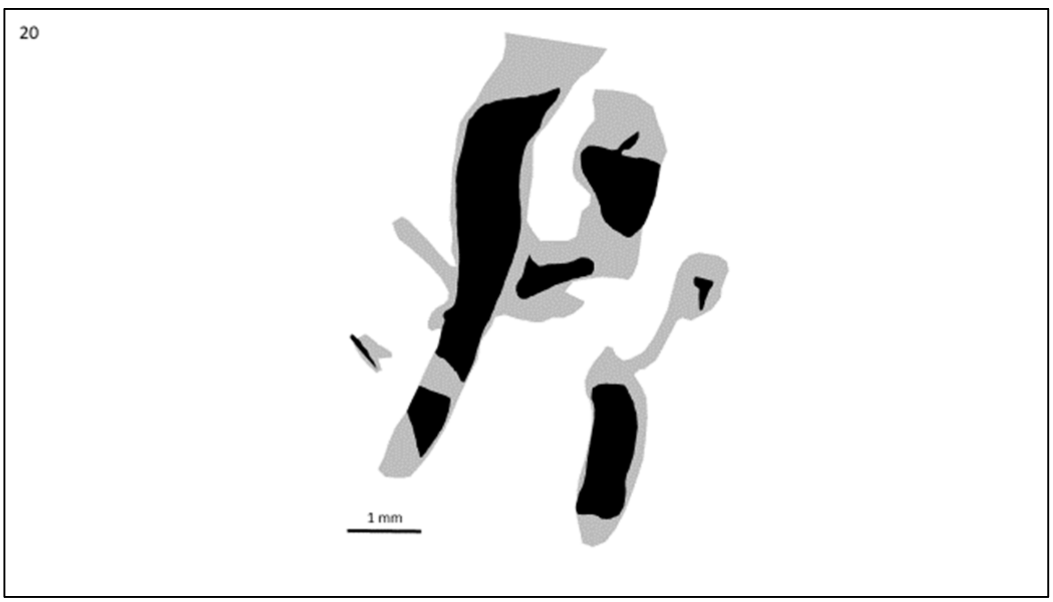
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30
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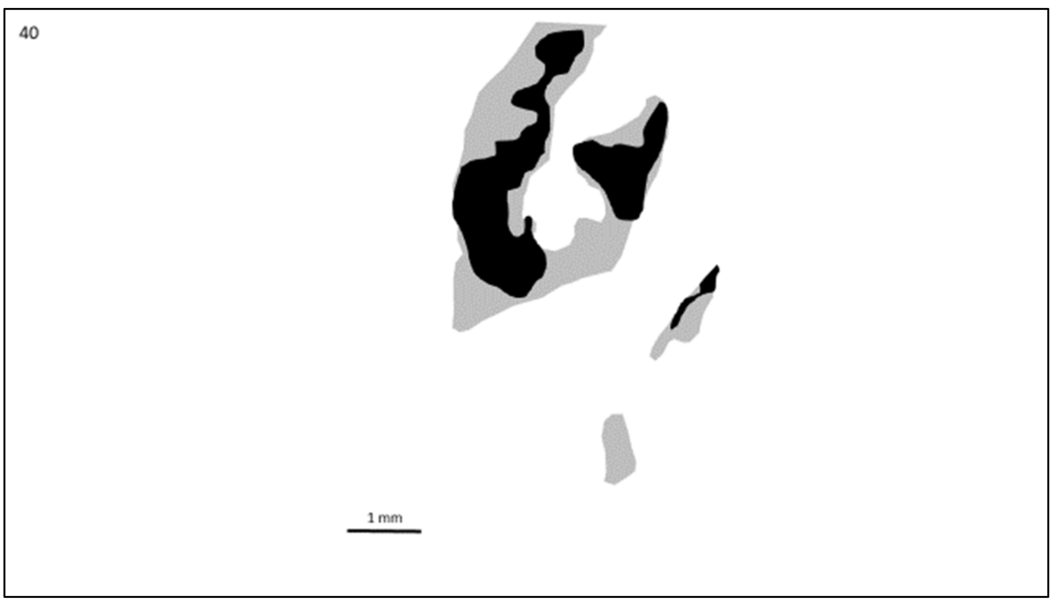
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50
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60
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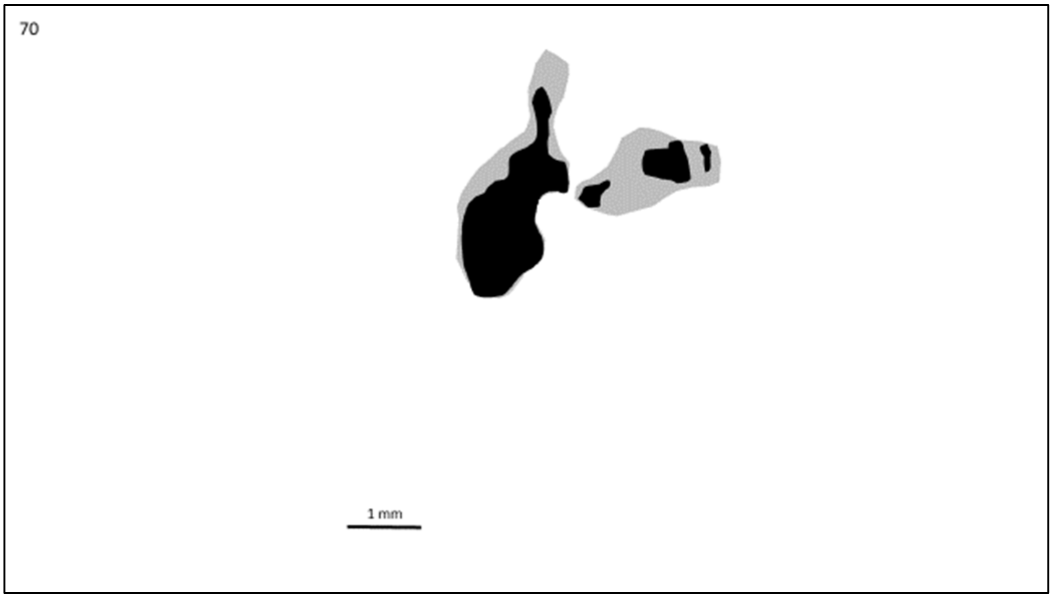
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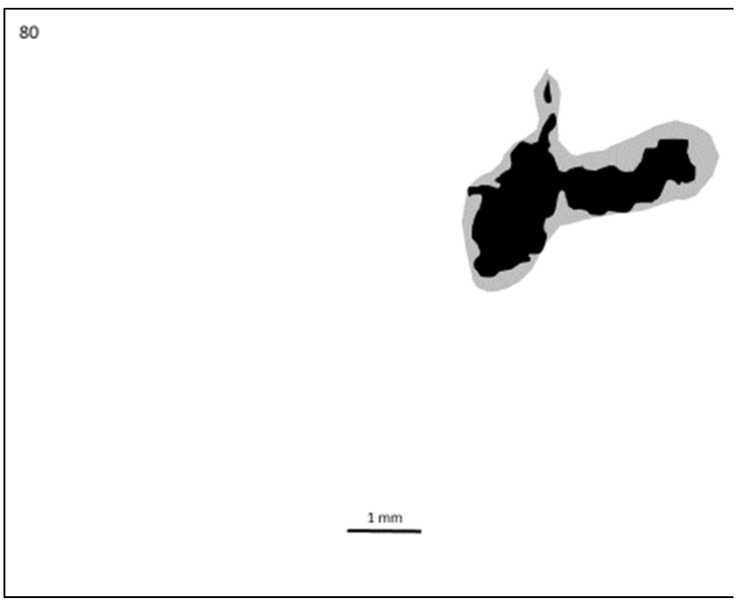
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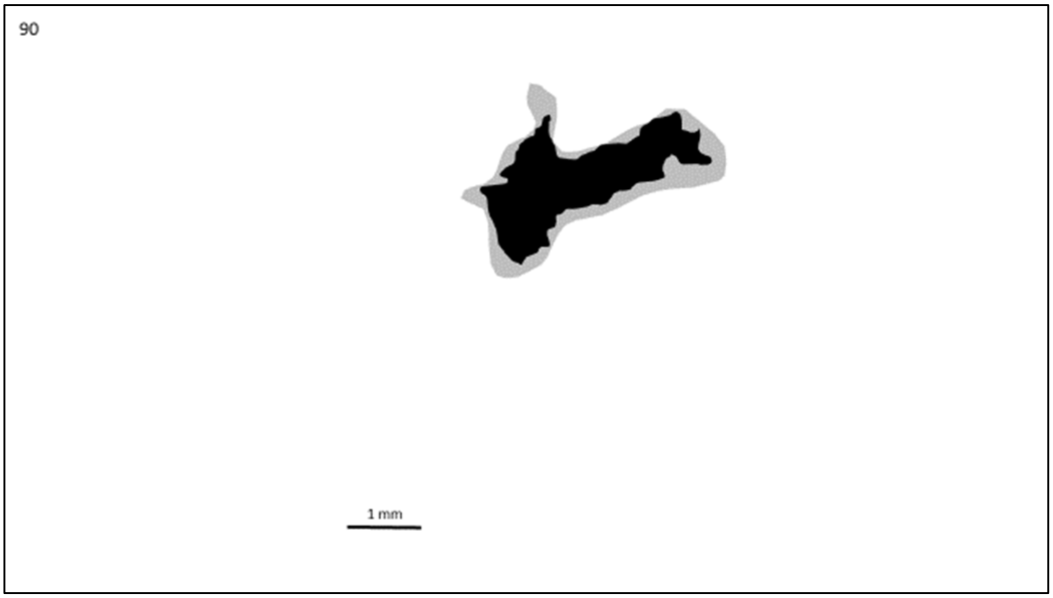
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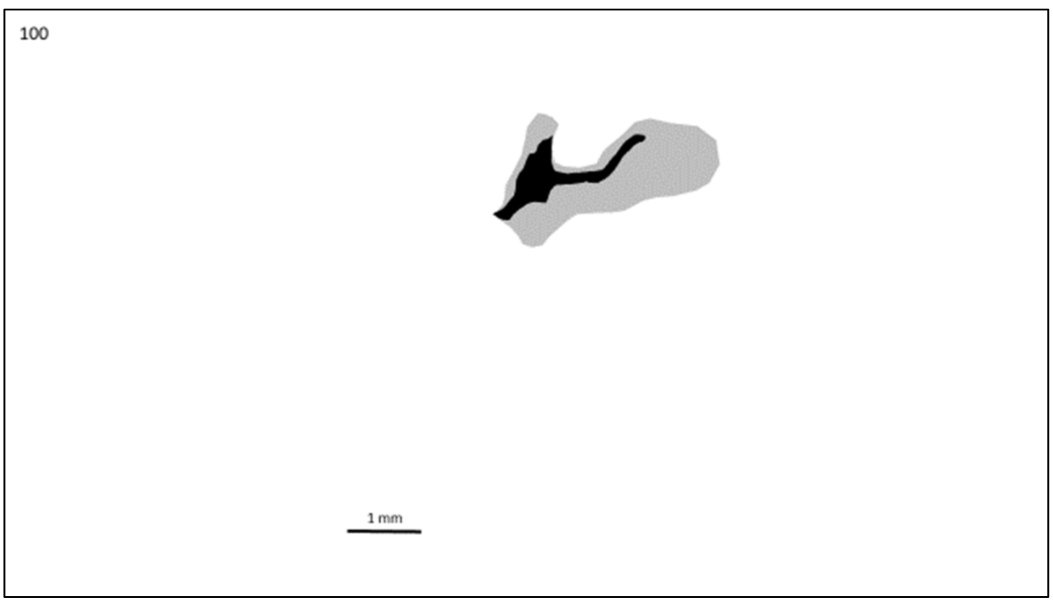
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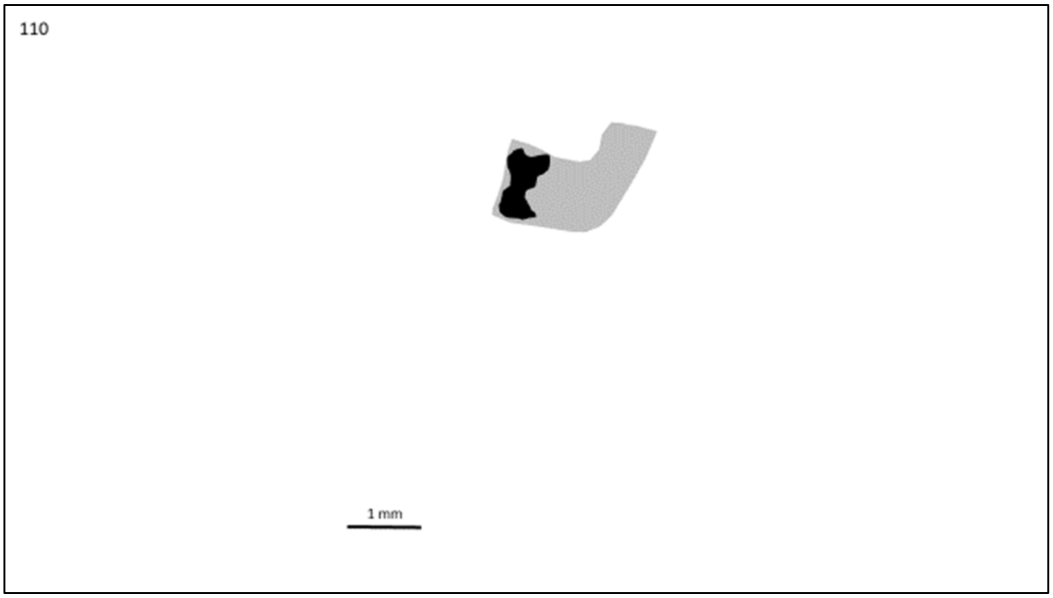
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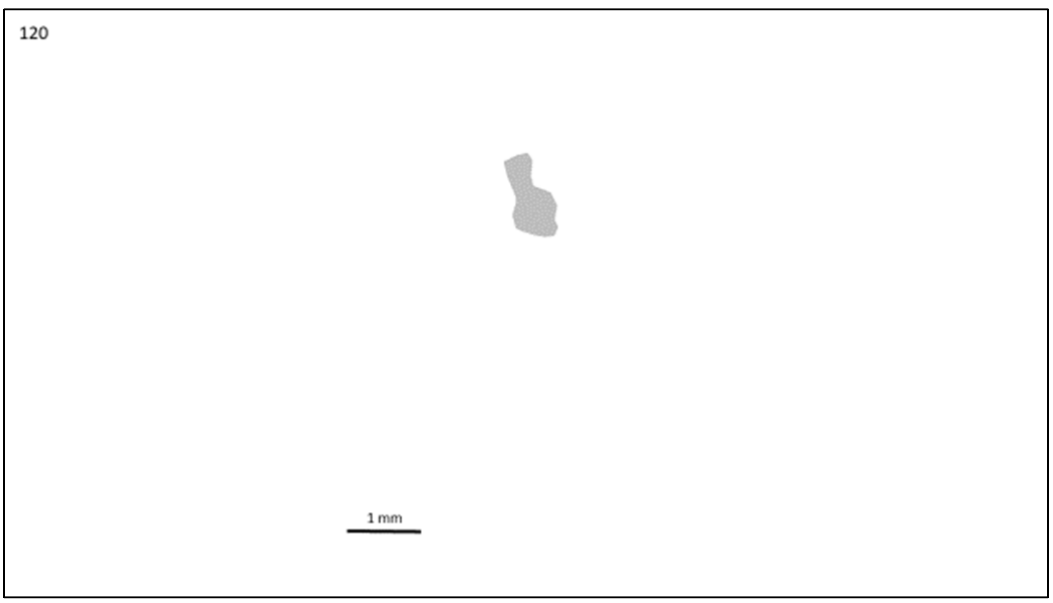
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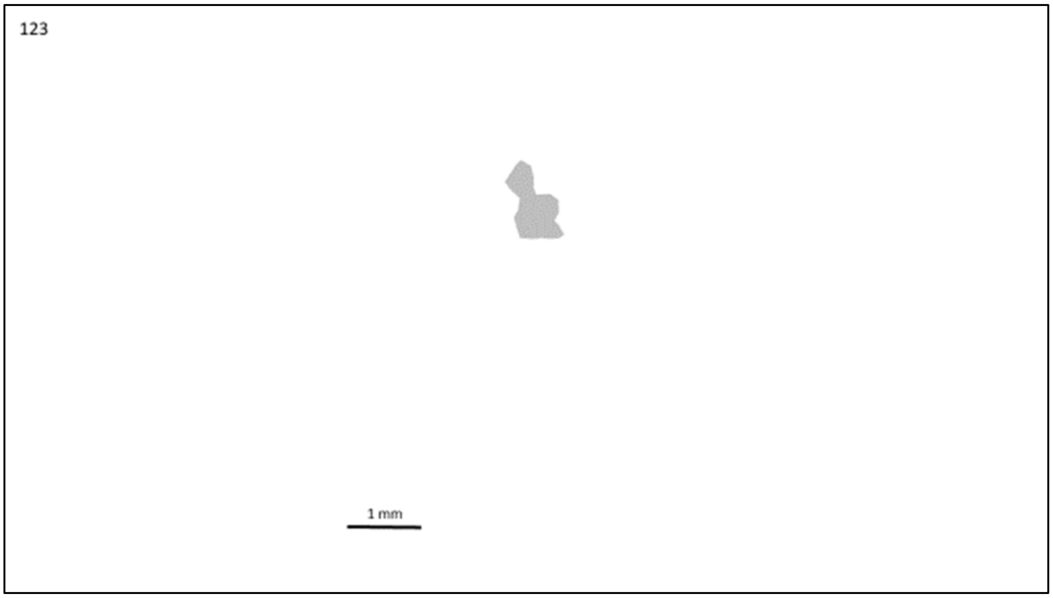

Figure DR5: Image stack of the segmentation of the outer wall (grey) and the open cavity (black) of the multiple branching cloudinomorph. The image stack features the segmentation of images every ten sections, including the first and last section.

Petrography of the cloudinomorph tubes

Cloudinomorph tubes from Omkyk Farm have three distinct cement generations in thin section. The earliest cement is an acicular cement nucleating from the tube wall which is then followed by bladed calcite crystals that are poorly zoned and inclusion rich. The last cement generation is blocky calcite spar (Fig. DR6).

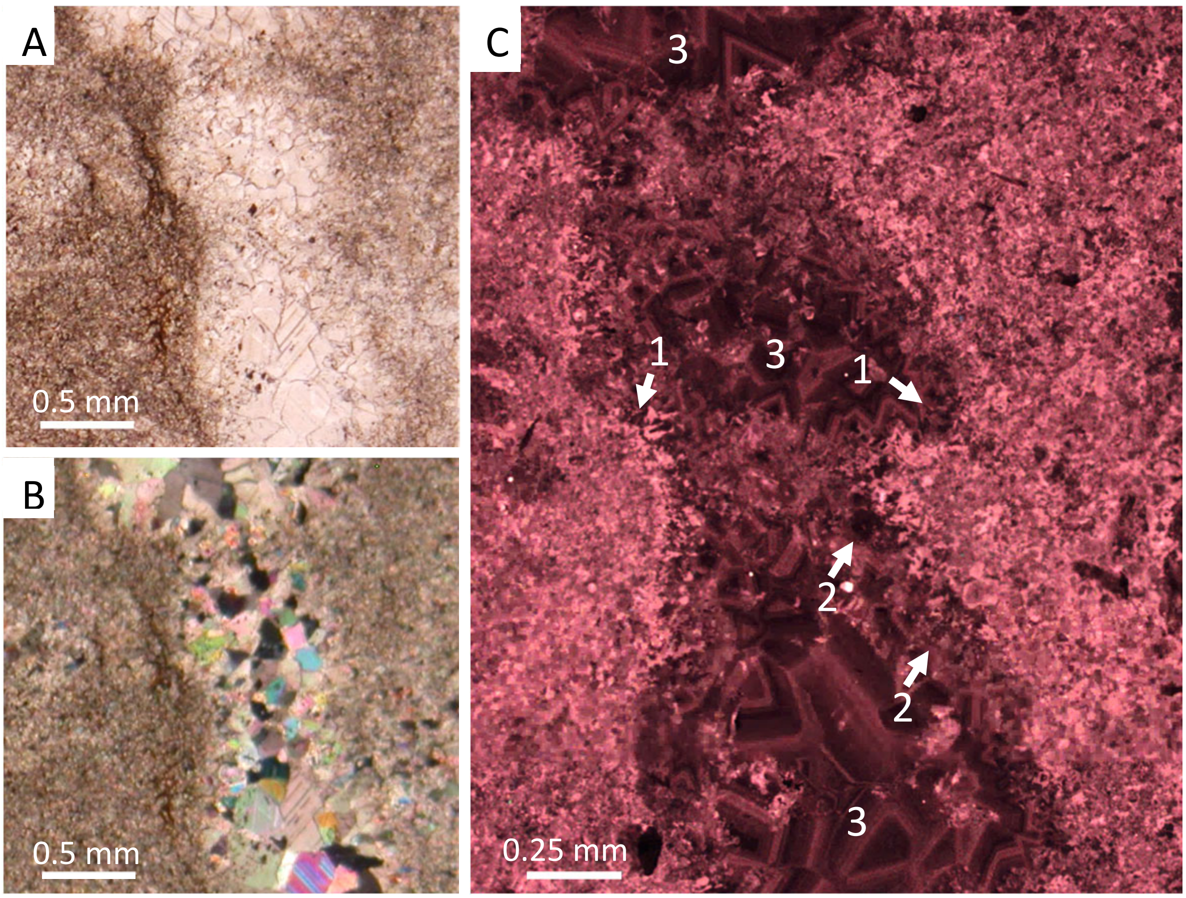

Figure DR6: Photomicrographs of cements within cloudinomorphs from highly polished thin sections. A: Plane polarized light image, B: Cross polarized light image. C: Cathodoluminesent image. Early, fine acicular crystals nucleate from the tube all with dark and bright luminescence (1). Poorly-zoned bladed calcite crystals formed after the early acicular cement (2), with well zoned, blocky sparry calcite (3) infills the rest of the cavity.

Measurements were taken of the isopachous cement crust within the parent tube from images of polished sections of the sample during serial sectioning of the multiple branching cloudinomorph, indicating an general narrow range of thickness of crust (Fig. DR7). The isopachous crust is continuous throughout the parent and daughter tubes that share an open cavity (Fig. DR2).

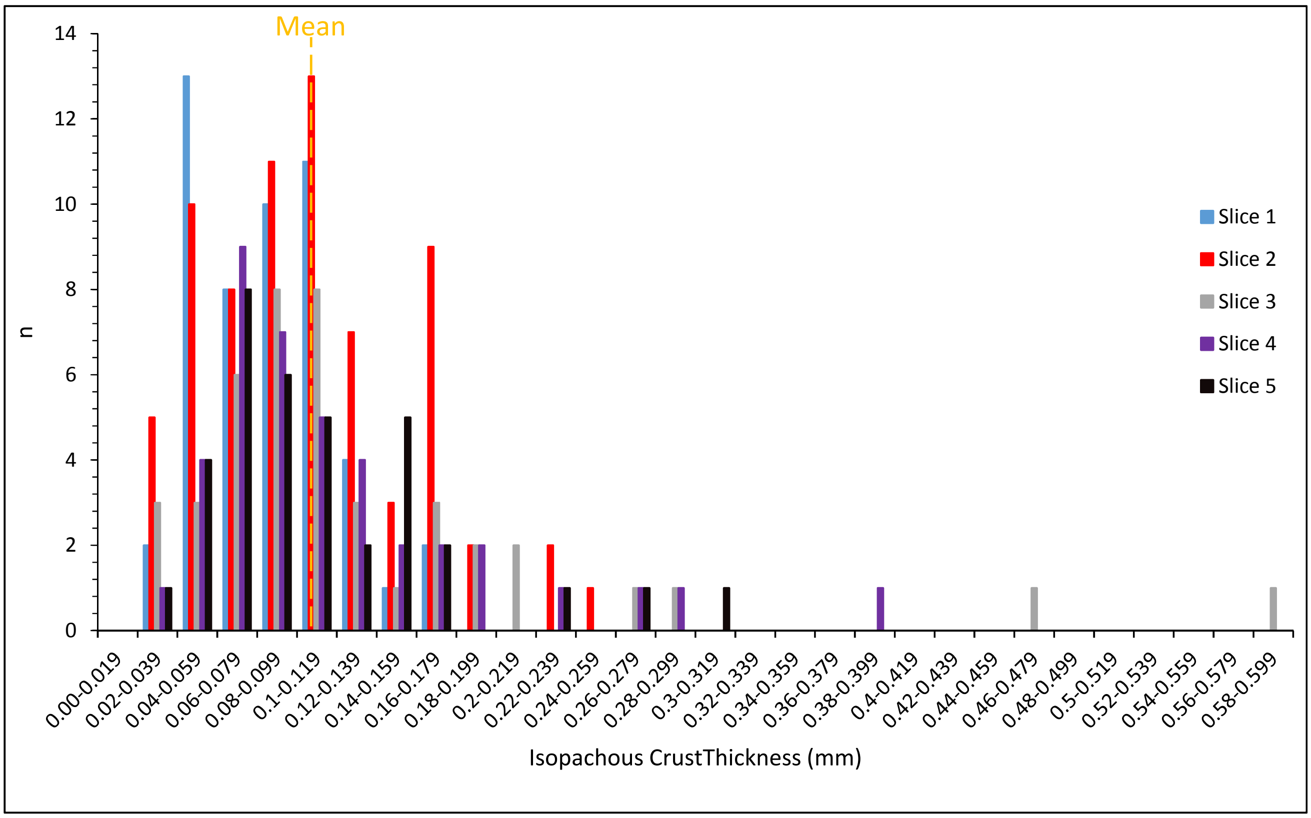

Figure DR7: Thickness of the isopachous crust in the parent tubes measured from 5 slices throughout serial sectioning.

Trend, plunge of cloudinomorph branches and attachments

The branches and the attachment of the multiple branching cloudinomorph model have varying orientations from the parent tube, indicated by the blue arrow in Fig. DR8. The trend ranges from 26.6° to 299.1° (Table DR2). However, the plunge of is consistently low, ranging from 1.3° to 9.0° (Table DR2), with measurements taken from the middle of the tube.

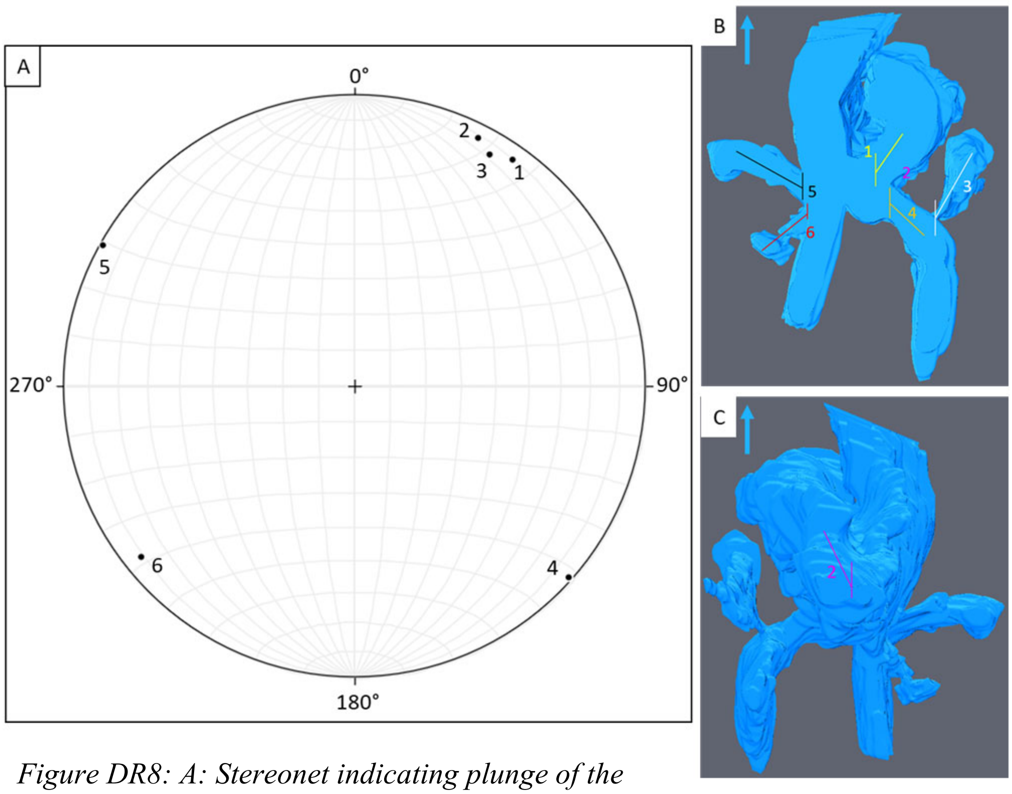

Figure DR8: A: Stereonet indicating plunge of the branches and attachment from the multiple branching cloudinomorph model with the trend taken from the orientation arrow indicated in figures B and C, the orientation of the parent tube. Numbers correspond to the branches and attachment site in B and C. B: Plan view of model with trend lines for each branch or attachment. C: View of underside of the model with trend line for a branch indicated.

Branch/ Attachment	**Trend (°)**	**Plunge (°)**
1	35.1	6.0
2	26.6	5.7
3	30.2	9.0
4	131.8	1.7
5	299.1	1.4
6	231.3	7.1

Table DR2: Trend and plunge of branches at the attachment in the multiple branching model with branch number corresponding to Fig. DR8.