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Acadialithus, a new nannofossil genus from offshore Eastern Newfoundland, Canada

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Abstract A new nannofossil genus, *Acadialithus*, and two new species, *A. dennei* and *A. valentinei* are described from late Tithonian aged sediments of offshore eastern Newfoundland, Canada.

Keywords calcareous nannofossils, taxonomy, new genus, new species, Canada, Newfoundland, Acadialithus, Tithonian

1. Introduction

A new nannofossil genus, *Acadialithus*, and two new species, *A. dennei* and *A. valentinei,* were observed during routine analysis of nannofossil samples from late Tithonian aged sediments from open file exploration wells from offshore eastern Newfoundland, Canada.

2. Materials and methods

Core and ditch-cuttings samples from two exploration wells offshore eastern Newfoundland, Canada were studied for nannofossil biostratigraphy. The two wells are Panther P-52 (UWI 300P524710047300), drilled by Husky and others in 1985–1986, and Baccalieu I-78 (UWI 300I784800046000), drilled by Esso and others in 1985. Standard smear slide techniques (Bown & Young, 1998) were adopted for the preparation of slides, which were analysed using a Zeiss Axiophot microscope at x1250 magnification. The photographs were taken using an Olympus DP-72 digital microscope camera with Olympus CellSens software. The photographs are unprocessed and are presented at 2500x magnification. The samples studied are available in the collection of the Canada Newfoundland and Labrador Offshore Petroleum Board (CNLOPB), in St John's, Newfoundland, Canada (http://cnlopb.nl.ca).

3. Biostratigraphy

The samples studied yielded moderately well preserved (with minor etching and/or overgrowth on most specimens, which did not prevent their identification) and moderately high diversity assemblages. Nannofossil abundance fluctuates from sample to sample, but is generally high (>500 specimens per 100 fields of view). *Watznaueria barnesiae* is the most abundant form recovered. Associated species include *W. fossacincta, Polycostella senaria, Cyclagelosphaera margerelii, Polypodorhabdus escaigii,* small *Nannoconus* spp., *W. britannica* and *W. frequens.* The late Tithonian age is based on the presence of consistent to common *Polycostella senaria* (Bralower *et al*., 1989; Casellato, 2010), which here includes all of the hexaliths with straight-sided (*Hexalithus strictus* Bergen, 1994, junior synonym *H. geometricus* Casellato, 2010), concave (*Polycostella senaria* Thierstein, 1971) or convex (*H. noeliae* Loeblich & Tappan, 1966) element peripheries, in the absence of *Micrantholithus parvistellatus* Varol (1991).

The *Polycostella senaria* group of hexaliths occur from a level in the Tithonian above the base of *P. beckmannii* and range up into the Lower Berriasian (Bralower *et al*., 1989, Bergen, 1994), but are only common in the Upper Tithonian (clearly seen in the distribution charts in Bralower *et al*., 1989). *Micrantholithus parvistellatus* was described by Varol (1991) as common in Lower Berriasian sediments from Irian Jaya in Indonesia. This species has only rarely been recorded since, but is common in the studied sections (along with diverse Lower Berriasian assemblages including *Nannoconus kamptneri kamptneri, Rhagodiscus nebulosus* and *Tranolithus incus*) immediately above where the *P. senaria* group is common.

4. Systematic palaeontology

In this section a new genus *Acadialithus* and two new species *A. dennei* and *A. valentinei* are described.

Acadialithus n. gen.

Derivation of name: *Acadia* (French): parts of the former French colonial empire in Atlantic Canada.
Diagnosis: Nannoliths with a vertical wall made up of two vertically stacked cycles, with six to seven elements in each cycle. A wide central opening is present.
Type Species: *Acadialithus valentinei* n. gen., n. sp.
Description: Calcareous nannofossil having a vertical wall with two cycles which are made up of six to seven elements. No structures were observed in the large central opening. The heights of the two cycles are approximately equal. The elements in the cycles of the wall are vertical to slightly inclined. The elements in the cycles of the wall are roughly L-shaped in plan view, with one end of the elements extending outward to form a lateral projection of the element, where two elements are joined. In plan view, the lateral projections of each element in the upper cycle project at the opposite end of each element, compared to the lateral projections of the underlying elements of the lower cycle (see Figure 1 and Plate 2).

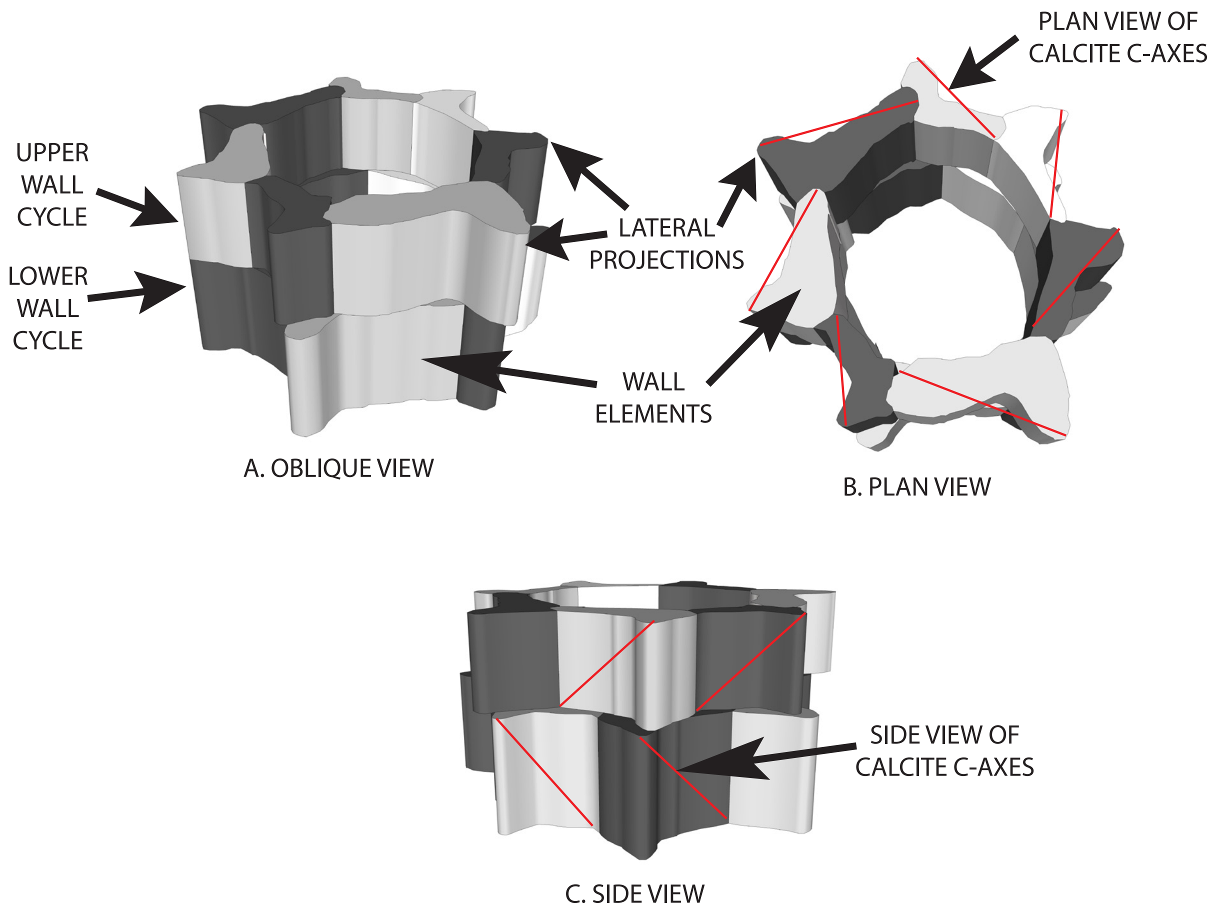

Figure 1: Schematic model of *Acadialithus valentinei* n.gen, n. sp. to illustrate the authors understanding of the structure of the genus. **A**. Oblique view, showing the upper and lower cycles of wall elements and the lateral projections present on each wall cycle element. **B**. Plan view, showing the interpreted orientation of the calcite c-axes of the elements in the upper wall cycle. **C**. Side view, showing the interpreted orientation of the calcite c-axes of the elements in the upper and lower wall cycles

From plan view observations with a quartz plate, the c-axes of the calcite crystal comprising each element are oblique at an angle of ~30° to the long axis of the element (Figure 1). This is clearly demonstrated in the specimen shown in Pl. 1, figs 19–20, and Pl. 2, figs 1–2 (all of the same specimen). This specimen has an isolated single cycle of *A. valentinei* n. sp. seen in plan view. The elements in this specimen, which are dark under crossed-polarising light (labelled "A" in Pl. 2, figs 1–2), are not parallel to the polarising axes (as they would be if the c-axes in these elements were tangential) but at an angle of ~30°. The species of the genus are identified based on the number of elements in each cycle.

Remarks: The oblique orientation of the calcite c-axes of the wall elements in plan view is very unusual, being unlike most heterococcoliths, which have radial to sub-radial distribution of c-axes in plan view, and unlike most nannoliths, which have tangential to sub-tangential c-axes in plan view. The unusual c-axis orientation of *Acadialithus* suggests that it is unlikely to be closely related to either heterococcoliths or to the major Upper Jurassic to Lower Cretaceous nannolith groups, such as the families Nannoconaceae, Braarudosphaeraceae and Polycyclolithaceae.

Acadialithus differs from members of the family Polycyclolithaceae by the orientation of the wall elements, and in the absence of a diaphragm. Both cycles in species belonging to the Polycyclolithaceae are made up of elements with tangential c-axes in plan view, in contrast to *Acadialithus,* where the elements in both cycles have oblique c-axes in plan view. No members of the family Polycyclolithaceae are known from the Berriasian or older.

The families Braarudosphaeraceae and Nannoconaceae both feature radial elements with tangential c-axes in plan view. Both families feature multiple cycles of stacked elements in plan view, unlike the two cycles seen in *Acadialithus*. *Acadialithus* is distinguished from the superficially similar Lower Cretaceous genus *Trapezopentus* Wind & Čepek (1979) by having two cycles of elements and a hexagonal or heptagonal outline in plan-view. The latter genus has a single-cycle wall and is strongly pentagonal in shape. Moreover, no lateral projections were noted in the elements in *Trapezopentus* Wind & Čepek (1979), as are seen in *Acadialithus*. With no clear affinities to any known coccolith or nannolith families, it is possible that *Acadialithus* is the only member of an extinct family.

Acadialithus has been observed in Upper Tithonian sediments from offshore eastern Newfoundland, Canada (this study), from the Baltimore Canyon area, offshore of the northeast coast of the United States (Valentine, 1980), offshore in the eastern Gulf of Mexico (Rich Denne, Jim Pospichal pers. comm.), and from the Pernik District of Bulgaria (Sinnyovsky, 2005).

Acadialithus dennei n. gen., n. sp.
Pl. 1, figs 1–14; Pl. 2, figs 9–16

Brachiolithus? sp. "hexagonal form" Valentine (1980), plate 2, fig. 2

Genus et species indet. Sinnyovsky (2005), plate 2, figs 26–28

Derivation of name: In honor of nannofossil specialist Richard Denne, Texas Christian University, Dallas, Texas, USA, who has observed this species offshore in the eastern Gulf of Mexico.

Diagnosis: A species of *Acadialithus* having six elements in each cycle of the wall.

Holotype: Pl. 1, figs 1–2.

Paratype: Pl. 1, figs 3–4.

Type Level: Upper Tithonian.

Type Locality: Panther P-52 exploration well, cuttings sample at 2780–2790m, Jeanne d'Arc Basin, offshore east coast of Canada.

Dimensions of holotype: Maximum diameter (including lateral projections) = 8.8μm. Diameter of the central opening = 3.6μm. Width of the wall = 2.6μm.

Remarks: *Acadialithus dennei* n. gen., n. sp. differs from *A. valentinei* n. sp. by having six elements in each cycle of the wall, rather than the seven elements of *A. valentinei.* Valentine (1980) recorded both *A. dennei* and *A. valentinei* n. sp. as a "common constituent" (Valentine, 1980, p. 74) from samples (12,700 to 13,240') that he regarded as Berriasian. This interval also contains *Polycostella senaria*, so it is here regarded as Upper Tithonian. Unfortunately, Valentine (1980) did not present a detailed distribution chart for the COST B-3 well. Sinnyovsky (2005) records both *A. dennei* and *A. valentinei* n. sp. as common from sample Be 263, near the top of the Upper Tithonian.

Acadialithus valentinei n. gen, n. sp.
Figure 1; Pl. 1, figs 15–20; Pl. 2, figs 1–6

Brachiolithus? sp. "septagonal form" Valentine (1980), plate 2, fig. 1

Genus et species indet Sinnyovsky (2005), plate 2, fig 29

Derivation of name: In honor of nannofossil specialist Page C. Valentine, United States Geological Survey, California, USA, who figured specimens of *Acadialithus dennei* n. sp. and *A. valentinei* in Valentine (1980).

Diagnosis: A species of *Acadialithus* with seven elements in each cycle of the wall.

Holotype: Pl. 1, figs 15–16.

Paratype: Pl. 1, figs 17–18.

Type Level: Upper Tithonian.

Type Locality: Baccalieu I-78 exploration well, 3287.18m, offshore eastern Newfoundland, Canada.

Dimensions of holotype: Maximum diameter (including lateral projections) = 8.0μm. Diameter of the central opening = 4.4μm. Width of the wall = 1.8μm.

Remarks: *Acadialithus valentinei* has seven elements in each cycle of the wall rather than the six elements of *A. dennei* n. sp.

5. Discussion

It is intriguing that a large and distinctive nannofossil, which can be present in high abundance (1–5 specimens per field of view at 1000x), and with a broad geographic distribution, has been so rarely recorded previously, despite many detailed nannofossil studies of the Upper Tithonian interval (Thierstein, 1973, Roth, 1983, Roth *et al*., 1983, Rahman & Roth, 1991, Bralower *et al*., 1989, Casellato, 2010, Bergen *et al*., 2013). The fact that *Acadialithus* has been recorded in the Upper Tithonian in the Atlantic Ocean basin, in the high-latitude, cool surface-water of offshore Newfoundland area, the mid-latitude Baltimore Canyon area, and the low-latitude, warm surface-water eastern Gulf of Mexico suggests that the genus does not have a strongly temperature-controlled distribution.

With the intensive study given to the Tithonian/Berriasian boundary interval in Deep Sea Drilling Project Hole 534A, offshore Florida (Roth, 1983, Roth *et al*., 1983, Bergen, 1994, Bralower *et al*., 1989, Rahman & Roth, 1991, Casellato, 2010, Bergen *et al*., 2013), if *Acadialithus* is present in this well, it must be extremely rare, or more likely, absent. As *Acadialithus* has a short range within the late Tithonian, the absence of any species of this genus in DSDP Hole 534A suggests that there may be missing section in the Upper Tithonian in this well. This missing section may be widespread throughout the Atlantic Ocean basin.

6. Acknowledgements

I am grateful to Richard Denne (Texas Christian University, Dallas, USA), Robert Campbell (Shell, Houston, USA), Jim Bergen (Paleo in the Hill Country, Brenham, USA), Kevin Cooper (RPS Energy, UK), Kristalina Stoykova (Bulgarian Academy of Sciences, Bulgaria) and Jim Pospichal (Bugware, Tallahassee, USA) for helpful discussions on the taxonomy and biostratigraphy of *Acadialithus.* I'm also very grateful to Paul Bown and Emanuela Mattioli for their constructive reviews.

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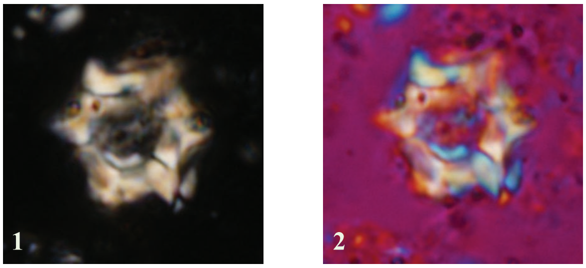
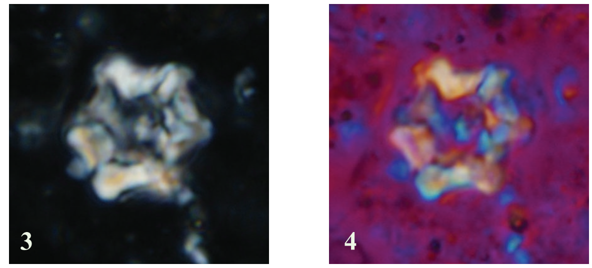
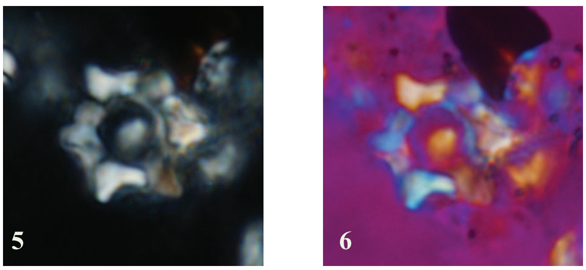
Plate 1



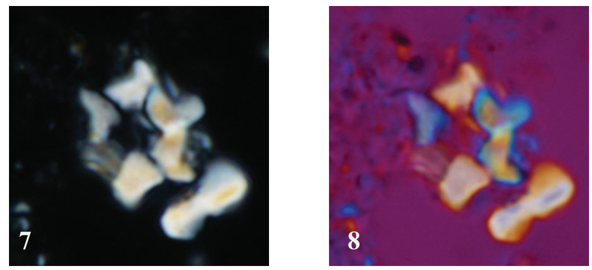
1-2. *Acadialithus dennei* n. sp. Holotype
Panther P-52 2780-90m



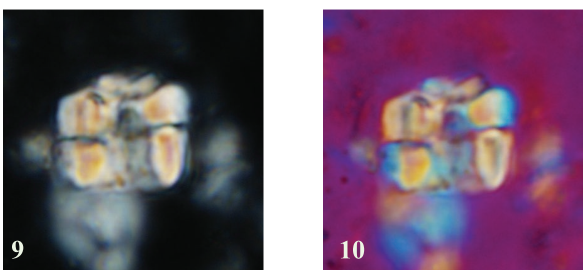
3-4. *A. dennei* n.sp. Paratype
Panther P-52 2780-90m



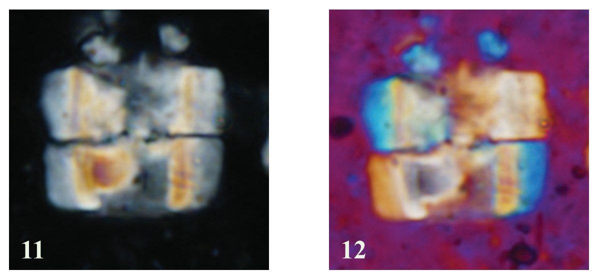
5-6. *A. dennei* n.sp.
Panther P-52 2780-90m



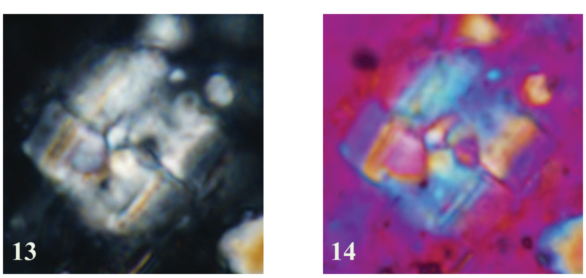
7-8. *A. dennei* n.sp.
Panther P-52 2780-90m



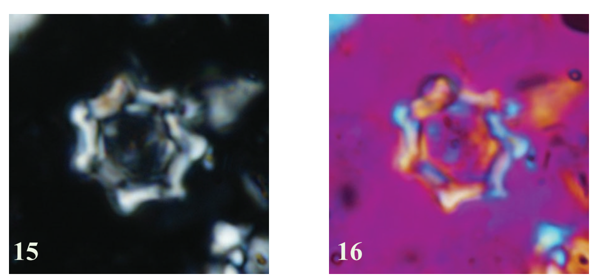
9-10. *A. dennei* n.sp. side view
Panther P-52 2780-90m



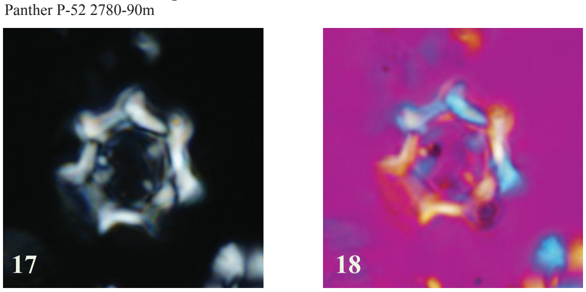
11-12. *A. dennei* n.sp. side view
Panther P-52 2780-90m



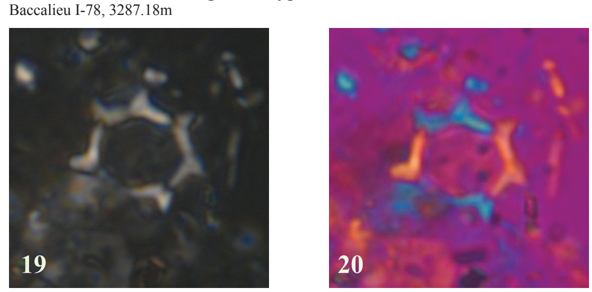
13-14. *A. dennei* n.sp. side view
Panther P-52 2780-90m



15-16. *A. valentinei* n. sp. Holotype
Baccalieu I-78, 3287.18m



17-18. *A. valentinei* n. sp. Paratype
Baccalieu I-78, 3287.18m

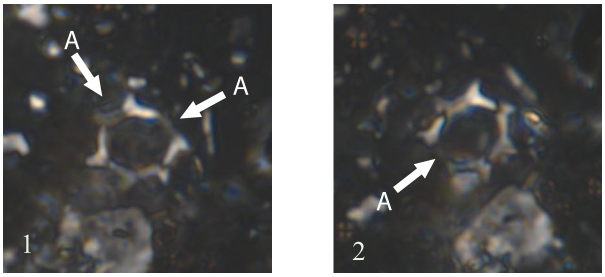


19-20. *A. valentinei* n. sp. Isolated single cycle
Baccalieu I-78, 3287.18m

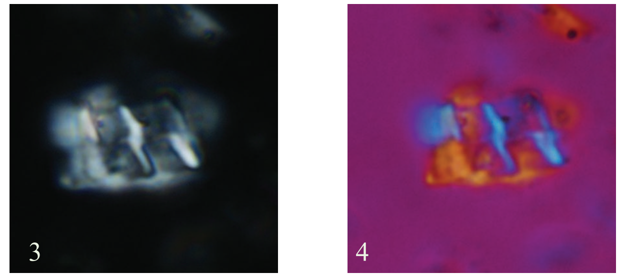
10um
all photos 2500x

Plate 1: Light microscope photographs. PL = plain light; XPL = cross-polarised light; QPL = cross-polarised light with quartz plate. Columns 1, 3 in XPL. Columns 2, 4 in QPL

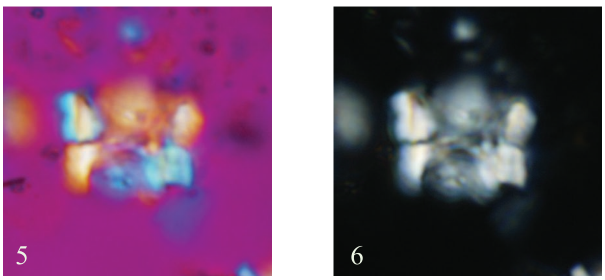
Plate 2



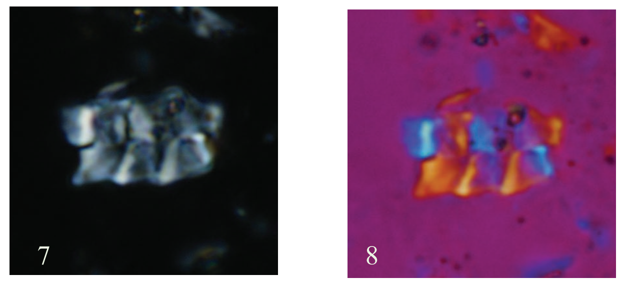
1-2. *A. valentinei* n. sp. Isolated single cycle (same specimen as Pl. 1, figs 19-20). Dark elements labelled "A"). Baccalieu I-78, 3287.18m



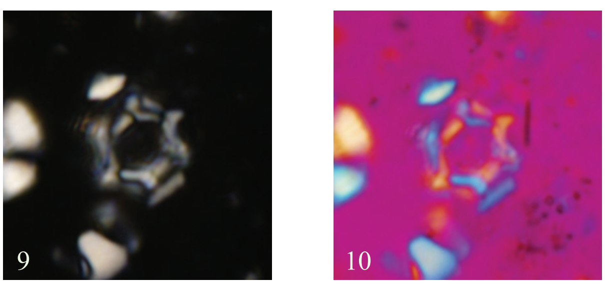
3-4. *Acadialithus valentinei* n. sp. side view
Baccalieu I-78, 3287.18m



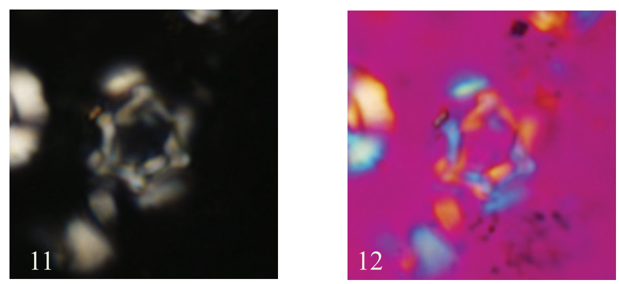
5-6. *Acadialithus valentinei* n. sp. side view
Baccalieu I-78, 3287.18m



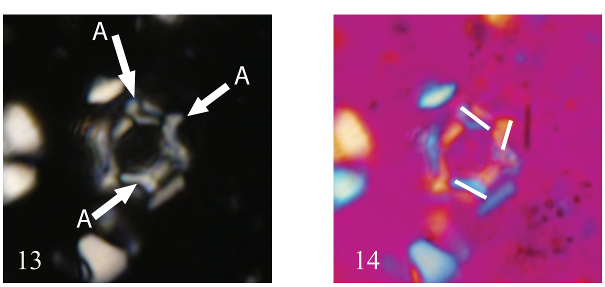
3-4. *A. valentinei* n. sp. side view
Baccalieu I-78, 3287.18m



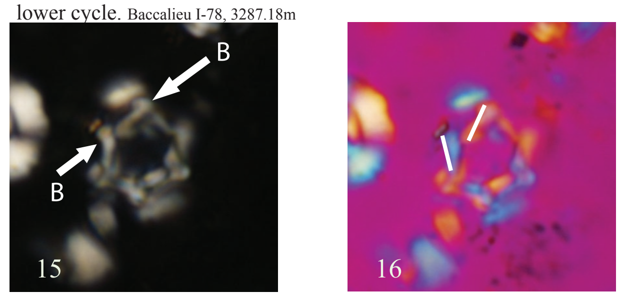
9-10. *Acadialithus dennei* n. sp. Focus on upper cycle
Baccalieu I-78, 3287.18m.



11-12. *A. dennei* n.sp. (same specimen as figs 9-10). Focus on lower cycle. Baccalieu I-78, 3287.18m



13-14. *A. dennei* n.sp. (same specimen as figs 9-10).
Focus on upper cycle. Elements clearly belonging to upper cycle labelled "A" on fig. 13, plan view orientation of c-axes labelled on fig. 14. Baccalieu I-. 78, 3287.18m



15-16. *A. dennei* n.sp. (same specimen as figs 9-10).
Focus on lower cycle. Elements clearly belonging to upper cycle labelled "B" on fig. 15, plan view orientation of c-axes labelled on fig. 16. Baccalieu I-78, 3287.18m

10um

all photos 2500x

Plate 2: Light microscope photographs. PL = plain light, XPL = cross-polarised light, QPL = cross-polarised light with quartz plate. Figs 1–3, 6–7, 9, 11, 13, 15 in XPL. Figs 4–5, 8, 10, 12, 14, 16 in QPL