Leary, R.J., Umhoefer, P., Smith, M.E., Smith, T.M., Saylor, J.E., Riggs, N., Burr, G., Lodes, E., Foley, D., Licht, A., Mueller, M.A., and Baird, C., 2020, Provenance of Pennsylvanian–Permian sedimentary rocks associated with the Ancestral Rocky Mountains orogeny in southwestern Laurentia: Implications for continental-scale Laurentian sediment transport systems: Lithosphere, https://doi.org/10.1130/L1115.1. **GSA Data Repository Item 2020103**

# Fusulinid Biostratigraphy of Ryan Leary Samples from Mescal Mountains, Southern Arizona

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## INTRODUCTION

Ryan Leary (University of Northern Arizona) submitted ten thin-sections from three fusulinid samples for biostratigraphic analysis. Samples were from two nearby sections (sections 1PL and 2PL) from the Mescal Mountains in southern Arizona. Photomicrographs of the fusulinids in the thin-sections are included with this report. Sample numbers on the thin-sections are listed below.

<u>Mescal Mts, Arizona</u>
(1 PL = section, 514 = meters above base of section, A= sample)
1PL-514-A
1PL-514-B
1PL-514-C
1PL-515-D
1PL-492-A
1PL-492-B
1PL-492-C
2PL-89-A
2PL-89-B
2PL-89-C

## NOTE ON CURRENT PENNSYLVANIAN-PERMIAN (VIRGILIAN-WOLFCAMPIAN) BOUNDARY

Of significance to this project is the recent upward shifting of the Pennsylvanian-Permian boundary. According to IUGS conodont biostratigraphy of the Eurasian global boundary stratotype, the base of the Permian (Wolfcampian) is currently placed at the first basal occurrence of the conodont *Streptognathodus isolatus*. That horizon was first correlated into the North American Midcontinent at the contact between the Glenrock Limestone and Bennett Shales members of the the Red Eagle Limestone in Kansas. As a result of that correlation, the North American interval traditionally considered to be early Wolfcampian (earliest Permian) is now transferred to the latest Virgilian (latest Pennsylvanian). In the Permian Basin of west Texas and New Mexico, the systemic boundary was raised from the base of the so-called Bursum interval to the top of that interval. The orphaned interval is commonly referred to informally as the "Bursumian" or the "Newwellian". Some authors have not accepted this

boundary shift (e.g., Wilde, 2006). Wahlman (2013, 2019) discusses this chronostratigraphic boundary shift in more detail, particularly as relates to fusulinid biostratigraphic zones.

## MESCAL MOUNTAINS, SOUTHERN ARIZONA

### Samples

The Mescal Mountains are about 80 miles ESE of Phoenix, Arizona. Ten thin-sections from three fusulinid samples from the Horquilla Limestone were submitted.

Two fusulinid samples from measured section 1PL were taken at 492 meters and 514 meters above the base of the section. A sandstone unit slightly higher in the section at 532 meters was mapped as being in the Horquilla Limestone, but Leary says that it is similar to Earp Formation sandstone units seen elsewhere in the region. Leary submitted the fusulinid samples in order to determine if the fusulinid age-dates could indicate whether the 532 m sandstone unit is part of the Horquilla Limestone (as it has been mapped), or if it could actually be considered to be in the Earp Formation.

The third Mescal Mts fusulinid sample was from 89 m above the base of section 2PL (2PL-89). According to Leary, the 2PL section is considered to be "directly (and nearly continuously) stratigraphically above 1PL", but the two sections are separated by a fault, which was interpreted in the field to have relatively minor throw (e.g., <10 meters).

### Previous Studies on Fusulinid Biostratigraphy in Southern Arizona

Publications that describe the stratigraphy and fusulinid faunas of the Horquilla Limestone and overlying Earp Formation in southern Arizona and adjacent southwestern New Mexico (Sabins and Ross, 1963; Ross and Tyrrell, 1965; Wilde, 2006) indicate that the lithostratigraphic contact between the Horquilla Limestone and Earp Formation represents a diachronous facies change and should not be used as a chronostratigraphic correlation surface.

Williams (1951 thesis) described some fusulinids from the Naco Limestone (later Naco Group, which contains the Horquilla Limestone and Earp Formation) near Bisbee, Arizona, and cited unpublished fusulinid studies of the area by L.G. Henbest. He illustrated Desmoinesian, Missourian, and Virgilian fusulinids from the section, and cited poorly preserved *Schwagerina* in his uppermost samples. He did not describe or illustrate the supposed *Schwagerina* and so it is impossible to assess if it was a latest Pennsylvanian or Early Permian form.

Zirkle (1952 thesis) described Atokan, Desmoineian, Virgilian, and possible "early Wolfcampian" fusulinids from the Naco Group in the Chiracahua Mountains of southeastern Arizona. No late Desmoinesian or Missourian fusulinids were reported. The uppermost

fusulinids described (*Schwgaerina emaciata* and *S. portalnensis* n. sp.) are both primitive elongate species typical of the "Bursumian" interval that has traditionally been considered early Wolfcampian but is now placed in the latest Virgilian.

Henbest (*in* Gilluly, Cooper and Williams, 1954) listed the following post-Desmoinesian fusulinids from the type area of the Horquilla Limestone and Earp Formation in the Gunnison Hills and Tombstone Hills (the age assignments for the species were assigned here):
<u>Virgilian</u>
*Dunbarinella*? sp.
*Triticites cullomensis*
*Triticites pygmaeus*
*Triticites secalicus*
<u>Latest Virgilian ("Bursumian")</u>
*Schwagerina* cf. *S. longissimoidea*
*Triticites obesus*?
*Triticites ventricosus*
*Triticites* aff. *T. tumidus*
*Triticites* aff. *T. rothi*

Thompson (1954, fig. 12) briefly summarized the Virgilian and early Wolfcampian fusulinids from the Naco Limestone in southern Arizona. In the exposures near Bisbee, he reported typical Naco Limestone overlain by redbeds, which are in turn overlain by a section of thin limestones containing the latest Virgilian ("Bursumian) fusulinids *Triticites meeki* and *Schwagerina grandensis*. In the Swisshelm Mountains, he reported middle Virgilian limestones (*Triticites* sp.) overlain by limestones containing earliest Wolfcampian fusulinids (*Paraschwagerina* cf. *P. kansasensis*, and *Pseudofusulina loringi*).

Sabins and Ross (1963) described the stratigraphy and fusulinids in the Chiricahua Mountains of southeastern Arizona, in much greater detail. Based on fusulinids, they age-dated the upper part of the Horquilla Limestone as Virgilian. They stated that the Virgilian rests unconformably on the Desmoinesian, with the upper Desmoinesian and probably the Missourian missing in that section. The early Virgilian part of the Horquilla Limestone was characterized by *Triticites cullomensis*, *T.* cf. *T. callosus* and *Waeringella chiricahuaensis*. The upper part of the Horquilla Limestone and lowermost part of the Earp Formation contained middle to late Virgilian fusulinids, including *Triticites cuchilloensis*, *T. rhodesi*, *T.* cf. *T. plummeri*, and *T. ventricosus sacramentoensis*. The highest occurrence of that latter fusulinid assemblage is in the lowermost 20 ft of the Earp Formation near Portal, Arizona (their Locality 9), but the assemblage extends to 235 ft above the base of the Earp Formation at Dunn Springs Mountain (their Locality 5). Therefore, they concluded that the Horquilla-Earp contact represents a diachronous facies change and not a time plane. The "Bursumian" part of the section (marked as "post-Virgilian" on their text-fig. 4) contained the fusulinids *Triticites rhodesi*, *T. pinguis*, *T. cellamagnus*, *Schwagerina emaciata*, *S. dunnensis*, *S. silverensis*, and *Rugosofusulina* sp.. Ross and Sabins

(1963, text-fig. 4) also showed that the middle part of the Earp Formation contains early Wolfcampian (Nealian) fusulinids, such as *Schwagerina vervillei*, *S. loringi*, *S. compacta*, *S. providens*, *Pseudoschwagerina uddeni*, and *Ps. portalensis*. The overlying upper part of the Earp Formation is barren of fusulinids. It should be noted that Sabins and Ross (1963, text-fig.4) apparently missed a fault around 1400 ft in their Portal-Locality 9 measured section, as above there is a repitition of the underlying fusulinid assemblage. The fusulinid assemblages suggest that there might actually be a second missed fault higher in the section around 2200 ft.

Ross and Tyrrell (1965) described the stratigraphy and fusulinid faunas of the Horquilla Limestone and Earp Formation in the Whetstone Mountains in southern Arizona, which are located perhaps 60-80 miles to the south of the Mescal Mountains. According to that study in the Whetstone Mountains, the lower Horquilla Limestone is Atokan-Desmoinesian in age, and the upper part of the Horquilla Limestone is Missourian-Virgilian in age. The uppermost part of the Horquilla Limestone and the lower 50-120 ft of the overlying Earp Formation were interpreted to be Virgilian. The uppermost fusulinid sample was "Bursumian" (latest Virgilian) in age. A summary of Ross and Tyrrell's Late Pennsylvanian stratigraphy and fusulinid faunas in the Whetstone Mountains is given below.

<u>Whetstone Mts Late Pennsylvanian Stratigraphy and Fusulinid Faunas</u>

(The footages above base of section from Ross and Tyrrell's (1965, fig. 4) measured section are approximated here.)

<u>Earp Formation</u>

- 1510 ft - Red chert conglomerate at contact between lower and upper members of the Earp Formation.
- 1500 ft - *Triticites southensis* (latest Virgilian, "Bursumian" - formerly considered earliest Wolfcampian - see Wahlman (2013, 2019) for discussion of current Pennsylvanian-Permian boundary).

1170-1500 ft - No fusulinids

1080-1170 ft - Lowermost Earp Formation - *Triticites whetstonensis*, *T. bensonensis*, *T. coronadoensis*, *T. mcgrewensis,* and *Dunbarinella* sp. A (Middle Virgilian)

<u>Horquilla Limestone</u>

1080 ft - Top of Horquilla Limestone

980-1080 ft - Uppermost Horquilla Limestone - *Triticites* cf. *T. plummeri*, *T. callosus, T. coronadoensis* (early middle Virgilian)

850-980 ft - Upper Horquilla Limestone - *T. fresnalensis*, *T. ohioensis* (Missourian)

Wilde (2006) published a large monograph on the fusulinids from the Horquilla Limestone in the Big Hatchett Mountains of southwestern New Mexico. He demonstrated that the Horquilla Limestone ranges in age from the Early Pennsylvanian (Morrowan) through the Early Permian (Wolfcampian). Paleogeographically, the Big Hatchet Mts section is situated near the Late Paleozoic shelf-margin of the Pedregosa Basin to the south. The Wolfcampian age of the uppermost part of the Horquilla Limestone there demonstrates that the upper part of the Horquilla Limestone gets progressively younger downdip toward the shelf margin. It should be noted that Wilde (2006) did not agree with the new conodont-based placement of the

Pennsylvanian-Permian boundary (see discussion in Wahlman (2013, 2019) of the terms "Bursumian" and Newwellian"). Wilde did recognize the fusulinid zone that characterizes the "Bursumian" interval, but he called it the "Newwellian" interval (after the New Well Peak section in the Big Hatchet Mts), and he continued to consider that interval to be earliest Wolfcampian in age as his zone PW-1 from Wilde (1990).

Therefore, previous fusulinid studies in southern Arizona and adjacent southwestern New Mexico indicate the Horquilla-Earp lithostratigraphic contact is progradtional and diachronous, and it cannot be used as a chronostratigraphic marker in the region. Apparently, diachronous facies changes around the Horquilla-Earp contact can occur locally on the flanks of local paleotopographic highs and basins (e.g., Sabins and Ross, 1963), but there is also a regional progradational facies change toward the deep basins to the south. A similar general southward Upper Pennsylvanian-Lower Permian progradational clastic to carbonate facies change is well-known in central and southern New Mexico.

All three fusulinid samples from the Mescal Mountains are age-dated as Virgilian (Late Pennsylvanian), with the uppermost sample (2PL-89) being latest Virgilian ("Bursumian").

## Fusulinid Biostratigraphy of Mescal Mountains Samples

The three Mescal Mountains samples are arranged below in descending stratigraphic order. It should be noted that the fusulinids in these samples form a similar sequence as shown in the Chiracahua Mts chart of Sabins and Ross (1963, text-fig. 4), i.e., in ascending order, *Triticites* cf. *T. cullomensis*, *Triticites plummeri*, and *Schwagerina* aff. *S. dunnensis*. In that Chriacahua Mts chart, the contact between the Horquilla Limestone and Earp Formation is just below the occurrence of *Triticites plummeri*.

### 2PL-89-A, B, C

**Lithology:** Skeletal wackestone-packstone, with common fusulinids, crinoid ossicles, brachiopod and mollusc shell fragments; sparse fenestrate bryozoan fragments, smaller foraminifera (*Globivalvulina*, *Pseudobradyina*, *Tetrataxis*, *Tuberitina*, palaeotextulariids); very sparse smaller fusulinids (*Millerella*, *Eostaffella*).

**Depositional environment:** Normal marine shelf, low to moderate energy.

**Fusulinids:** *Schwagerina* aff. *S. dunnensis* Sabins and Ross, 1963. There are no good axially oriented specimens of fusulinids in these thin-sections, but the fusulinids can be confidently age-dated as Late Pennsylvanian (Virgilian). They are moderate-sized, elongate fusiform morphotypes with rather pointed poles, weak septal fluting, and well-developed chomata. They are transitional forms between *Triticites* and the most primitive species of *Schwagerina*, which characterize the latest Virgilian ("Bursumian"). The fusulinids in this sample are most similar to *Schwagerina dunnensis*, a species described from the Chiracahua Mts by Sabins and Ross

(1963), who stated that it was similar to several Midcontinent "Bursumian" species, such as *Schwagerina longissimoidea*.

**Age:** Latest Virgilian ("Bursumian").

## 1PL-514-A, B, C, D

**Lithology:** Fusulinid-skeletal wackestone with pelleted mud matrix; common fusulinids; moderately common crinoid ossicles and small foraminifera (common *Globivalvulina*, with sparse endothyrids and *Tuberitina*); sparse brachiopods and ostracods.

**Depositional environment:** Normal marine shelf, low to moderate energy.

**Fusulinids:** *Triticites plummeri* Dunbar and Condra, 1927. The *Triticites* in this sample are all characterized by inflated fusiform shells with very thick keriothecal walls, moderate septal fluting, and a small proloculus. They are clearly part of the lineage of *Triticites plummeri*, which is a widely reported middle to late Virgilian species. Sabins and Ross (1963) reported this species from the Chiracahua Mts. The relatively large size and loose coiling of these specimens suggests a late Virgilian age (Myer, 1958; Kauffman and Roth, 1966). Wilde (2006) attempted to subdivide late Virgilian species in this lineage in the Horquilla Limestone of southwestern New Mexico, and the specimens in this sample closely resemble his new late Virgilian (Wilde 1990 zone VC-3, late Virgilian) species *Triticites legatum.*

**Age:** Late Virgilian -

## 1PL-492-A, B, C

**Lithology:** Fusulinid wackestone and packstone, with pelleted mud matrix. Common fusulinids; moderately common fenestrate bryozoan fragments; sparse crinoid ossicles, and brachiopod and mollusc fragments; very sparse smaller foraminifera (*Globivalvulina*, *Tuberitina*, palaeotextulariids).

**Depositional environment:** Normal marine shelf, low energy.

**Fusulinids:** *Triticites* cf. *T. cullomensis* Dunbar and Condra, 1927. Fusulinids in this sample are moderately large fusiform shells, with slightly irregular coiling, sparse and weak septal fluting, and a medium-sized proloculus. They are most similar to *Triticites cullomensis* Dunbar and Condra, 1927, which ranges through the upper part of the Shawnee Group in the Midcontinent region (Wahlman, 2013), but the morphotype has been also reported from early and late Virgilian strata. Sabins and Ross (1963) reported this species from the Chiracahua Mts.

**Age:** Late middle Virgilian

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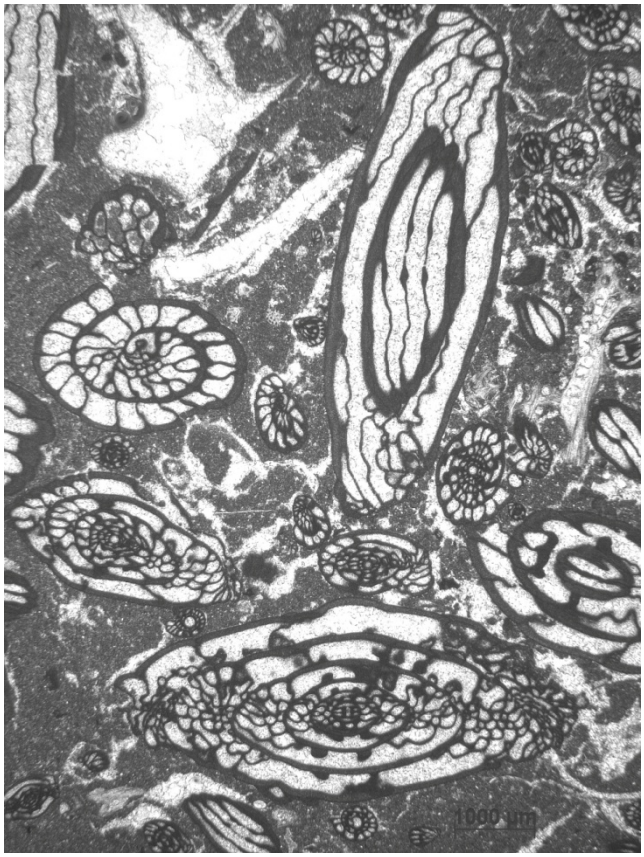
# Samples 1PL-492-A
# Mescal Mountains, Arizona

*Triticites* cf. *T. cullomensis* (late middle Virgilian)

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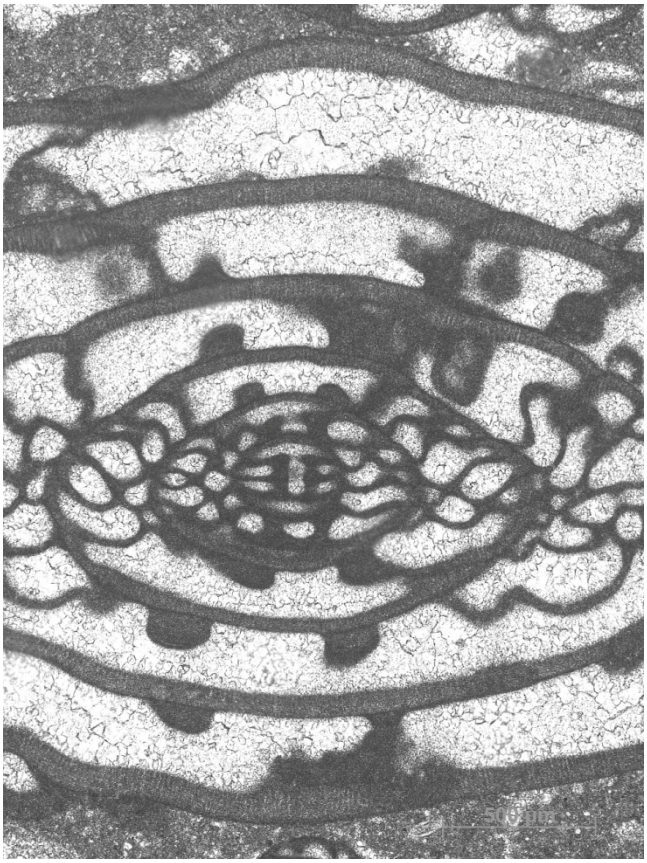

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*G.P. Wahlman, Wahlman Geological Services, LLC, Austin*
*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-492-A
# Mescal Mountains, Arizona

*Triticites* cf. *T. cullomensis* (late middle Virgilian)

X10

X10

X10

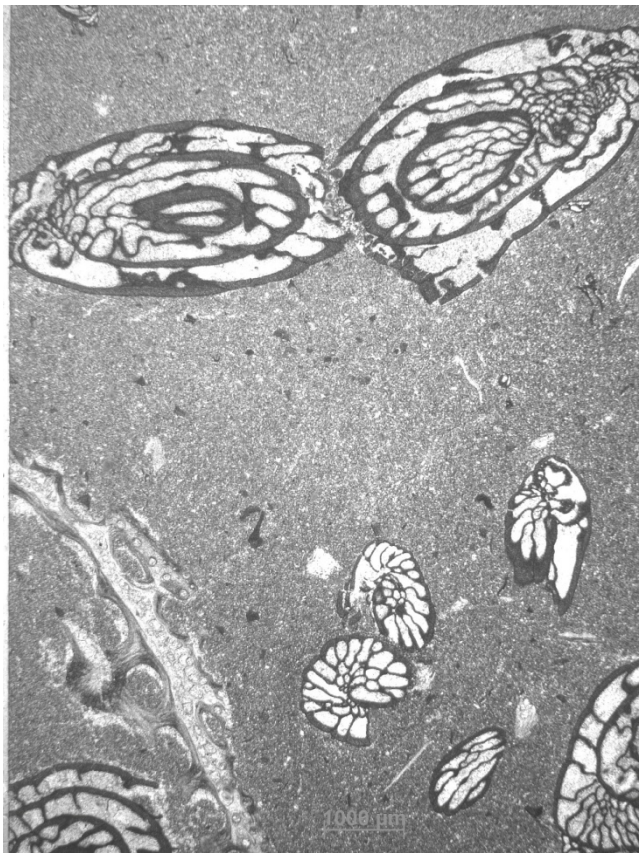
*G.P. Wahlman, Wahlman Geological Services, LLC, Austin*
*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-492-B
# Mescal Mountains, Arizona

*Triticites* cf. *T. cullomensis* (late middle Virgilian)

X10

X10




X10

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*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-492-C
# Mescal Mountains, Arizona

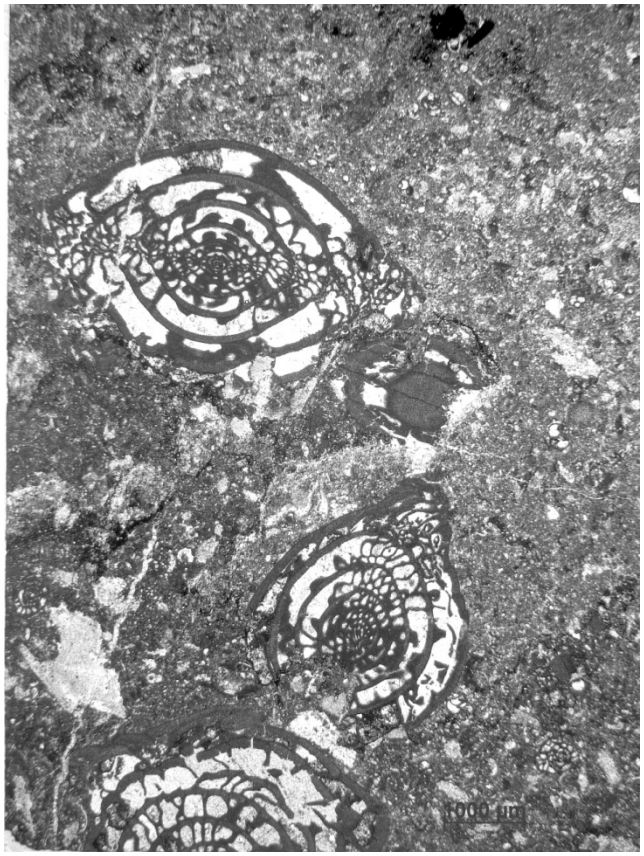
*Triticites* cf. *T. cullomensis* (late middle Virgilian)

X10

*G.P. Wahlman, Wahlman Geological Services, LLC, Austin*
*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-514-A
# Mescal Mountains, Arizona

*Triticites cf. T. plummeri* (LateVirgilian)



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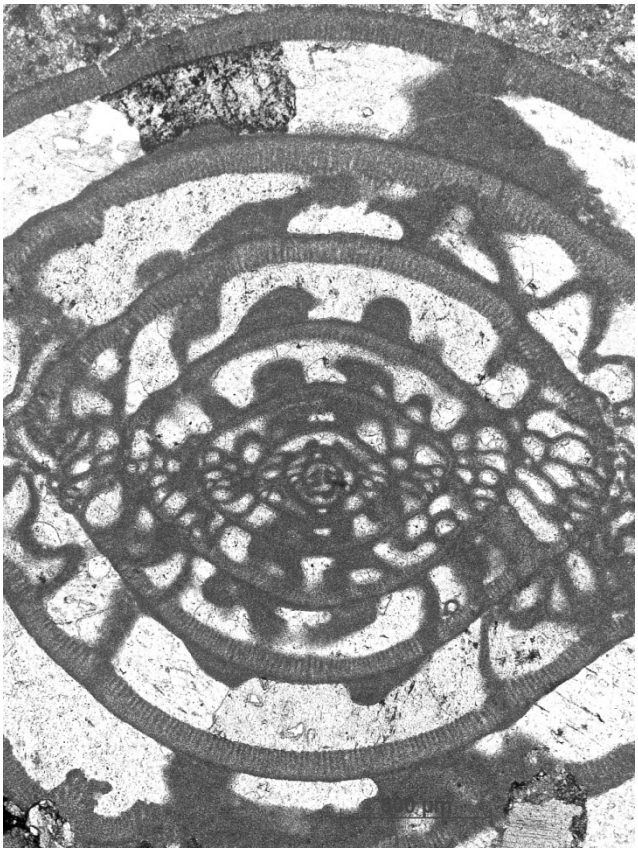

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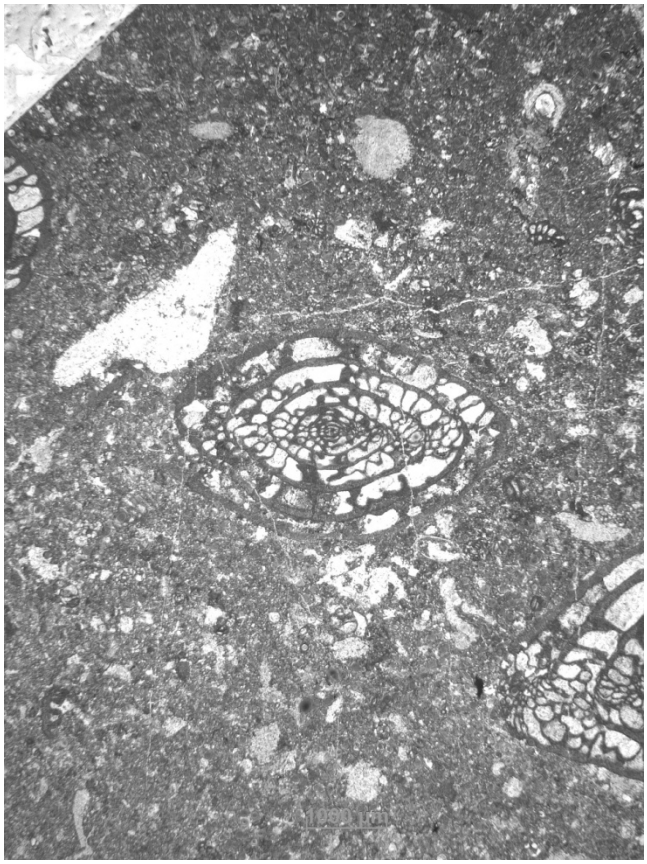
*G.P. Wahlman, Wahlman Geological Services, LLC, Austin*
*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-514-B
# Mescal Mountains, Arizona

*Triticites cf. T. plummeri* (LateVirgilian)



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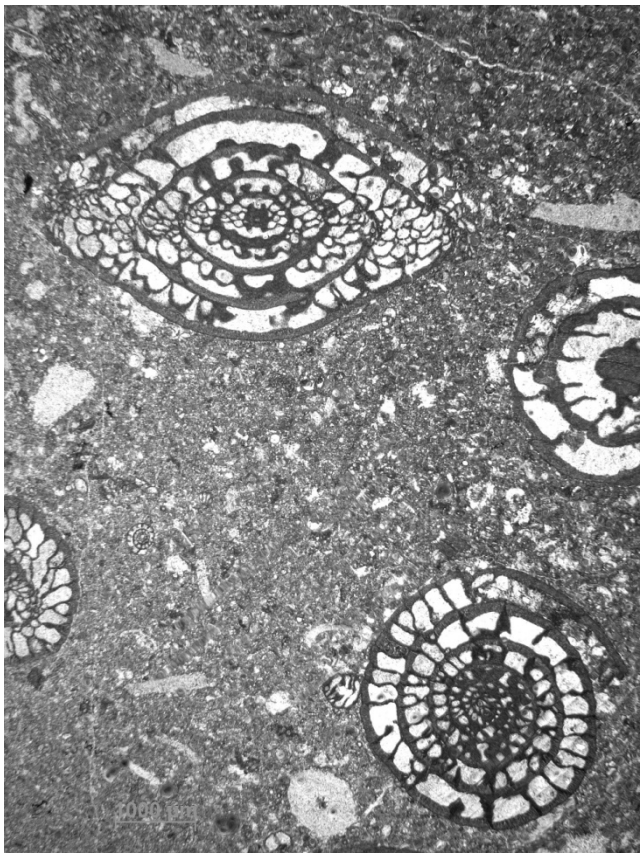

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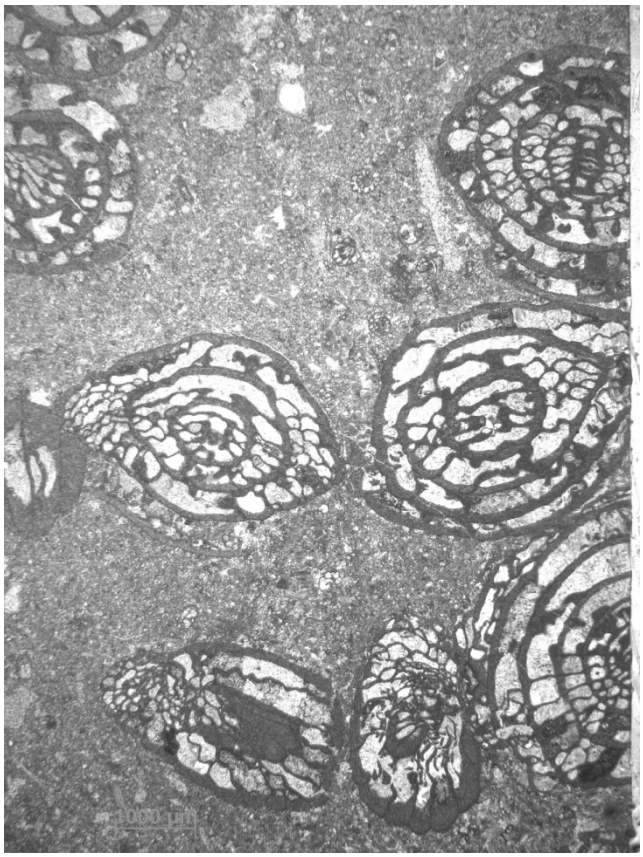

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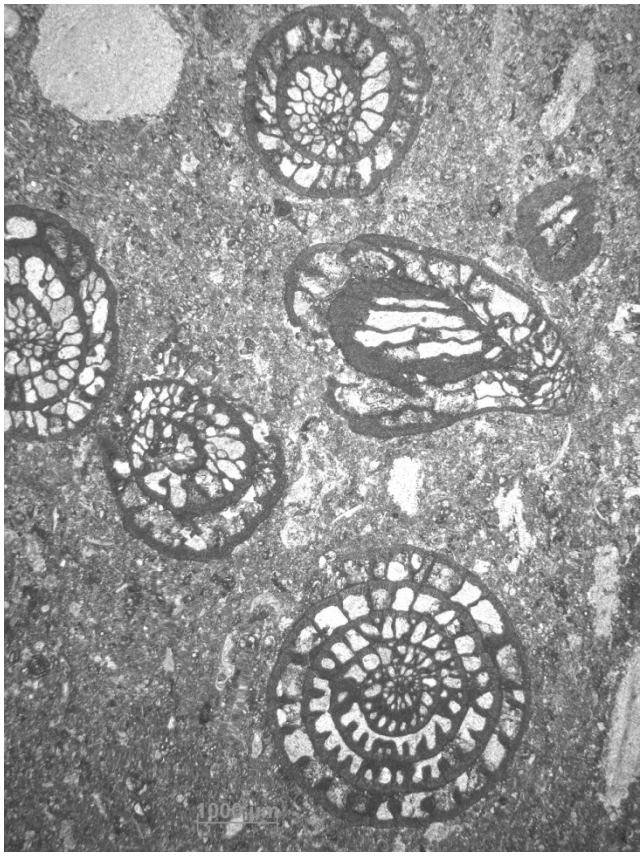
*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-514-C
# Mescal Mountains, Arizona

*Triticites cf. T. plummeri* (LateVirgilian)



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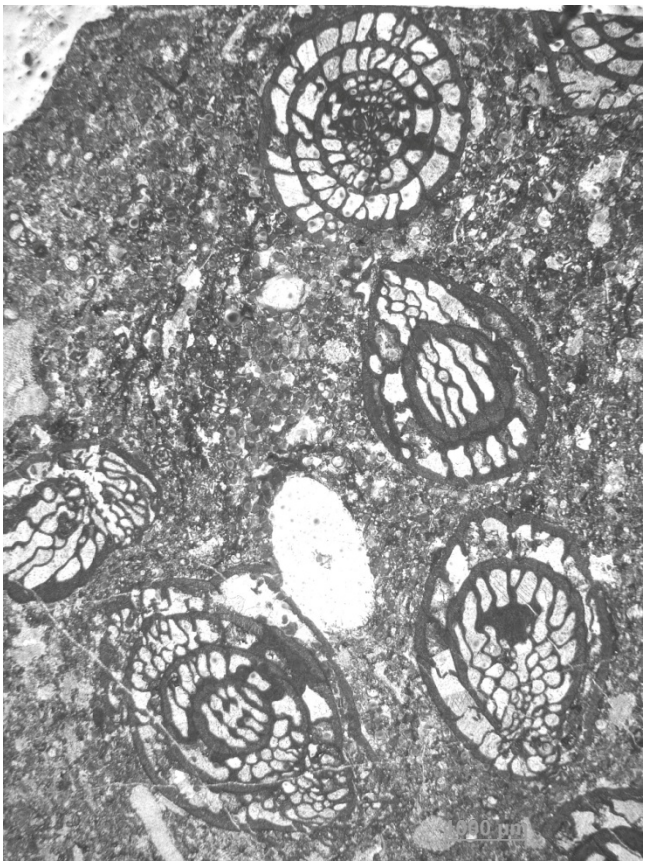

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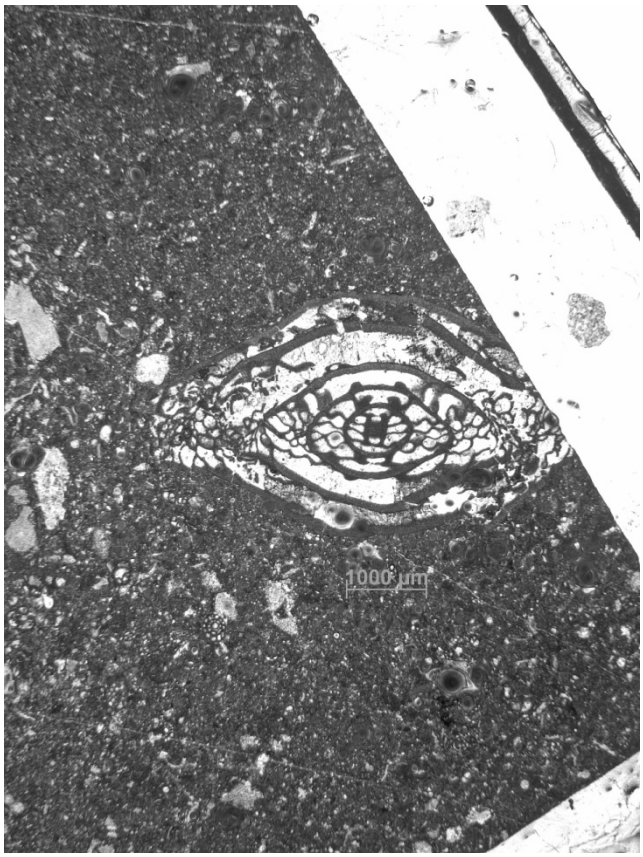
*(For Ryan Leary , University of Northern Arizona)*

# Samples 1PL-514-D
# Mescal Mountains, Arizona

*Triticites cf. T. plummeri* (LateVirgilian)

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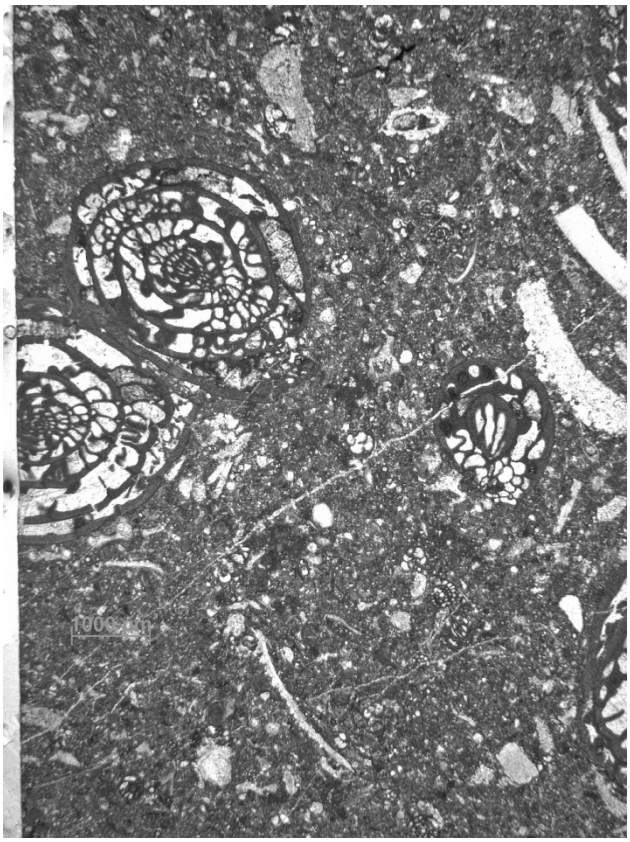

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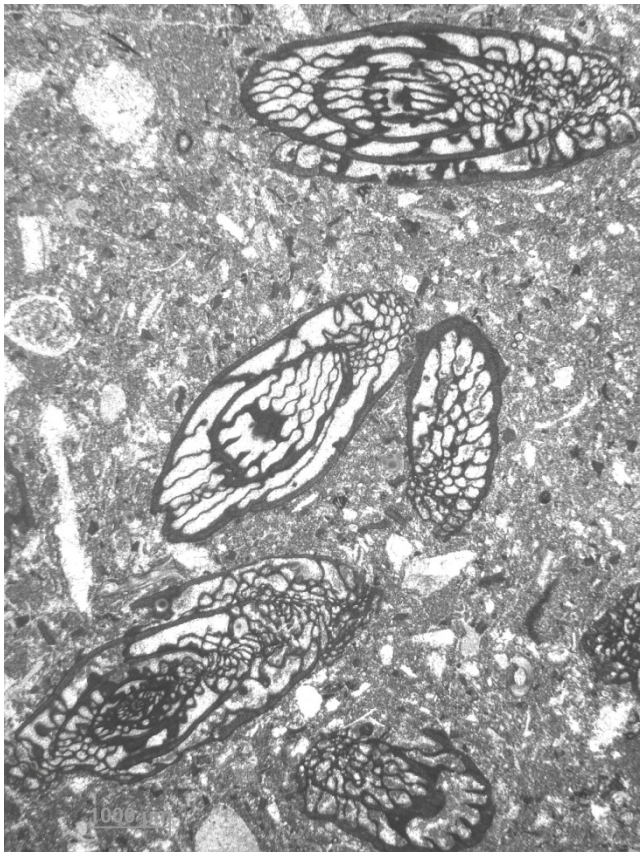
# Samples 2PL-89-A
# Mescal Mountains, Arizona

*Schwagerina* aff. *S. dunnensis*



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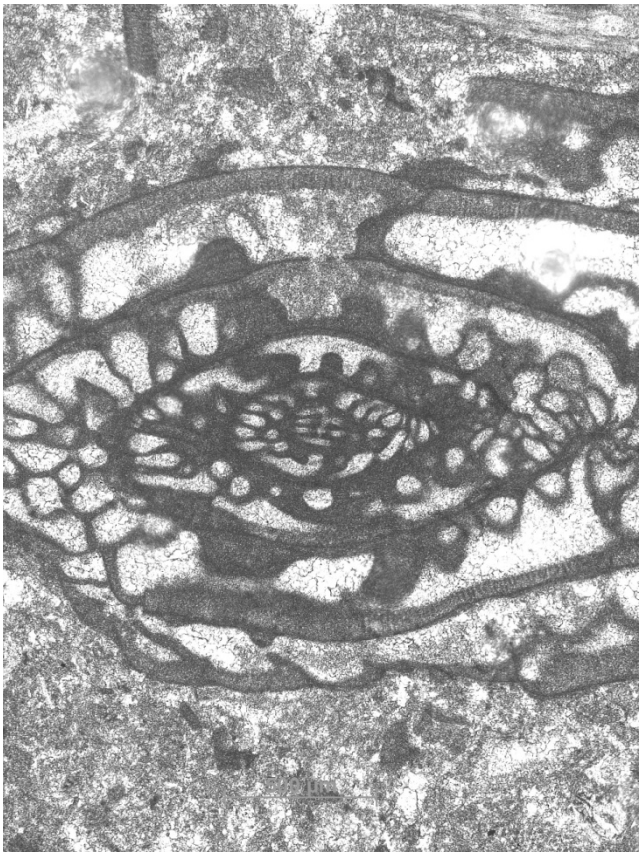

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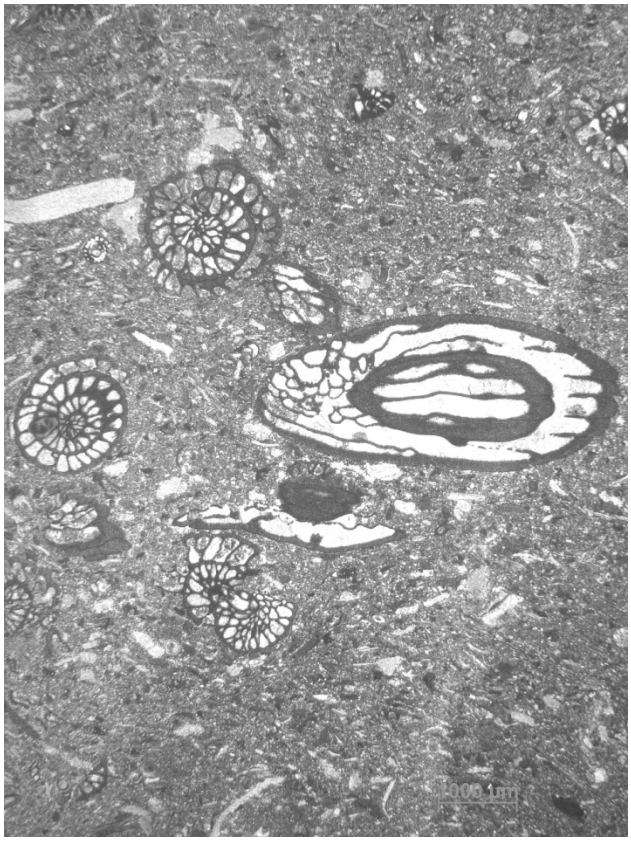

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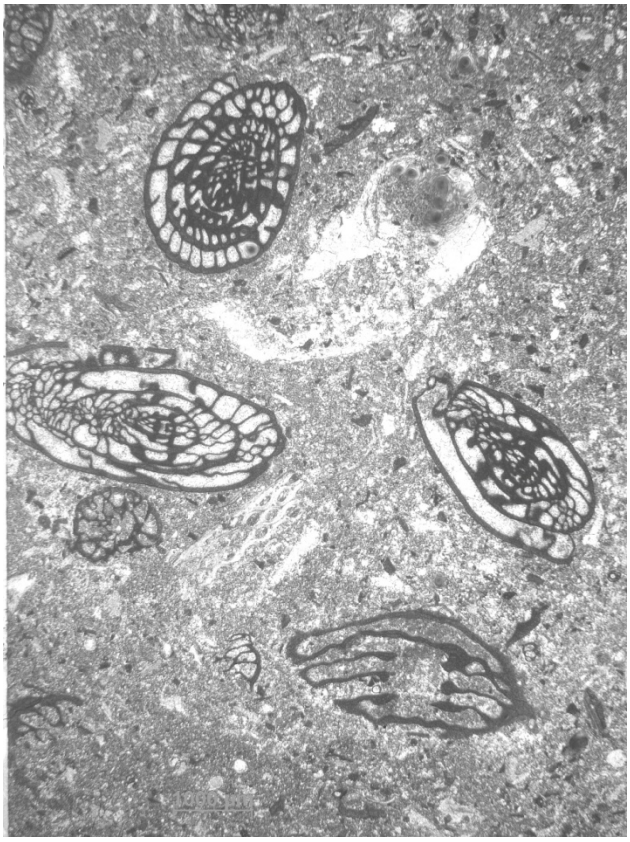

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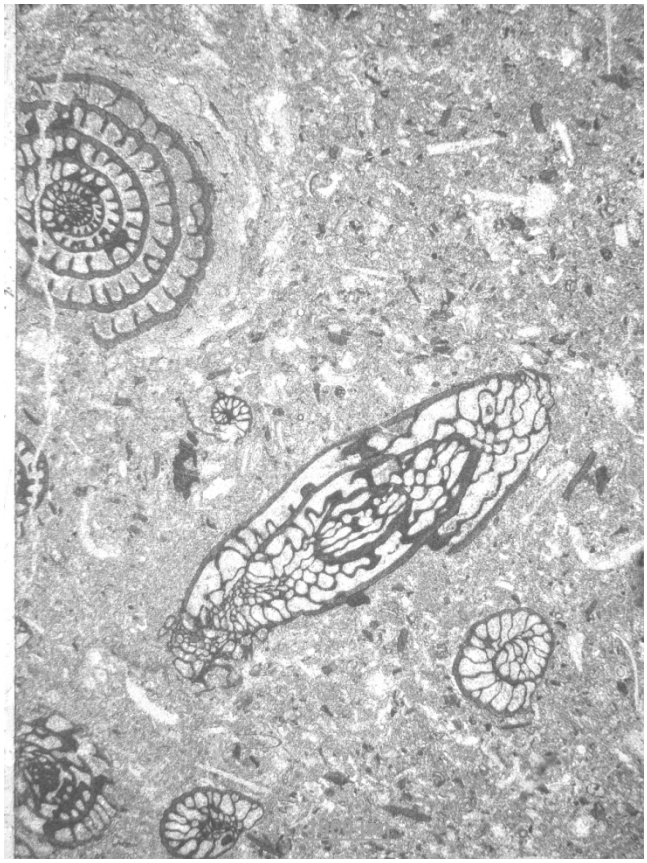
# Samples 2PL-89-B
# Mescal Mountains, Arizona

*Schwagerina* aff. *S. dunnensis*



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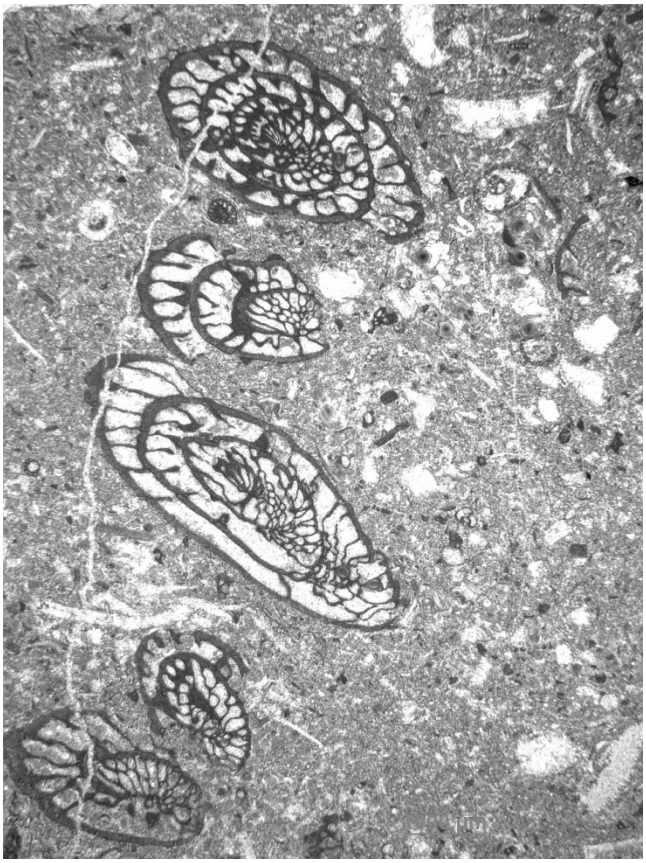

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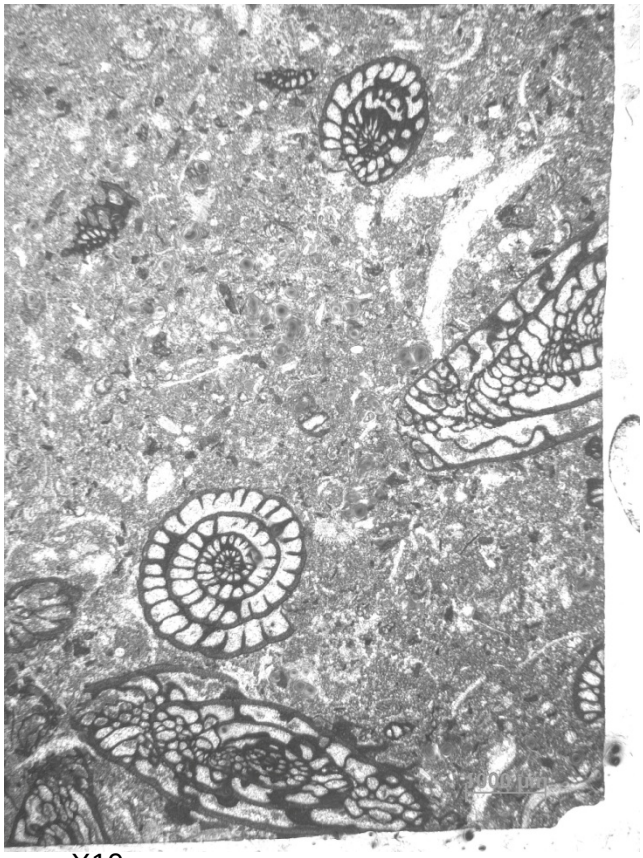

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*G.P. Wahlman, Wahlman Geological Services, LLC, Austin*
*(For Ryan Leary , University of Northern Arizona)*

# Samples 2PL-89-C
# Mescal Mountains, Arizona

*Schwagerina* aff. *S. dunnensis*

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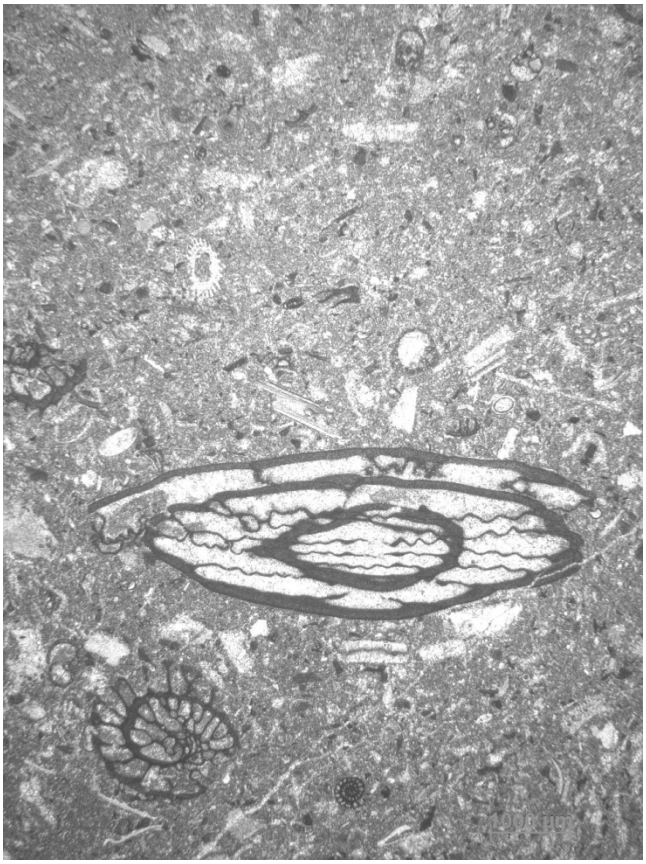

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*(For Ryan Leary , University of Northern Arizona)*