UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MODERN AND HOLOCENE CHRYSOMONAD CYSTS FROM UPPER ECHO LAKE, ELDORADO COUNTY, CALIFORNIA

by

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and

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OPEN-FILE REPORT
79-1461

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards or nomenclature

INTRODUCTION

This report is one of a series illustrating siliceous cysts from various localities. Although these cysts have been known for many years, they are so small that they cannot be observed in detail with optical microscopes. The recent development of the scanning electron microscope (SEM) has made possible much more detailed observations of the external features of these cysts, but as yet relatively few forms have been recorded in this way.

A major difficulty is taxonomic confusion. Many and perhaps all of these cysts are the resting stages of various algae of the phylum Chrysophyta; they will be referred to in the rest of this report as chrysomonad cysts, although other groups in addition to the Chrysomonadinae may be represented. Modern forms are found primarily in fresh water, and numerous authors have reported chrysomonad cysts from Holocene sediments (for example, see Nygaard, 1956). Older fossils have been recovered mostly from marine deposits, and are known as archaeomonads; whether the two groups are as distinct as this terminology suggests is not clear.

For an introduction to the literature on chrysomonad cysts and siliceous algal scales, the reader is referred to our preliminary annotated bibliography on the subject (Adam and Mahood, 1979a).

The fossil archaeomonads have been described and named entirely on the basis of their cysts. This is not advisable with modern forms, because the cysts are the remains of one stage of the life cycle of algae that presumably already have legitimate taxonomic names. Proper cyst nomenclature therefore depends on establishing which cysts are produced by which algae. At the moment, we have only a very limited knowledge of the forms that exist, and almost no knowledge of the phycological pedigrees of the various forms.

The present work is directed toward expanding our knowledge of the various cyst forms and their geographic and environmental distributions. Taxonomic problems are ignored, and the various cyst forms are simply given numbers, which have been assigned arbitrarily. These numbers are consistent throughout all reports in this series, and are being used to tabulate where the various forms occur. (A list of the previous reports in this series is given in Appendix A). The approach used has been that of "splitting", as opposed to "lumping"; it may well be desirable to lump together many of the forms described here when more is known about them.

The SEM photographs are the most important part of this paper, and no attempt has been made to reduce them to words. Supporting data have been placed in the captions.

SITE DESCRIPTION

Echo Lake is located in the westernmost Great Basin, just south of Lake Tahoe, at an elevation of about 2270 m (fig. 1). There are two main basins, Lower and Upper Echo Lakes, that are separated by a narrow inlet known locally as "The Channel". The water level in both lakes is controlled by a dam across the outlet of Lower Echo Lake. During the spring and summer, the water level is normally maintained about 2.5 m above the natural outlet; after early September, water is taken from Lower Echo Lake by a pipeline and flume across the crest of the Sierra Nevada into the American River drainage to the south, where it is used for power generation.

When the water level is high, the two lakes have a common surface level; when the water level is low, the Channel becomes a creek flowing into Lower Echo Lake. The surface of Upper Echo Lake is a little over a meter higher than the surface of Lower Echo Lake when both lakes are just overflowing through their natural outlets.

Samples

The chrysomonad cysts described in this report are from a series of samples taken from a core recovered from Upper Echo Lake. The core was taken during the summer of 1978, when the water level in the lake was high; at that time, the water depth at the coring site was about 15 m. The core was taken by J. Sims using a 6-m Mackereth corer; actual core recovery was about 4.8 m. Samples were processed using the techniques described by Mahood and Adam (1979b).

The stratigraphic positions of the chrysomonad samples in the Echo Lake core, as well as a curve showing sediment dry density, are shown in figure 2. The prominent dry density peak at a depth of 3.6 meters corresponds to a volcanic ash layer. This ash is probably the Mazama Ash, which has been identified in several nearby localities (Adam, 1967); if so, then the core spans the last 8000 to 9000 years.

The samples studied for this report were selected on the basis of raw sediment smear slides in which cysts were common. Cysts were observed throughout the core, however. No attempt is made to interpret the record of chrysomonad cysts from the Upper Echo Lake core, or to tabulate which forms occur in which samples. The photographs are presented as primary documentation of the occurrence of these forms in the Upper Echo Lake sediments; interpretation must await a better knowledge of the environmental and geographic distributions of these cysts, as well as the identification of the algae that produce them.

Negatives of the plates for this report are on

deposit at the USGS Photo Library, and prints can be obtained (at your expense) by writing to:

J. S. Geological Survey Library
Photo Library
Stop 914
Box 25406, Denver Federal Center
Denver, Colorado 80225

Acknowledgments

We thank J. Sims for recovering the core from the lake and R. Oscarson and E. Griffin for technical support.

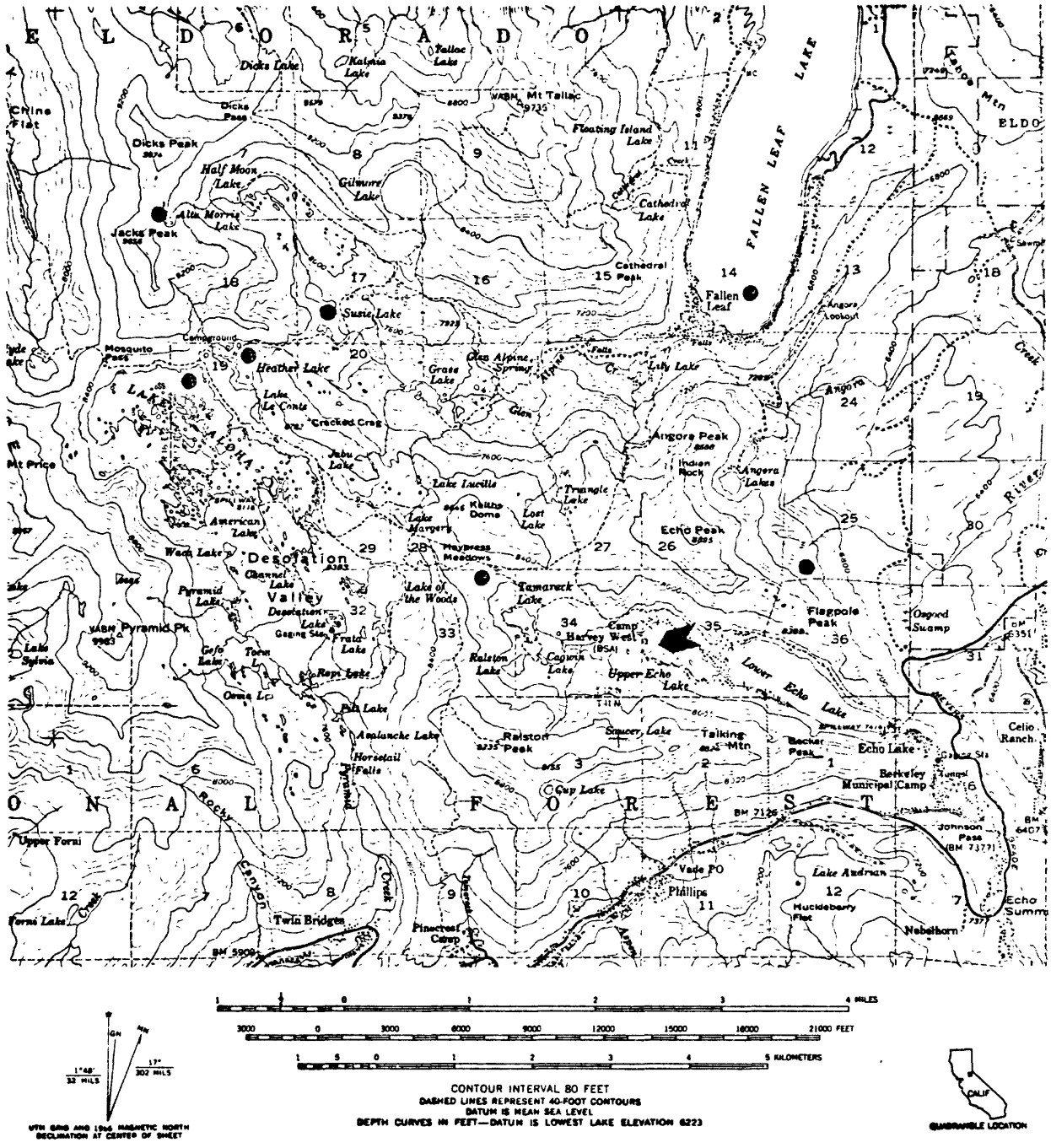


Figure 1.--Map showing the location of the core site (arrow). Dots mark the locations of other sites where we have observed chrysomonad cysts. Map is reduced from part of the USGS Fallen Leaf Lake 15-minute quadrangle.

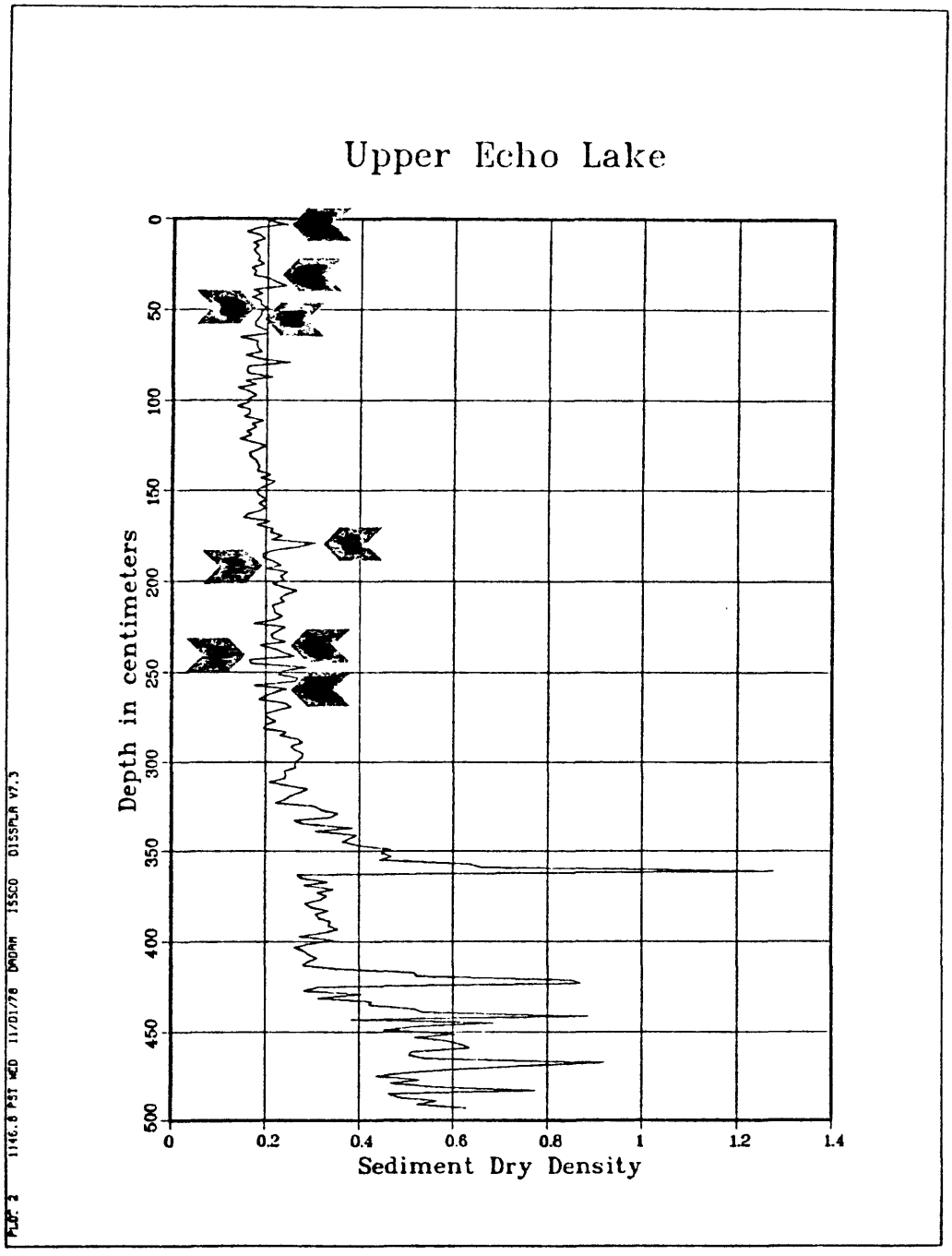


Figure 2.--Plot of sediment dry density in grams per cubic centimeter versus depth for the Upper Echo Lake core. Arrows mark the depths of the chrysomonad samples studied for this report.

REFERENCES CITED

Adam, David P., 1967, Late Pleistocene and Recent palynology in the central Sierra Nevada, California: in Cushing, E. J., and Wright, H. E., Jr., editors, Quaternary Paleoecology, New Haven, Yale University Press, p. 275-301.

Adam, David P., and Mahood, Albert M., 1979, A preliminary annotated bibliography on siliceous algal cysts and scales. U. S. Geological Survey Open-File Report No. 79-1215, 34 p.

Cronberg, Gertrud, 1973, Development of cysts in Mallomonas spp. examined by scanning electron microscopy: Hydrobiologia, v. 43, n. 1-2, p. 29-38.

Freihofer, Warren C., 1952, The limnology of a High Sierra Nevada mountain lake: Echo Lake, Eldorado County, California: unpublished M.A. thesis (zoology), California University (Berkeley), 181 p.

Mahood, Albert D., and Adam, David P., 1979, Techniques used for the cleaning, concentration, and observation of chrysomonad cysts from sediments: U. S. Geological Survey Open-file Report Number 79-1431, 6 p.

Nygaard, Gunnar, 1956, Ancient and Recent flora of diatoms and Chrysophyceae in Lake Gribsø, in Berg, Kaj, and Petersen, I. C., eds., Studies on the Humic acid Lake Gribsø: Folia Limnologia Scandinavica, No. 8, p. 32-94, 12 plates.

Upper Echo Lake, Plate A

scale bar = 1 micrometer

1 - Type 45, sample 91, depth 181 cm.
(with adhering debris)

2 - Type 45, sample 91, depth 181 cm.

3 - Type 45, sample 91, depth 181 cm.

4 - Type 45, sample 28, depth 55 cm.

5 - Type 45, sample 117, depth 233 cm.

6 - Type 45, sample 15, depth 29 cm.

7 - Type 45, sample 121, depth 241 cm.

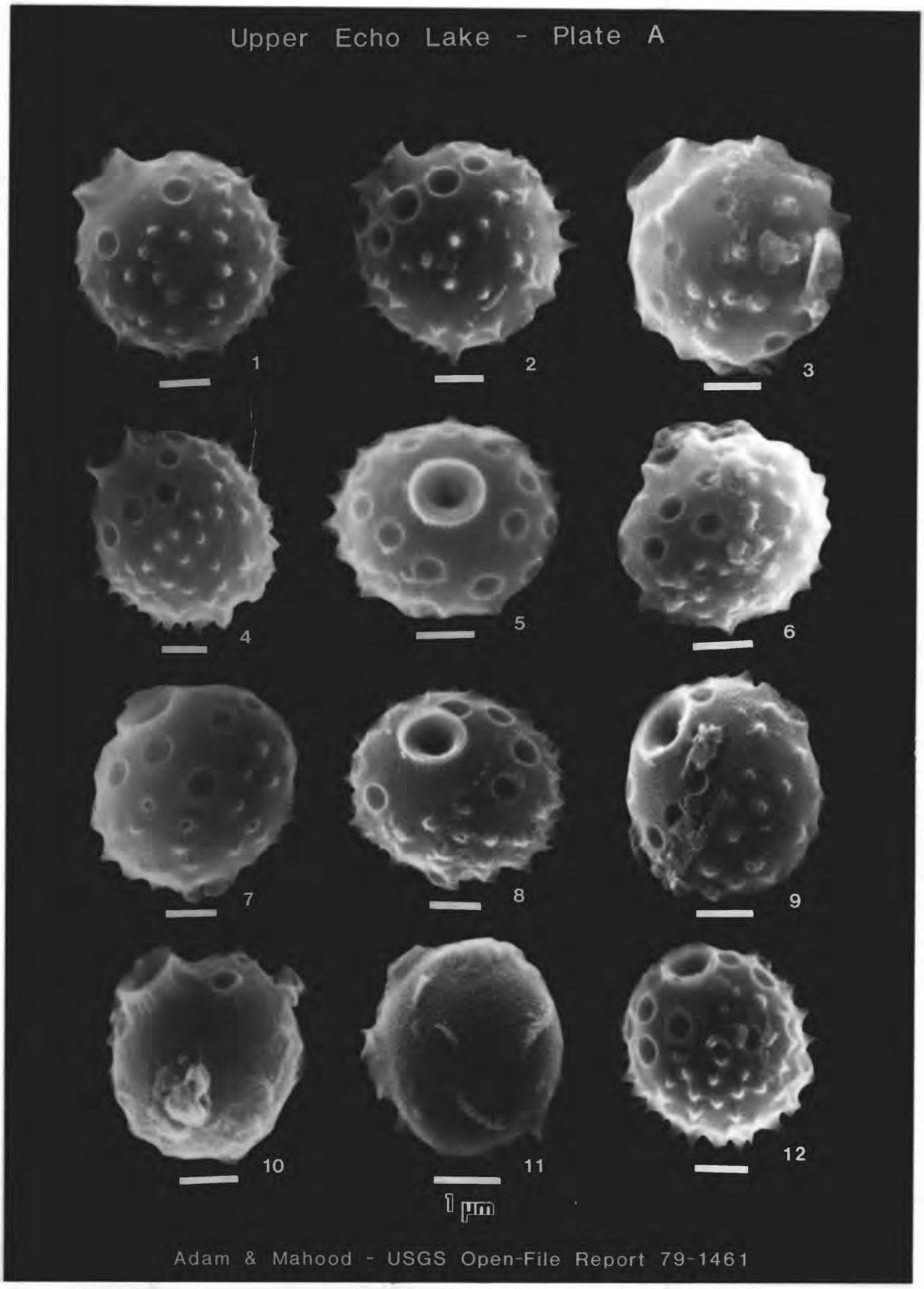
8 - Type 45, sample 25, depth 49 cm.

9 - Type 45, sample 91, depth 181 cm.
(with adhering debris)

10 - Type 46, sample 28, depth 55 cm.

11 - Type 46, sample 121, depth 241 cm.

12 - Type 45, sample 130, depth 259 cm.


Upper Echo Lake - Plate A
1
2
3
4
5
6
7
8
9
10
11
12
1 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate B

scale bar = 3 micrometers

1 - Type 47, sample 28, depth 55 cm.
(with adhering debris)

2 - Type 47, sample 15, depth 29 cm.
(with adhering debris)

3 - Type 48, sample 117, depth 233 cm.

4 - Type 49, sample 117, depth 233 cm.

5 - Type 49, sample 91, depth 181 cm.

6 - Type 49, sample 91, depth 181 cm.
(with adhering debris)

7 - Type 50, sample 15, depth 29 cm.
(poor exposure)

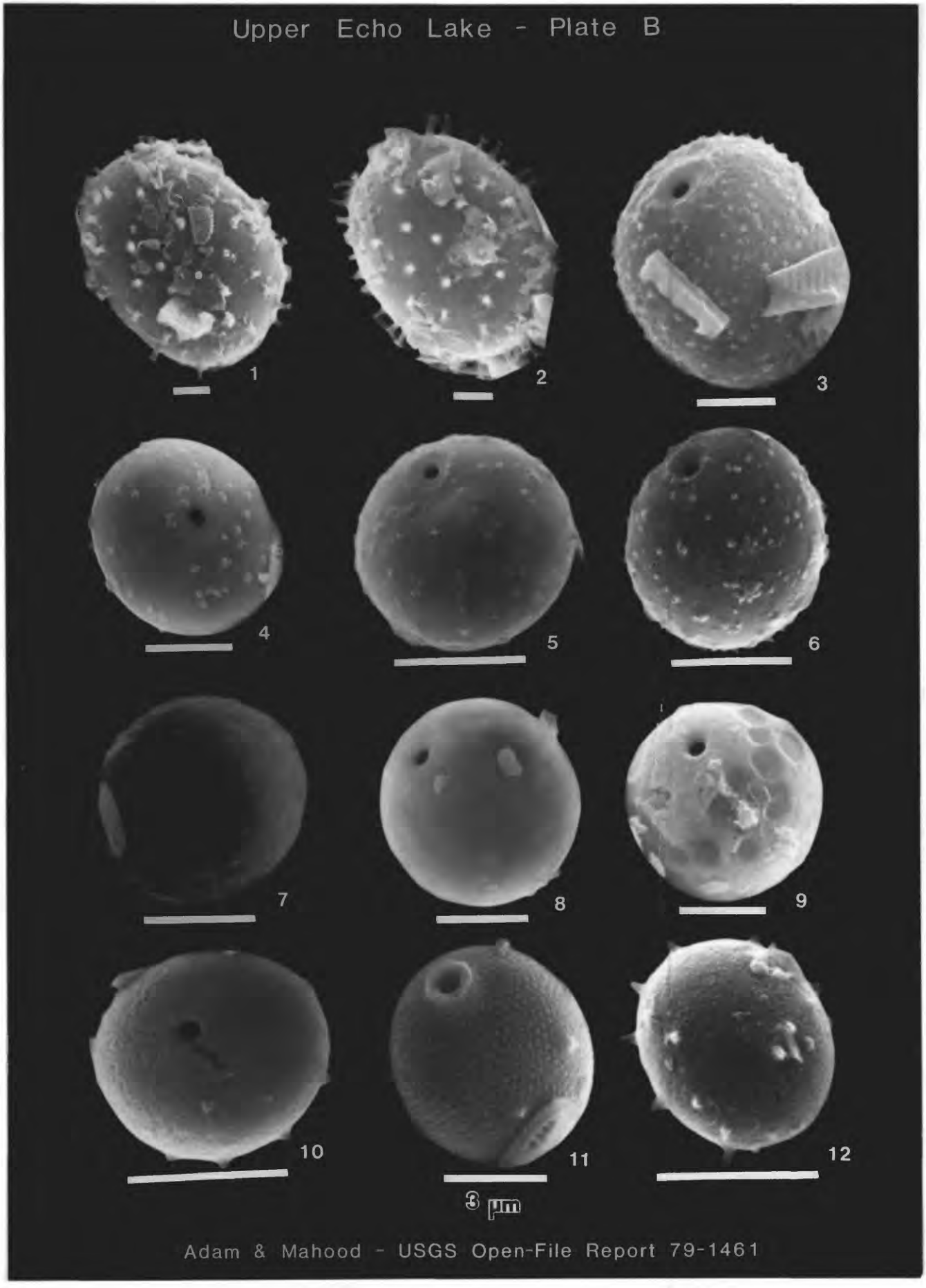
8 - Type 51, sample 15, depth 29 cm.

9 - Type 52, sample 15, depth 29 cm.

10 - Type 53, sample 121, depth 241 cm.

11 - Type 54, sample 121, depth 241 cm.
(with algal scale at bottom)

12 - Type 53(?), sample 91, depth 181 cm.
(with adhering debris)


Upper Echo Lake - Plate B
1
2
3
4
5
6
7
8
9
10
11
12
3 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate C

scale bar = 3 micrometers

1 - Type 55, sample 91, depth 181 cm.
(note reticulation)

2 - Type 56, sample 15, depth 29 cm.

3 - Type 56, sample 2, depth 3 cm.

4 - Type 56, sample 2, depth 3 cm.

5 - Type 57, sample 117, depth 233 cm.
(some debris; note holes)

6 - Type 58, sample 15, depth 29 cm.

7 - Type 59, sample 117, depth 233 cm.

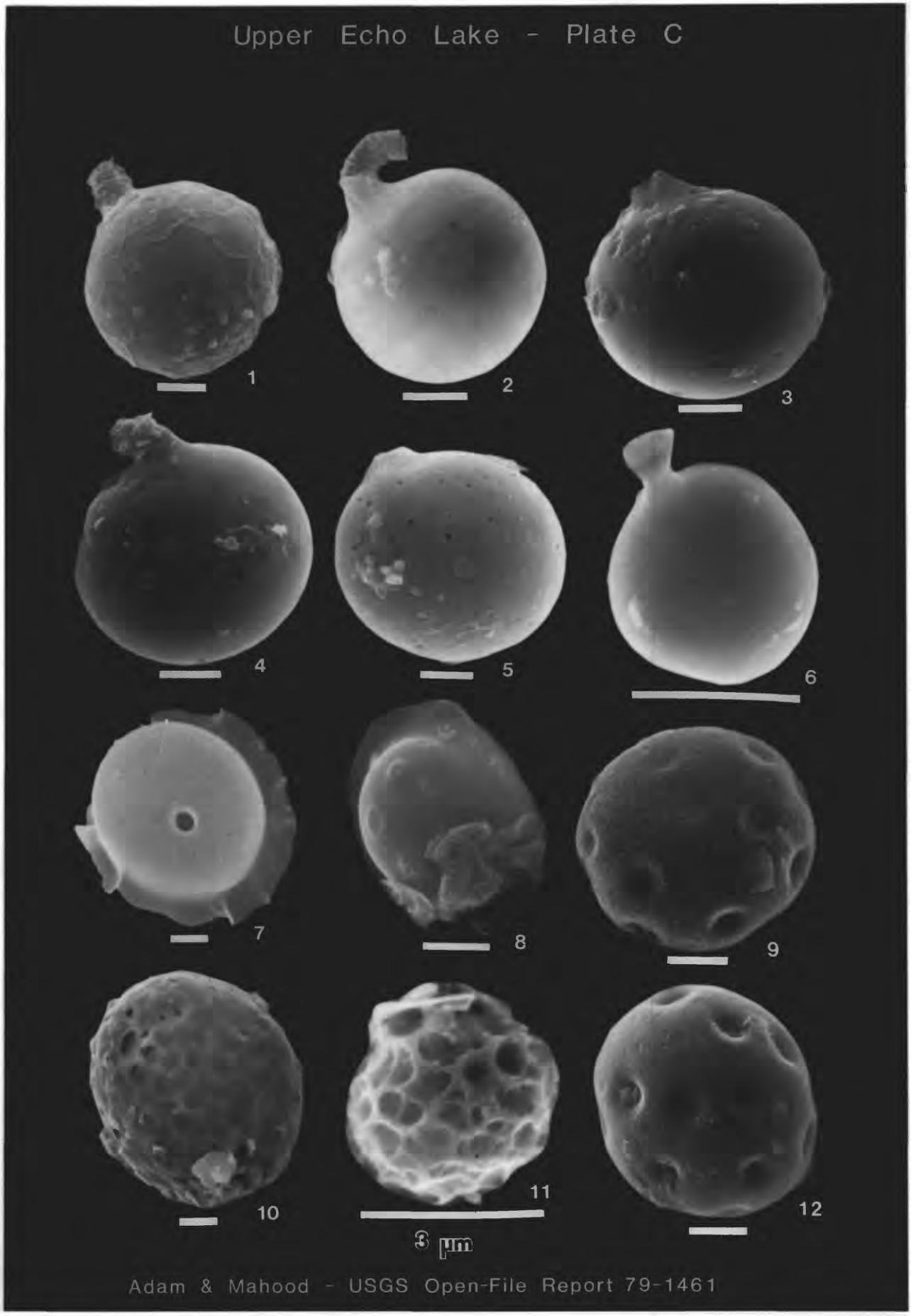
8 - Type 59, sample 28, depth 55 cm.
(with adhering debris)

9 - Type 60, sample 117, depth 233 cm.

10 - Type 61, sample 2, depth 3 cm.
(with adhering debris)

11 - Type 61, sample 117, depth 233 cm.
(with adhering debris)

12 - Type 60, sample 121, depth 241 cm.


Upper Echo Lake - Plate C
1
2
3
4
5
6
7
8
9
10
11
12
3 µm
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Upper Echo Lake, Plate D

scale bar = 1 micrometer

1 - Type 62, sample 28, depth 55 cm.

2 - Type 62, sample 28, depth 55 cm.
(same specimen as no. 1)

3 - Type 63, sample 28, depth 55 cm.

4 - Type 64, sample 117, depth 233 cm.

5 - Type 65, sample 121, depth 241 cm.

6 - Type 66, sample 130, depth 259 cm.
(with adhering debris)

7 - Type 67, sample 130, depth 259 cm.

8 - Type 68, sample 91, depth 181 cm.
(some debris; note
reticulation within pore)

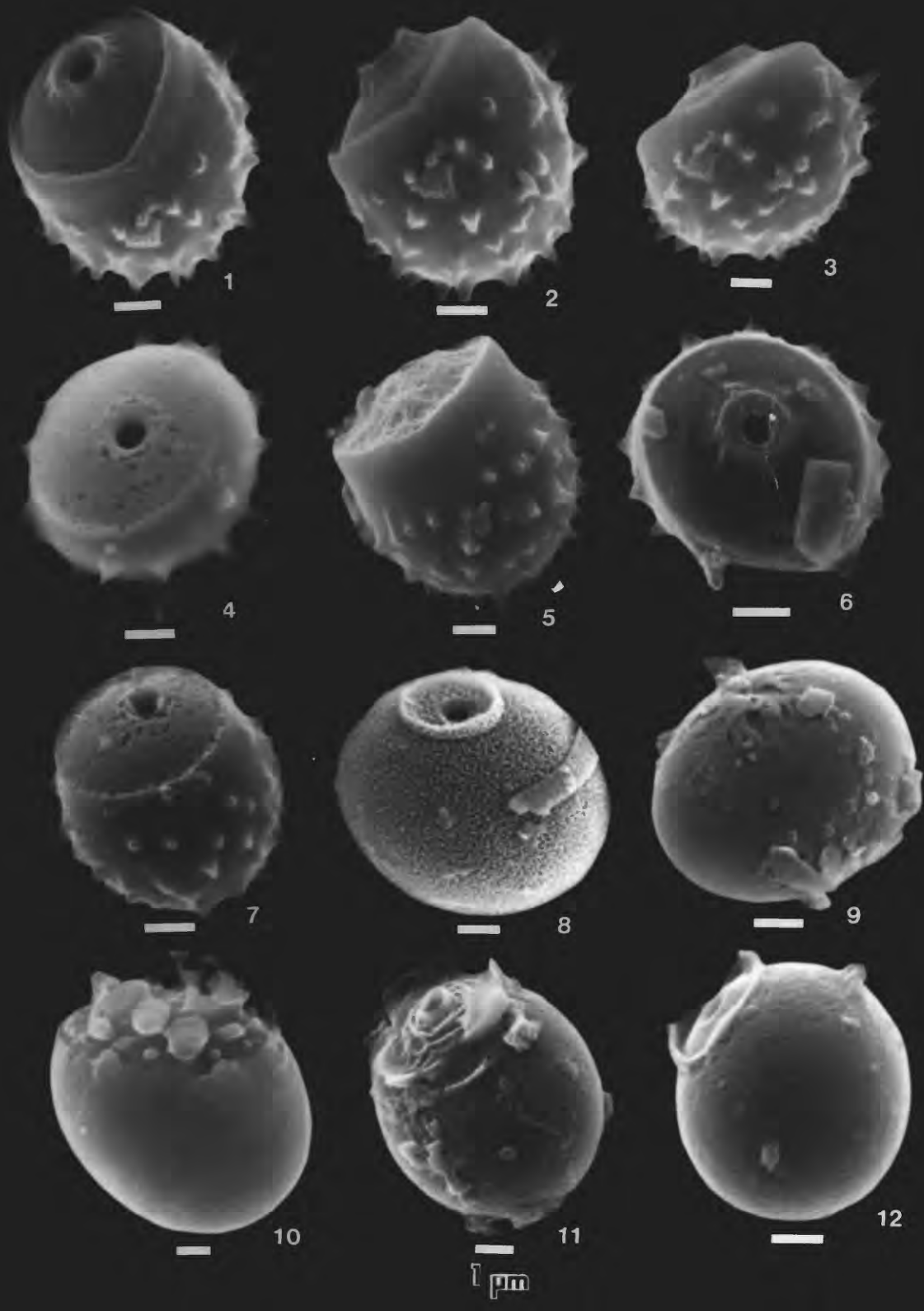
9 - Type 69, sample 25, depth 49 cm.
(some debris; root-like network
is apparently related to the pore)

10 - Type 70, sample 117, depth 233 cm.

11 - Type 71, sample 130, depth 259 cm.
(with adhering debris)

12 - Type 72, sample 130, depth 259 cm.

Upper Echo Lake - Plate D



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Upper Echo Lake, Plate E

scale bar = 1 micrometer

1 - Type 73, sample 130, depth 259 cm.

(with adhering debris)

2 - Type 74, sample 130, depth 259 cm.

3 - Type 75, sample 91, depth 181 cm.

(with adhering debris)

4 - Type 76, sample 91, depth 181 cm.

5 - Type 77, sample 91, depth 181 cm.

(with adhering debris)

6 - Type 78, sample 130, depth 259 cm.

(with adhering debris)

7 - Type 79, sample 117, depth 233 cm.

8 - Type 80, sample 91, depth 181 cm.
(Note attached algal scale, and also the two patches where the ornamentation has been thinned below the pore, perhaps because scales were once attached there as well. Compare also with the SEM photo of a cyst of Mallomonas ega in Cronberg (1973, fig. 6) that shows a similar surface pattern on the cyst.)

9 - Type 80, sample 28, depth 55 cm.

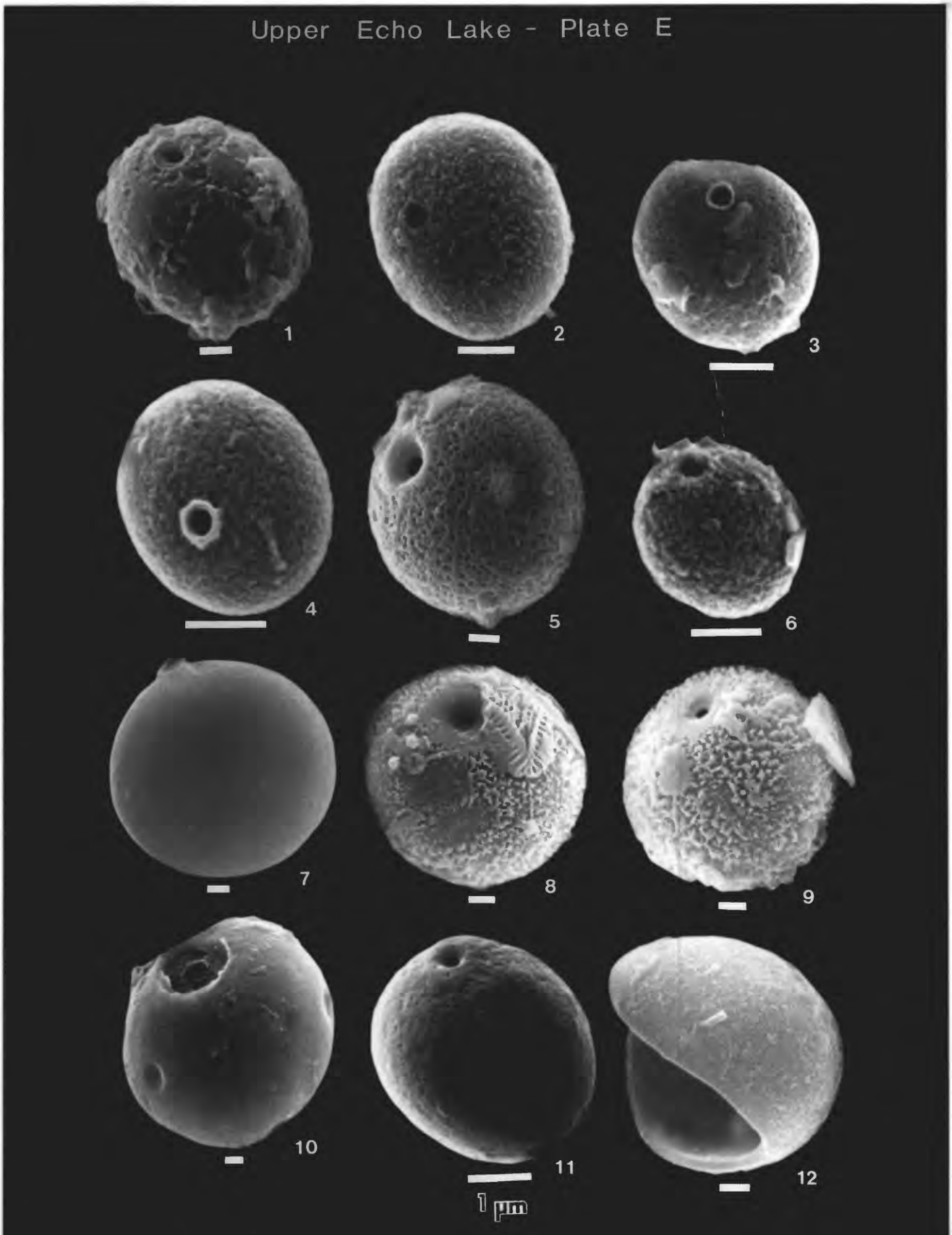
(with adhering debris)

10 - Type 81, sample 2, depth 3 cm.

11 - Type 82, sample 2, depth 3 cm.

12 - Indeterminate cyst, sample 28, depth 55 cm.

Upper Echo Lake - Plate E



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Upper Echo Lake, Plate F

scale bar = 3 micrometers

1 - Type 83, sample 121, depth 241 cm.

2 - Type 83, sample 91, depth 181 cm.
(with adhering debris)

3 - Type 83, sample 91, depth 181 cm.
(with adhering debris)

4 - Type 84, sample 117, depth 233 cm.

5 - Type 85, sample 121, depth 241 cm.
(plug is in pore)

6 - Type 86, sample 117, depth 233 cm.

7 - Type 87, sample 117, depth 233 cm.

8 - Type 88, sample 2, depth 3 cm.
(with adhering debris)

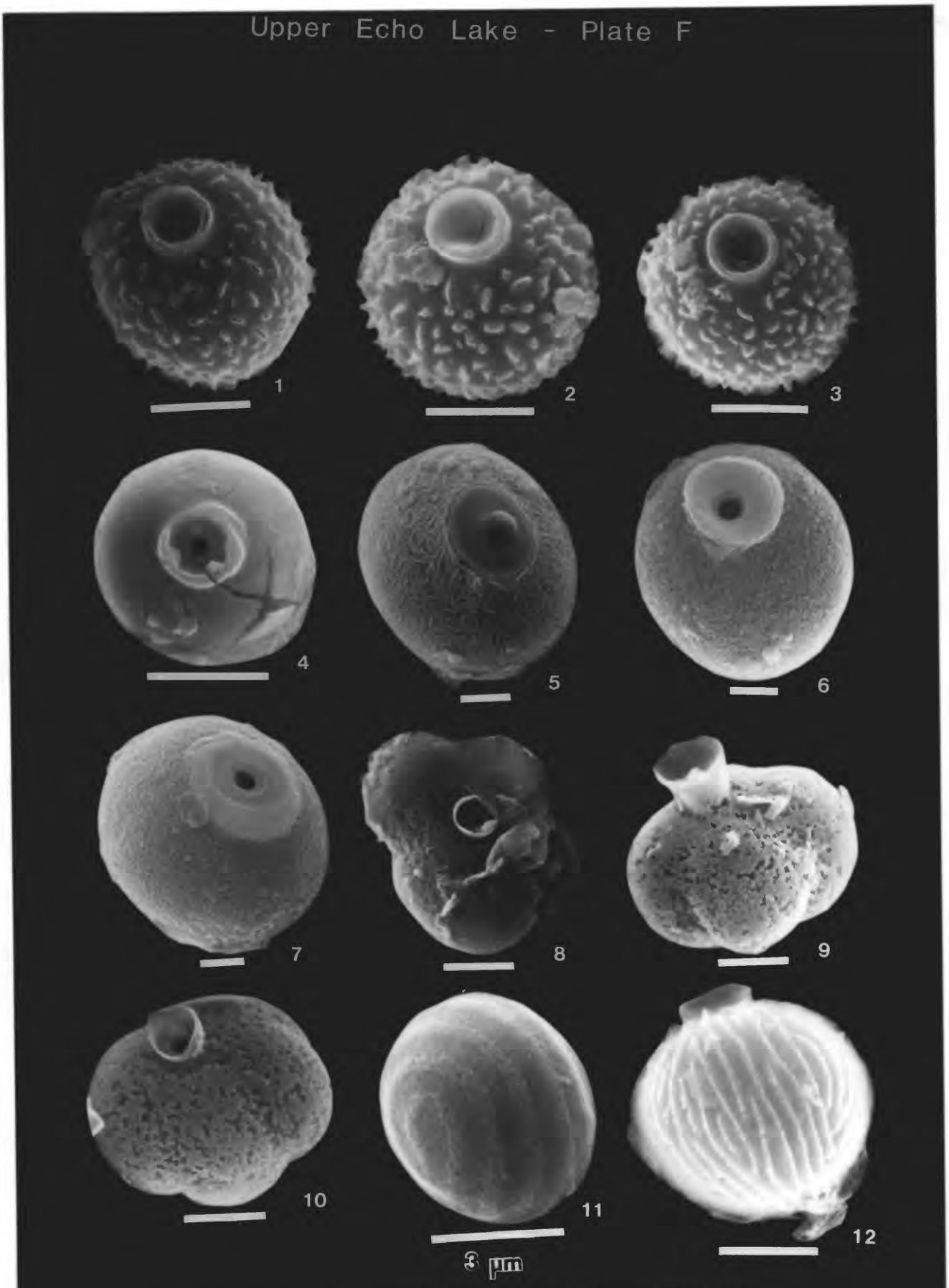
9 - Type 88, sample 91, depth 181 cm.

10 - Type 88, sample 121, depth 241 cm.

11 - Type 89, sample 117, depth 233 cm.

12 - Type 90, sample 15, depth 29 cm.

Upper Echo Lake - Plate F



Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate G

scale bar = 3 micrometers

1 - Type 91, sample 91, depth 181 cm.

2 - Type 92, sample 130, depth 259 cm.
(with adhering debris)

3 - Type 93, sample 28, depth 55 cm.
(with adhering debris)

4 - Type 94, sample 15, depth 29 cm.

5 - Type 95, sample 91, depth 181 cm.

6 - Type 96, sample 91, depth 181 cm.

7 - Type 97, sample 130, depth 259 cm.
(with adhering debris)

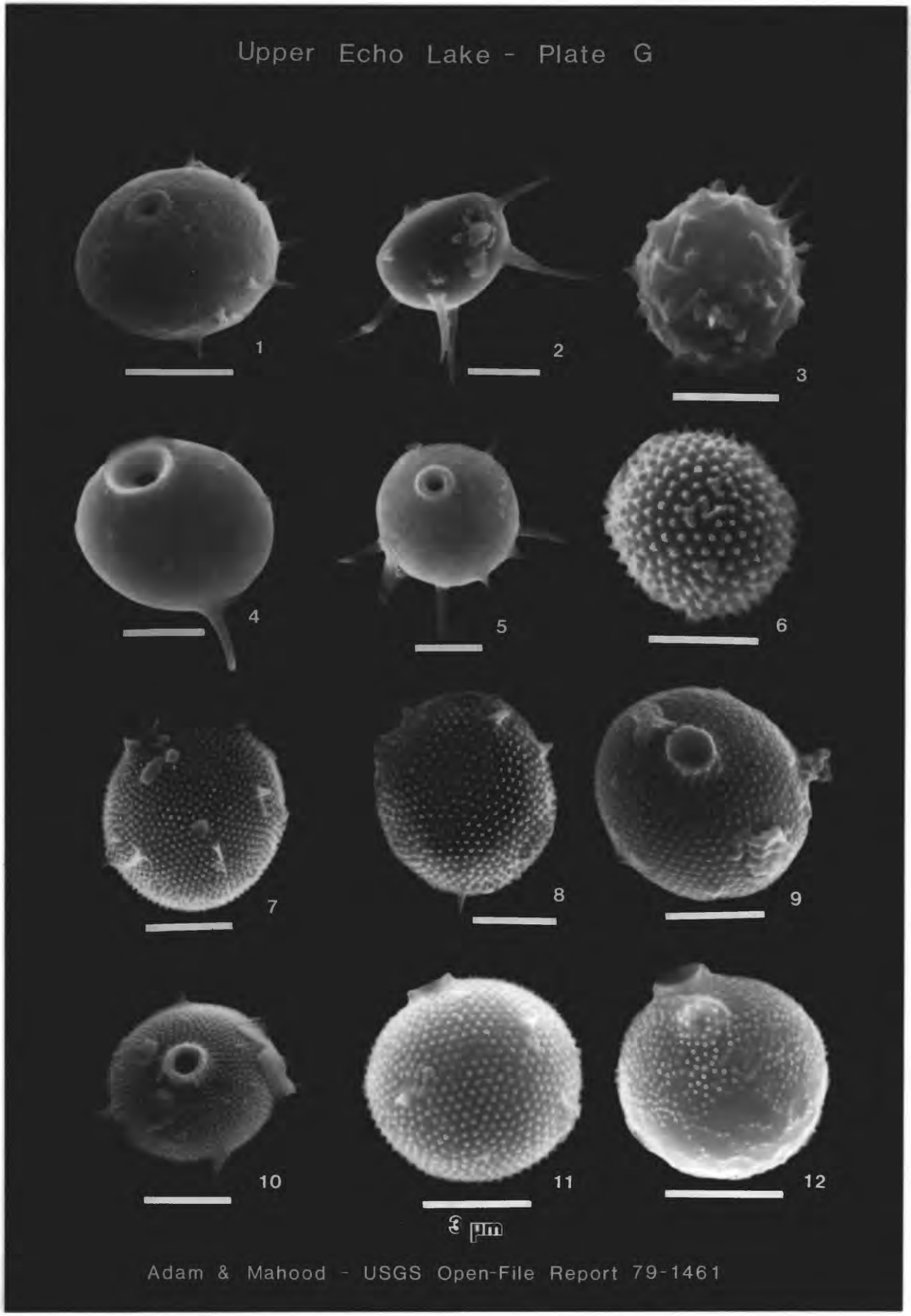
8 - Type 97, sample 2, depth 3 cm.

9 - Type 97, sample 2, depth 3 cm.
(with adhering debris;
plug still in bore)

10 - Type 97, sample 121, depth 241 cm.
(with adhering debris)

11 - Type 98, sample 117, depth 233 cm.

12 - Type 99, sample 15, depth 29 cm.


Upper Echo Lake - Plate G
1
2
3
4
5
6
7
8
9
10
11
12
5 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate H

scale bar = 1 micrometer

1 - Type 100, sample 15, depth 29 cm.

2 - Type 101, sample 2, depth 3 cm.

3 - Type 102, sample 91, depth 181 cm.

4 - Type 103, sample 15, depth 29 cm.

5 - Type 104, sample 121, depth 241 cm.
(with adhering debris)

6 - Type 105, sample 15, depth 29 cm.
(with adhering debris)

7 - Type 106, sample 117, depth 233 cm.

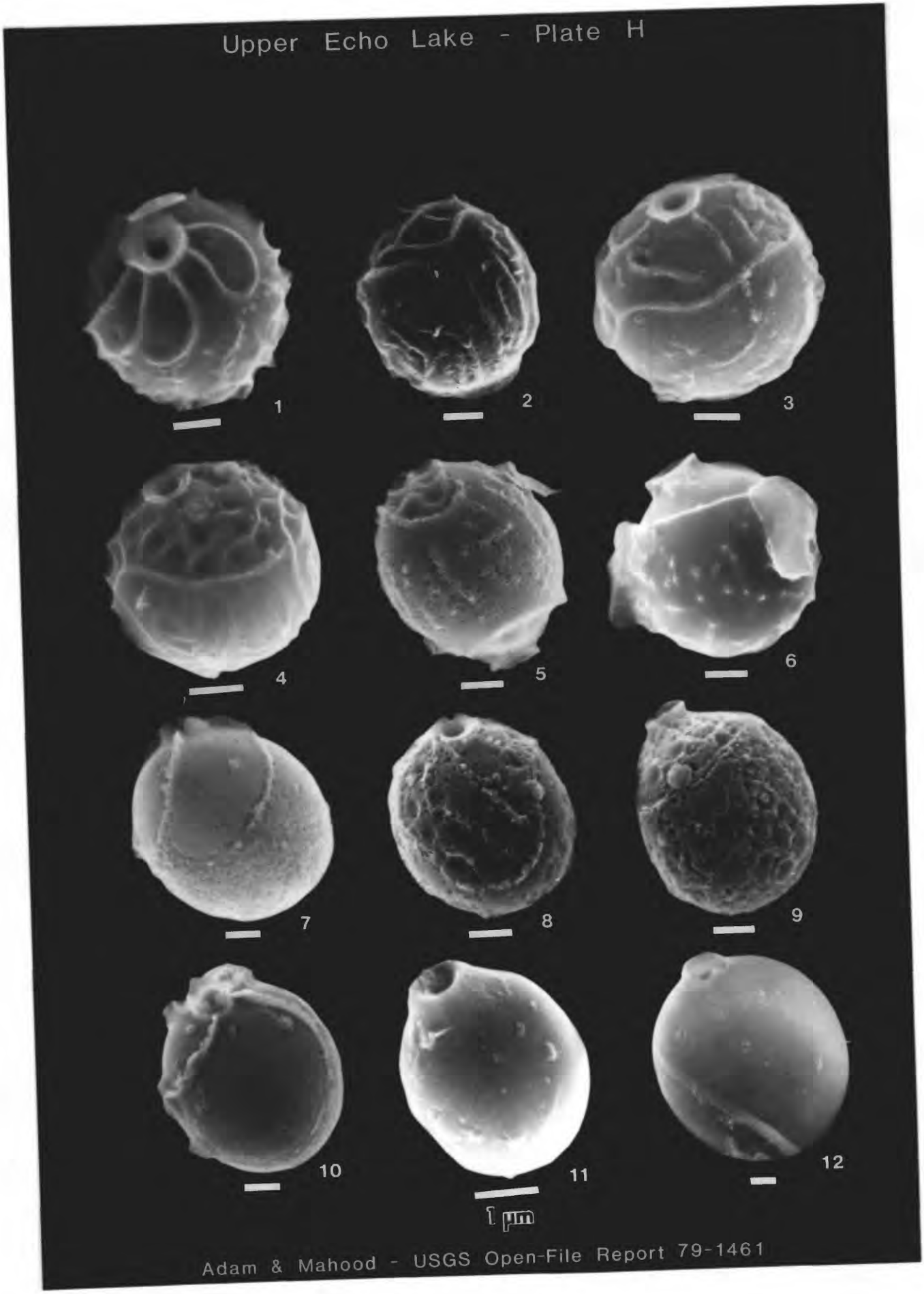
8 - Type 107, sample 25, depth 49 cm.

9 - Type 108, sample 130, depth 259 cm.

10 - Type 106, sample 130, depth 259 cm.

11 - Type 109, sample 28, depth 55 cm.

12 - Type 110, sample 15, depth 29 cm.


Upper Echo Lake - Plate H
1
2
3
4
5
6
7
8
9
10
11
12
1 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate I

scale bar = 1 micrometer

1 - Type 111, sample 28, depth 55 cm.

2 - Type 112, sample 91, depth 181 cm.
(with adhering debris)

3 - Type 113, sample 25, depth 49 cm.
(with adhering debris)

4 - Type 114, sample 91, depth 181 cm.

5 - Type 114, sample 28, depth 55 cm.

6 - Type 114, sample 91, depth 181 cm.

7 - Type 115, sample 15, depth 29 cm.

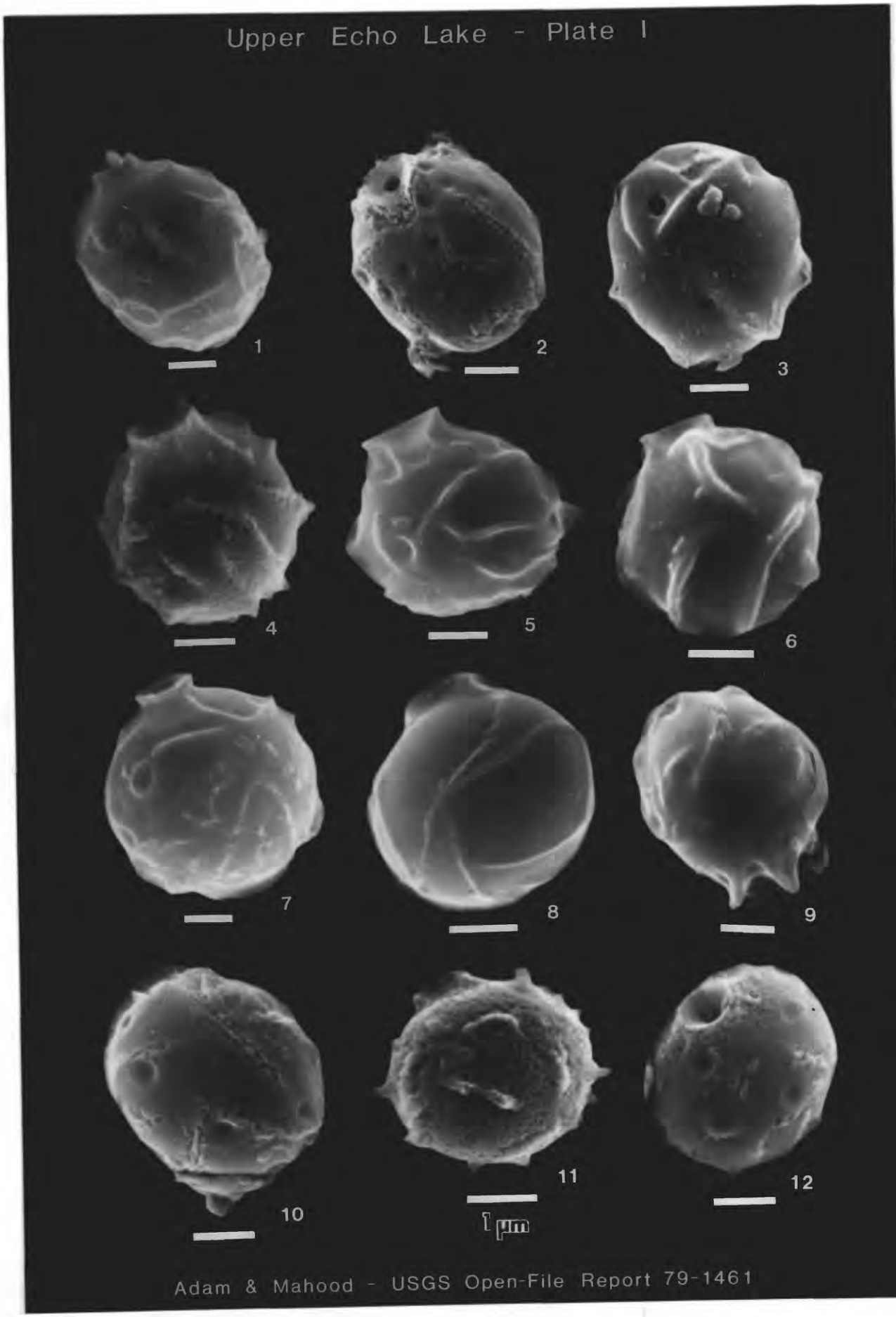
8 - Type 116, sample 28, depth 55 cm.

9 - Type 117, sample 28, depth 55 cm.

10 - Type 112, sample 25, depth 49 cm.
(with adhering debris)

11 - Type 46(?), sample 2, depth 3 cm.

12 - Type 118, sample 121, depth 241 cm.


Upper Echo Lake - Plate I
1
2
3
4
5
6
7
8
9
10
11
12
1 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate J

scale bar = 1 micrometer

1 - Type 46, sample 130, depth 259 cm.

2 - Type 46, sample 130, depth 259 cm.

3 - Type 119, sample 91, depth 181 cm.
(with adhering debris)

4 - Type 120, sample 25, depth 49 cm.

5 - Type 120, sample 130, depth 259 cm.

6 - Type 46(?), sample 130, depth 259 cm.

7 - Type 121, sample 130, depth 259 cm.

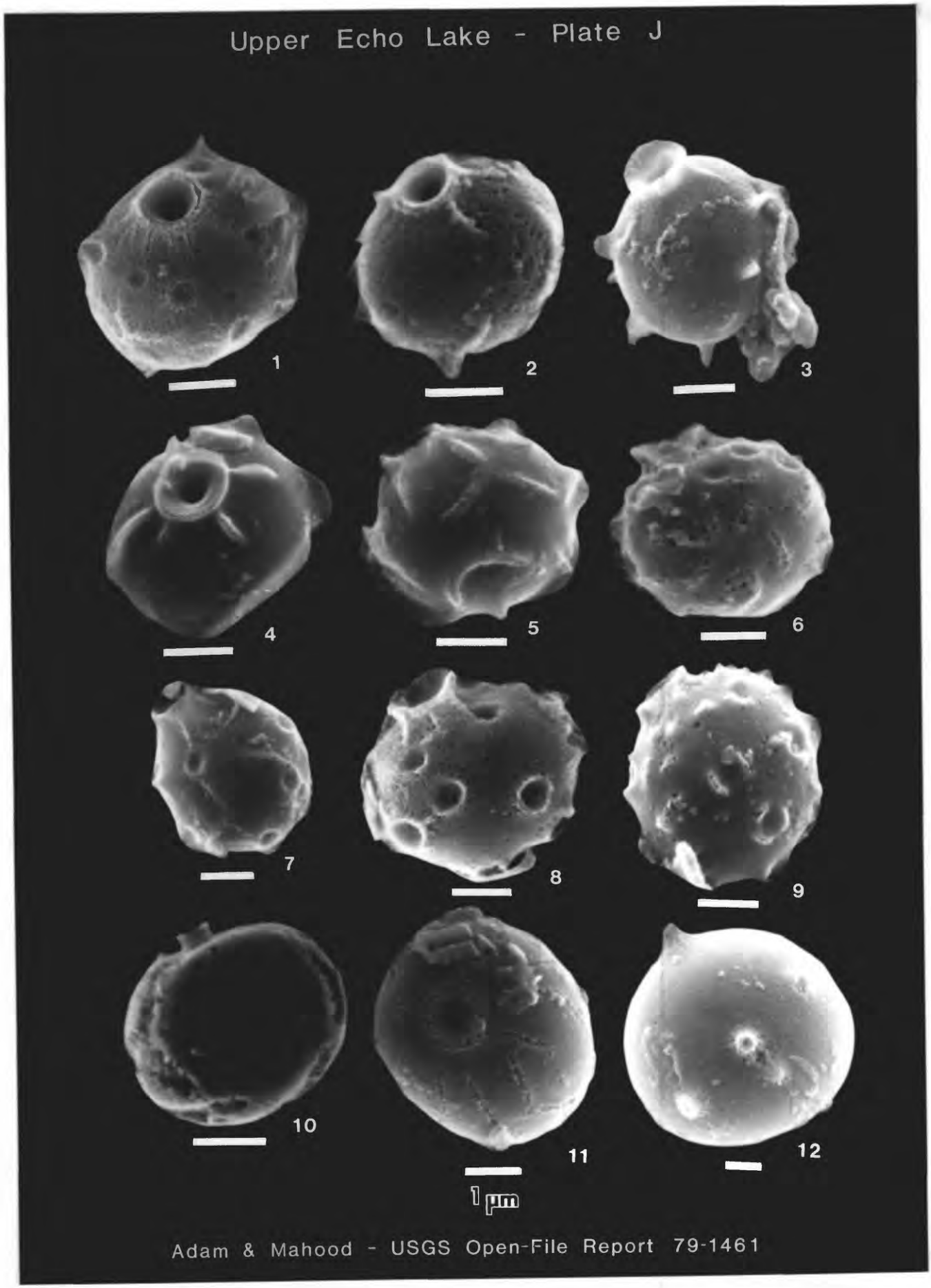
8 - Type 122, sample 91, depth 181 cm.

9 - Type 123, sample 91, depth 181 cm.
(with adhering debris)

10 - Type 88(?), sample 130, depth 259 cm.

11 - Type 124, sample 121, depth 241 cm.
(with adhering debris)

12 - Type 94(?), sample 91, depth 181 cm.


Upper Echo Lake - Plate J
1
2
3
4
5
6
7
8
9
10
11
12
1 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate K

scale bar = 1 micrometer

1 - Type 125, sample 28, depth 55 cm.
(with adhering debris)

2 - Type 126, sample 2, depth 3 cm.
(with adhering debris)

3 - Type 76, sample 130, depth 259 cm.

4 - Type 127, sample 130, depth 259 cm.
(with adhering debris)

5 - Type 128, sample 25, depth 49 cm.
(with adhering debris)

6 - Type 129, sample 130, depth 259 cm.
(with adhering debris)

7 - Type 130, sample 130, depth 259 cm.
(with adhering debris)

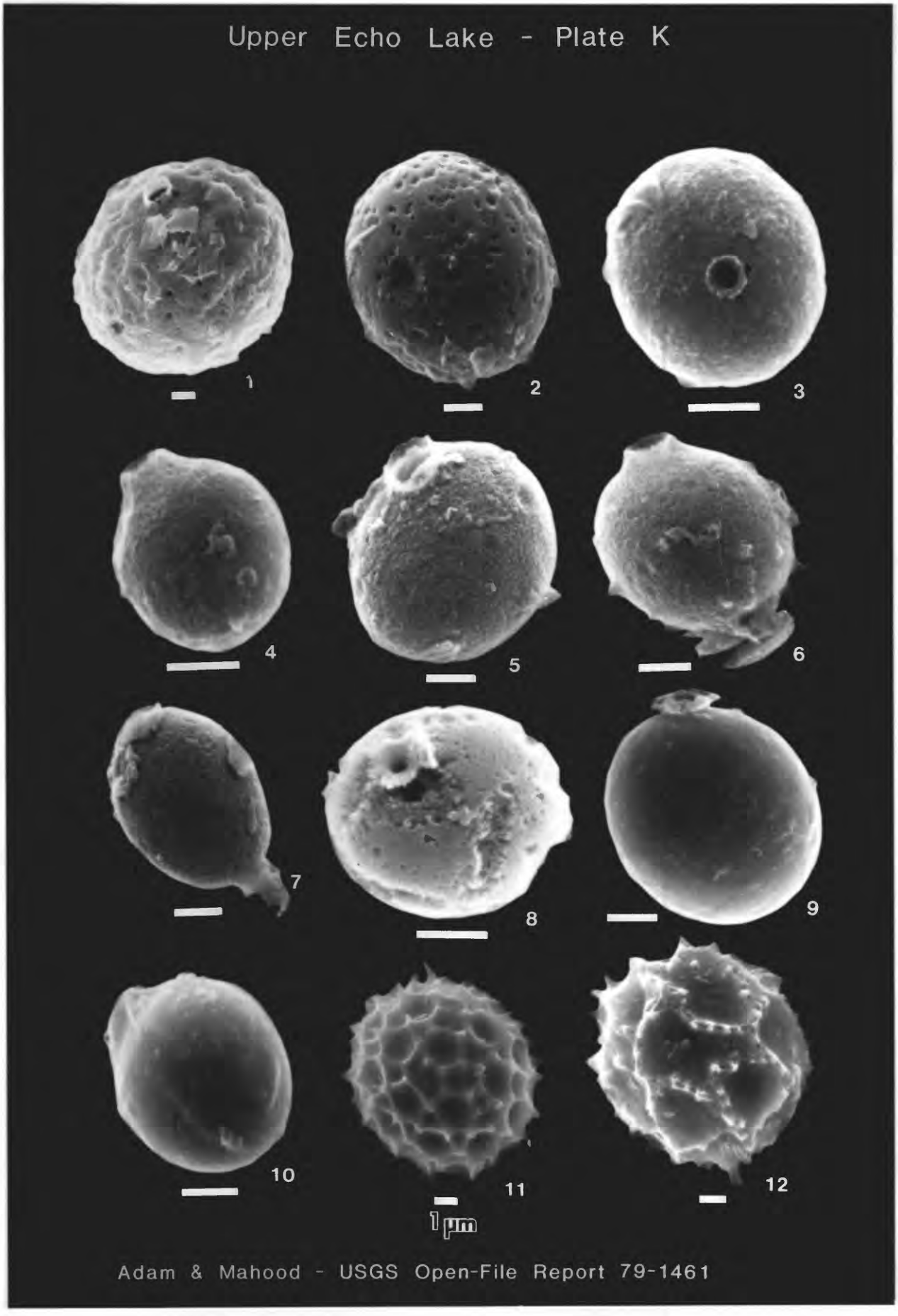
8 - Type 124, sample 130, depth 259 cm.
(corroded)

9 - Type 131, sample 130, depth 259 cm.

10 - Type 127, sample 28, depth 55 cm.

11 - Type 132, sample 121, depth 241 cm.

12 - Type 133, sample 2, depth 3 cm.


Upper Echo Lake - Plate K
1
2
3
4
5
6
7
8
9
10
11
12
1 µm
Adam & Mahood - USGS Open-File Report 79-1461

Upper Echo Lake, Plate L

scale bar = 3 micrometers

1 - Type 134, sample 91, depth 181 cm.
(with adhering debris)

2 - Type 135, sample 91, depth 181 cm.

3 - Type 135, sample 2, depth 3 cm.
(with adhering debris)

4 - Type 136, sample 28, depth 55 cm.
(with adhering debris)

5 - Type 137, sample 28, depth 55 cm.
(with adhering debris)

6 - Type 136, sample 91, depth 181 cm.
(with adhering debris)

7 - Algal scale, sample 28, depth 55 cm.

8 - Algal scale, sample 28, depth 55 cm.

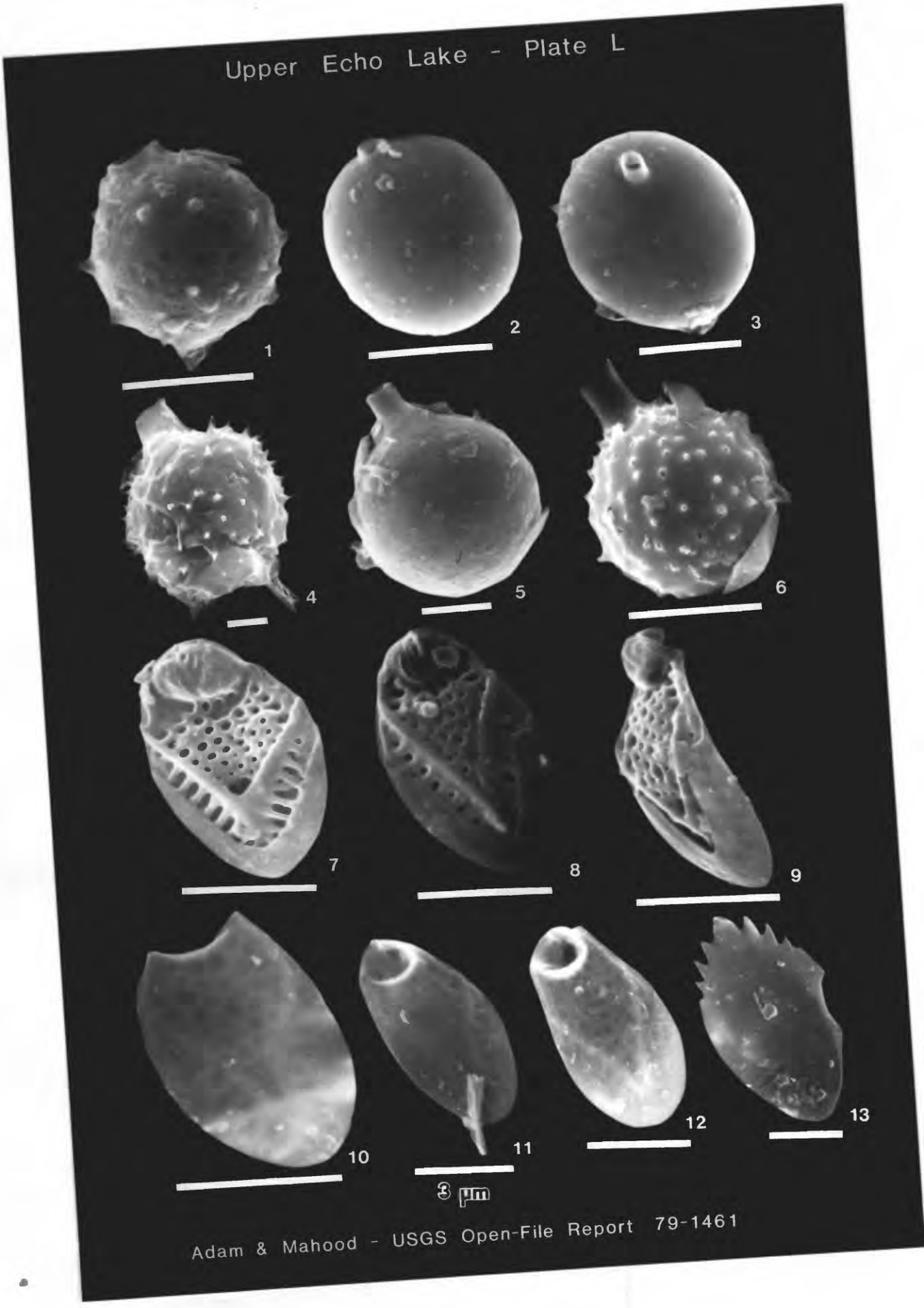
9 - Algal scale, sample 28, depth 55 cm.

10 - Algal scale, sample 28, depth 55 cm.

11 - Algal scale, sample 28, depth 55 cm.

12 - Algal scale, sample 28, depth 55 cm.

13 - Algal scale, sample 130, depth 259 cm.


Upper Echo Lake - Plate L
1
2
3
4
5
6
7
8
9
10
11
12
13
3 µm
Adam & Mahood - USGS Open-File Report 79-1461

APPENDIX A

PREVIOUS REPORTS IN THIS SERIES

Mahood, Albert D., and Adam, David P., 1979a, Late Pleistocene chrysomonad cysts from core 7, Clear Lake, Lake County, California: U. S. Geological Survey Open-file Report Number 79-971, 11 p., 4 plates. Defines types 1 through 44.

Adam, David P., and Mahood, Albert D., 1979a, A preliminary annotated bibliography on siliceous algal cysts and scales: U. S. Geological Survey Open-file Report Number 79-1215, 34 p.

Mahood, Albert D., and Adam, David P., 1979b, Techniques used for the cleaning, concentration, and observation of chrysomonad cysts from sediments: U. S. Geological Survey Open-file Report Number 79-1431, 6 p.