UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SCANNING ELECTRON MICROGRAPHS OF MODERN AND LATE HOLOCENE CHRYSOMONAD CYSTS FROM HARDEN LAKE MEADOW, YOSEMITE NATIONAL PARK, CALIFORNIA

by

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OPEN-FILE REPORT
81-46

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 Adam and Mahood (1979), a preliminary annotated bibliography on the subject.

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 towards 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. Sample preparation techniques are generally the same as those used for preparing diatom samples; details may be found in Mahood and Adam (1979).

The purpose of these initial reports is to provide primary documentation of the occurrence of particular cyst forms at particular localities, and to provide a means by which the SEM photographs of the cysts may be placed in a permanent depository. Counts of the relative abundance of the various forms and interpretations of their significance have not yet been attempted, but must await a more complete understanding of the range of cyst morphologies.

We have illustrated all of the distinctive cyst forms found in the sample, using the best available photographs. In some instances we have included more than one photograph of a given form, but we have not included all of the photographs we have taken.

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:

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

SITE DESCRIPTION

Harden Lake meadow is located at an elevation of 2290 m atop the south wall of the Grand Canyon of the Tuolumne River, on the western slope of the Sierra Nevada. The site occupies a saddle on the ridge that separates the drainages of the North and Middle Forks of the Tuolumne River (Fig. 1).

During times of maximum glaciation in the Sierra Nevada, a major valley glacier flowed down the North Fork of the Tuolumne River and completely filled the valley, which is over 1000 m deep just north of Harden Lake. At several different times ice flowed over the drainage divide from the North Fork into the drainage of the Middle Fork of the Tuolumne River at the low saddle now occupied by Harden Lake and Harden Lake meadow. Each such event left moraines in the saddle; there are at least five moraines present; these increase in age from north to south, and are shown schematically in Fig. 2.

The youngest moraines (set 1) are found to the north of Harden Lake, and are responsible for the basin of Harden Lake itself. The lake is an unusual one for the Sierra Nevada in that it does not overflow; during the summer of 1978, the water surface of the lake was about 2 m below the lowest point on the drainage divide, and there were no signs of recent overflow, which would

have occurred to the south, into Harden Lake meadow.

To the south, Harden Lake is bounded by moraine 2, which separates Harden Lake from Harden Lake meadow. This moraine is older than moraine 1 to the north of Harden Lake, but is still very well preserved, with steep sides and many large boulders on both the north and south sides.

Moraine 3 is much older than the first two, judging from the much higher degree of surface weathering and the subdued topography. This rather small moraine forms a low rise that extends as a forested peninsula into Harden Lake meadow from the east. The deposits are overridden at their eastern end by the deposits of moraine 2, and the difference in appearance between the two sets of deposits where they meet is striking.

A fourth set of moraines lies just to the south of Harden Lake meadow; it is clearly visible on aerial photographs, but is hard to see on the ground because of heavy forest cover.

The fifth set of moraines is located well beyond the inner four sets, and extends both well down into the valley of the Middle Fork of the Tuolumne and well up the hill to the west of Harden Lake. It is the oldest of the moraines, and must represent either a more severe glaciation than those that produced the inner four sets, or else a glaciation that overflowed the

Grand Canyon of the Tuolumne to a greater extent than subsequent glaciations because that canyon had not yet been eroded to its present depth.

The surface of Harden Lake meadow is presently covered with peat. Because the meadow occupies a depression that was created by a glacial advance older than the last glacial maximum in the area, an attempt was made to recover a sediment core from the meadow, in the hope that a thick peat deposit would provide a pollen record extending back through and beyond the last glacial maximum. Instead, it was found that the peat is only 70-80 cm deep over the entire meadow, and is underlain by sand and grus with some interbedded organic material. The present peat is apparently the result of Neoglacial-age wet conditions during the past 2000 to 3000 years.

This interpretation is reinforced by the occurrence of thin layers of volcanic ash at depths of 17 and 36 cm in the Harden Lake meadow peat. Similar ash layers were found in deposits within Neoglacial moraines above Siesta Lake, about 6.5 km south of Harden Lake meadow. Although the ashes have not been chemically correlated between the two sites, they are probably the same ashes at both localities; one of them probably also corresponds to the 1200 yr BP ash recognized by Wood (1975).

A shallow peat deposit comparable in depth to the Harden Lake meadow peat was also found on the upslope side of the outermost moraine (moraine 5) on the side of the hill to the west of Harden Lake meadow. The ages of the two depressions are different, and the presence of similar surface deposits is therefore taken as evidence that peat-forming conditions were not active in this area during the mid-Holocene, but were initiated at the start of the Neoglacial interval some 2000 to 3000 years ago. This is in general agreement with the conclusions reached by Wood (1975) in his study of mountain meadow deposits of the Sierra Nevada.

Two samples were studied for this report. The first, sample 115, was taken from the surface of the meadow; the cysts are shown on plates A-E. The other, sample 117, came from a depth of 36 cm, next to a thin volcanic ash horizon; cysts from sample 117 are shown on Plates F-I. The cyst assemblages are distinctly different; whether the differences can be attributed to the effects of the ash layer is not known. A list of the cyst types encountered in the two samples is shown in Table 1.

Cyst_type	Surface	36_cm		Cyst_type	Surface	36_cm
1	?			271	X	
2	X	X		274	X	
5	X			275	X	
6		X		276	X	
18	X	X		277	X	
36		X		279	X	
51		X		287	X	
155	X	X		294	X	
156		X		295	X	
159		X		296	X	
160	X			298	?	
161	X	X		334	?	X
190	?			335		X
200		X		337		X
205	X			338		X
206	X	X		339		X
257	X			340		X
258	X			341		X
259	X			342		X
260	X			343		X
261	X			344		X
262	X			345		X
263	X			346		X
264	X			347		X
265	X			348		X
266	X			372		X
268	X			373		X
269	X			376		?
270	X					

Table 1.--List of cyst types found in samples 115 and 117.

REFERENCES CITED

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

Grospietsch, Th., 1980, Rhizopoden in der Moorforschung: in Göttlich, Karlhans, Moor- und Torfkunde, ed. 2, Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung, p. 38-46.

Mahood, Albert D., and Adam, David P., 1979, Techniques used for the cleaning, concentration, and examination of chrysomonad cysts from sediments: U. S. Geological Survey Open-File Report Number 79-1431, 5 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.

Wood, Spencer H., 1975, Holocene stratigraphy and chronology of mountain meadows, Sierra Nevada, California: Ph.D. dissertation, California Institute of Technology, Pasadena, California, 180 p.

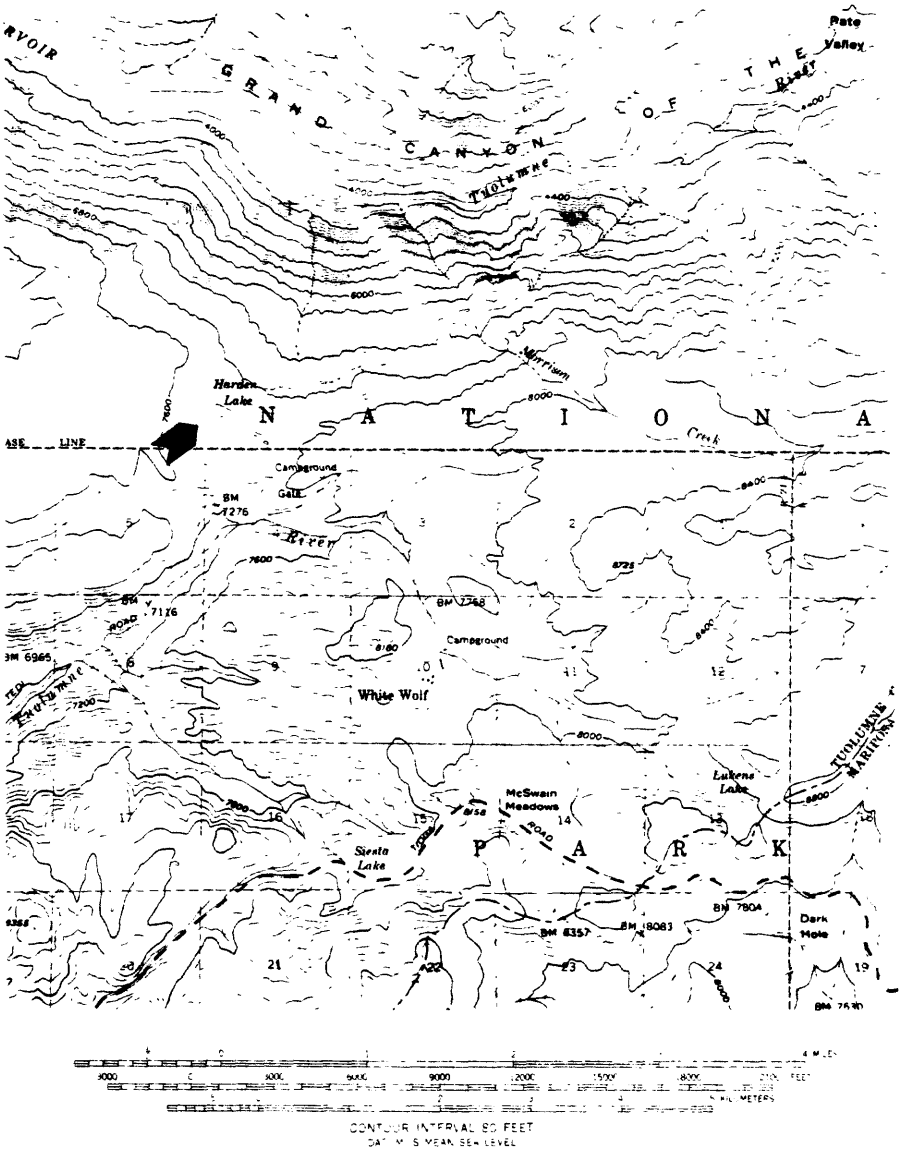


Figure 1.--Map showing the location of Harden Lake and Harden Lake meadow (arrow). Map is reduced from part of the USGS Hetch Hetchy Reservoir 15-minute quadrangle.

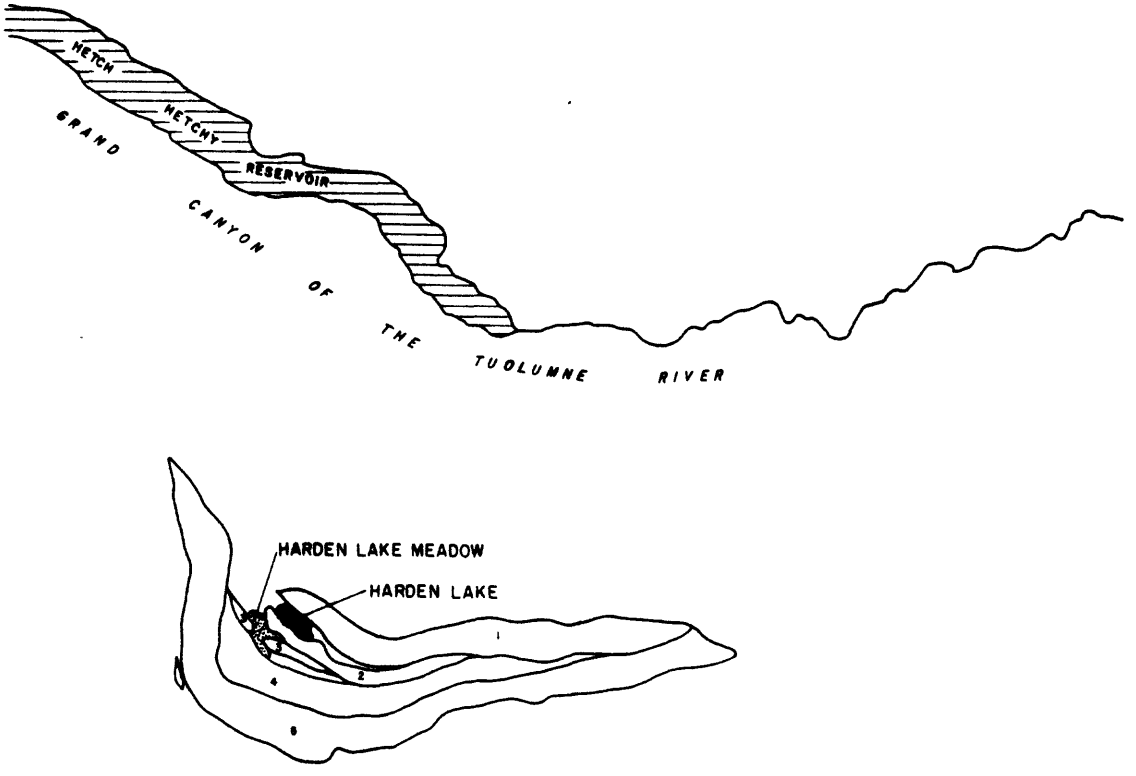


Figure 2.--Outline map showing relations of the moraines near Harden Lake and Harden Lake meadow. Moraines are numbered from 1 (youngest) to 5 (oldest). Outlines were traced from aerial photograph number GS-VJS 2-11, taken on 26 September 1955.

Harden Lake Meadow, Plate A
Sample 115, taken from modern surface
scale bar = 3 micrometers

1 - Type 5

2 - Type 5

3 - Type 160

4 - Type 2

5 - Type 2

6 - Type 2
(with adhering debris)

7 - Type 1?

8 - Type 257

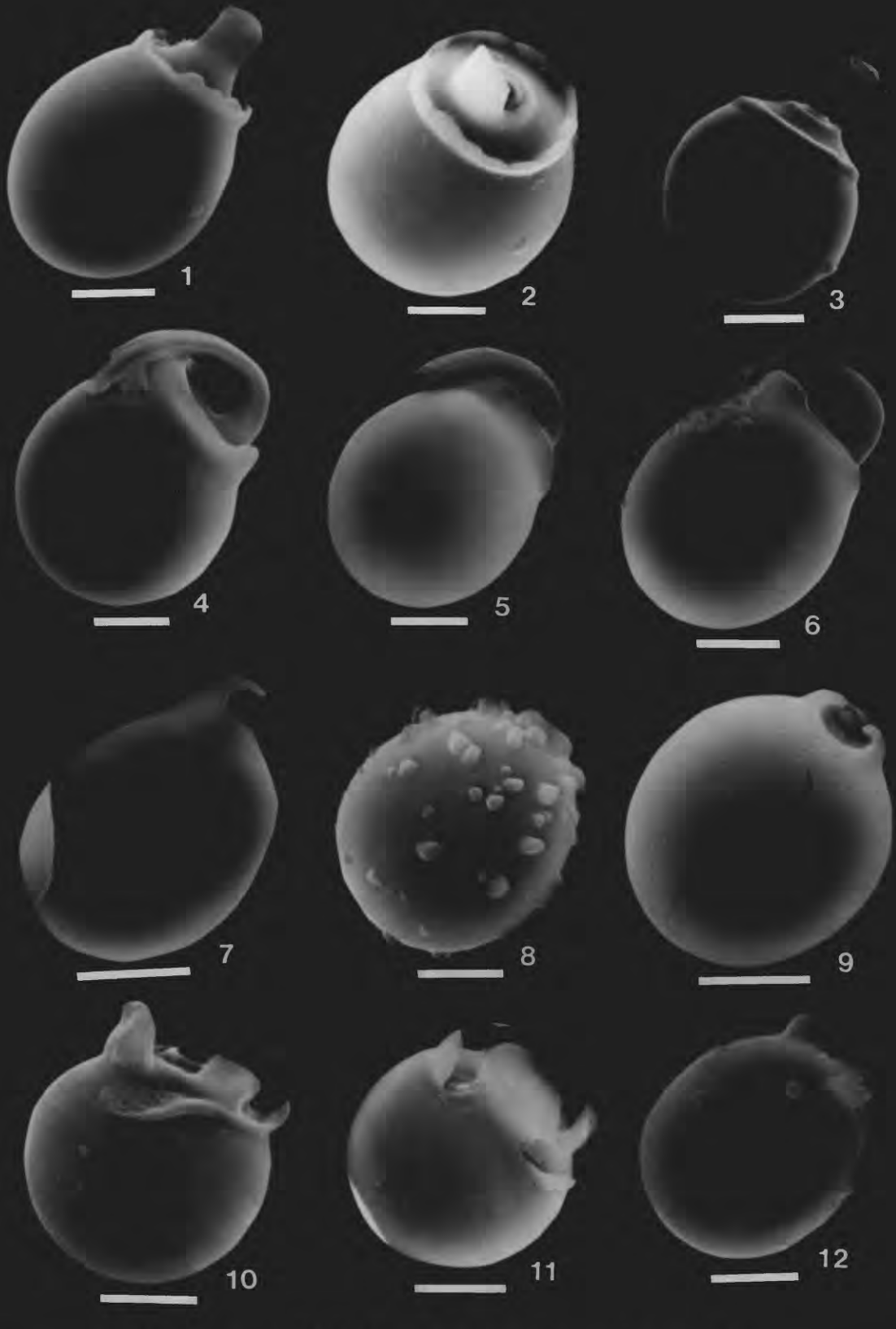
9 - Type 258

10 - Type 259

11 - Type 259

12 - Type 260

Harden Lake Meadow - Plate A



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Harden Lake Meadow, Plate B
Sample 115, taken from modern surface
scale bar = 3 micrometers

1 - Type 261
(plug is still in aperture)

2 - Type 262
(aperture not visible)

3 - Type 263
(aperture not visible)

4 - Type 261
(with adhering debris - aperture at top right(?))

5 - Type 261
(aperture not visible)

6 - Type 261
(aperture not visible)

7 - Type 294

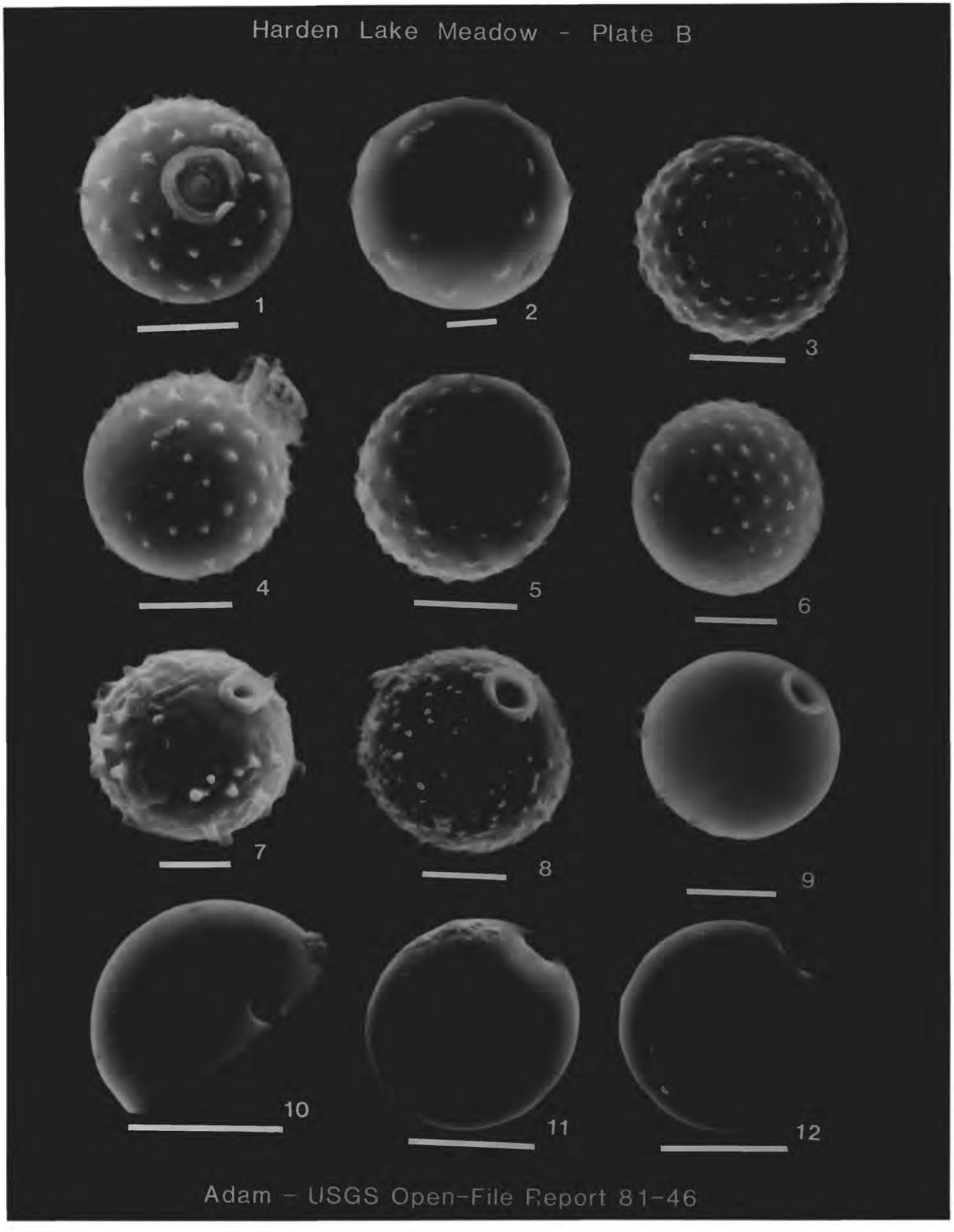
8 - Type 295

9 - Type 296

10 - Type 264
(probably not a chrysomonad)

11 - Type 264
(probably not a chrysomonad)

12 - Type 264
(probably not a chrysomonad)


Harden Lake Meadow - Plate B
1
2
3
4
5
6
7
8
9
10
11
12
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Harden Lake Meadow, Plate C
Sample 115, taken from modern surface
scale bar = 3 micrometers

1 - Type 265

2 - Type 266

3 - Indeterminate cyst

4 - Type 287

5 - Type 205

6 - Type 268

7 - Type 269

8 - Type 270

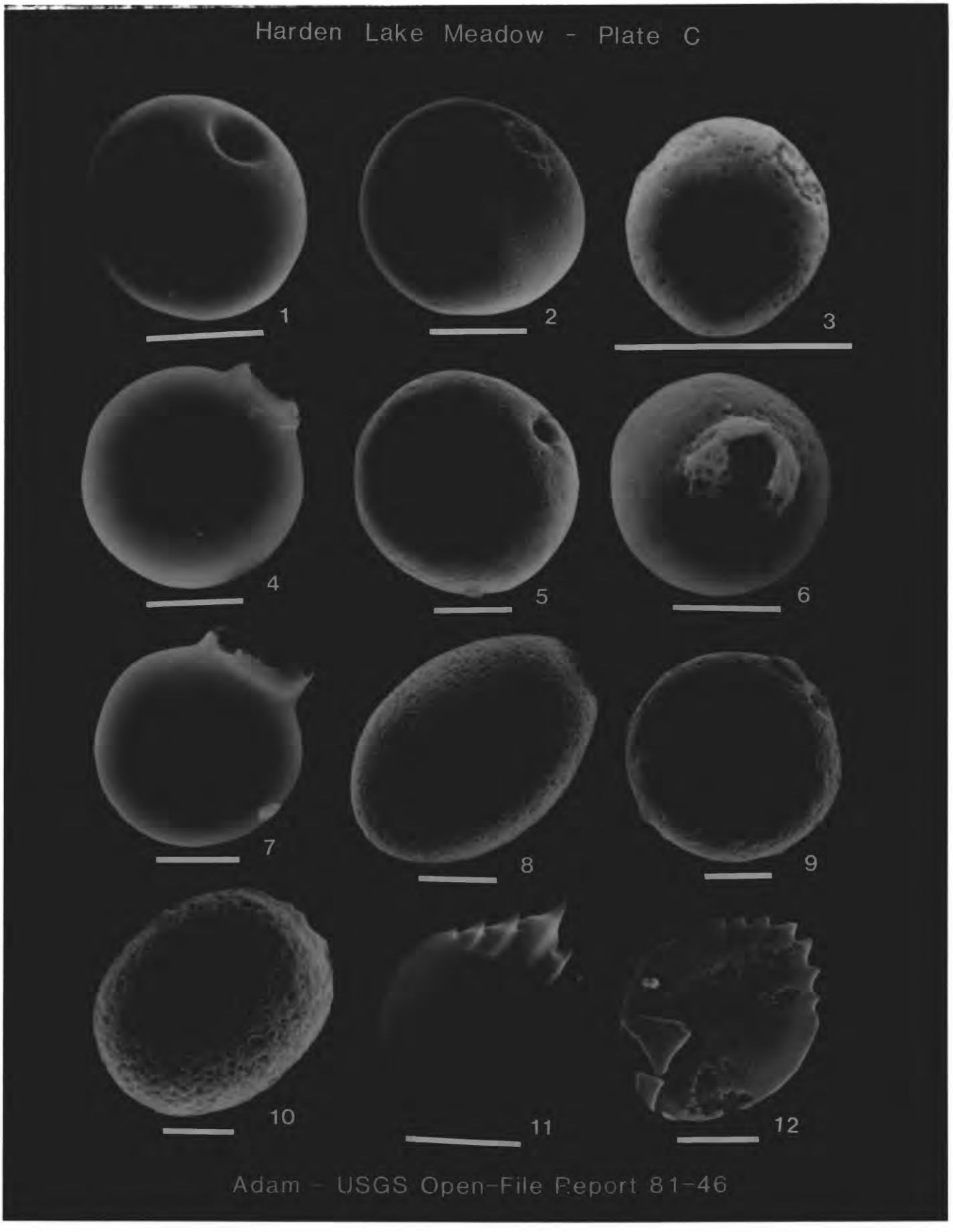
9 - Type 271

10 - Type 190(?)

11 - Rhizopod scale
(cf. Euglypha acanthophora in Grospietsch, 1980, Plate 21J, fig. 9)

12 - Rhizopod scale
(cf. Euglypha acanthophora in Grospietsch, 1980, Plate 21J, fig. 9)

Harden Lake Meadow - Plate C



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Harden Lake Meadow, Plate D
Sample 115, taken from modern surface
scale bar = 3 micrometers

1 - Type 18

2 - Type 18

3 - Type 18(?)

4 - Type 274

5 - Type 275

6 - Type 18(?)
(with adhering debris)

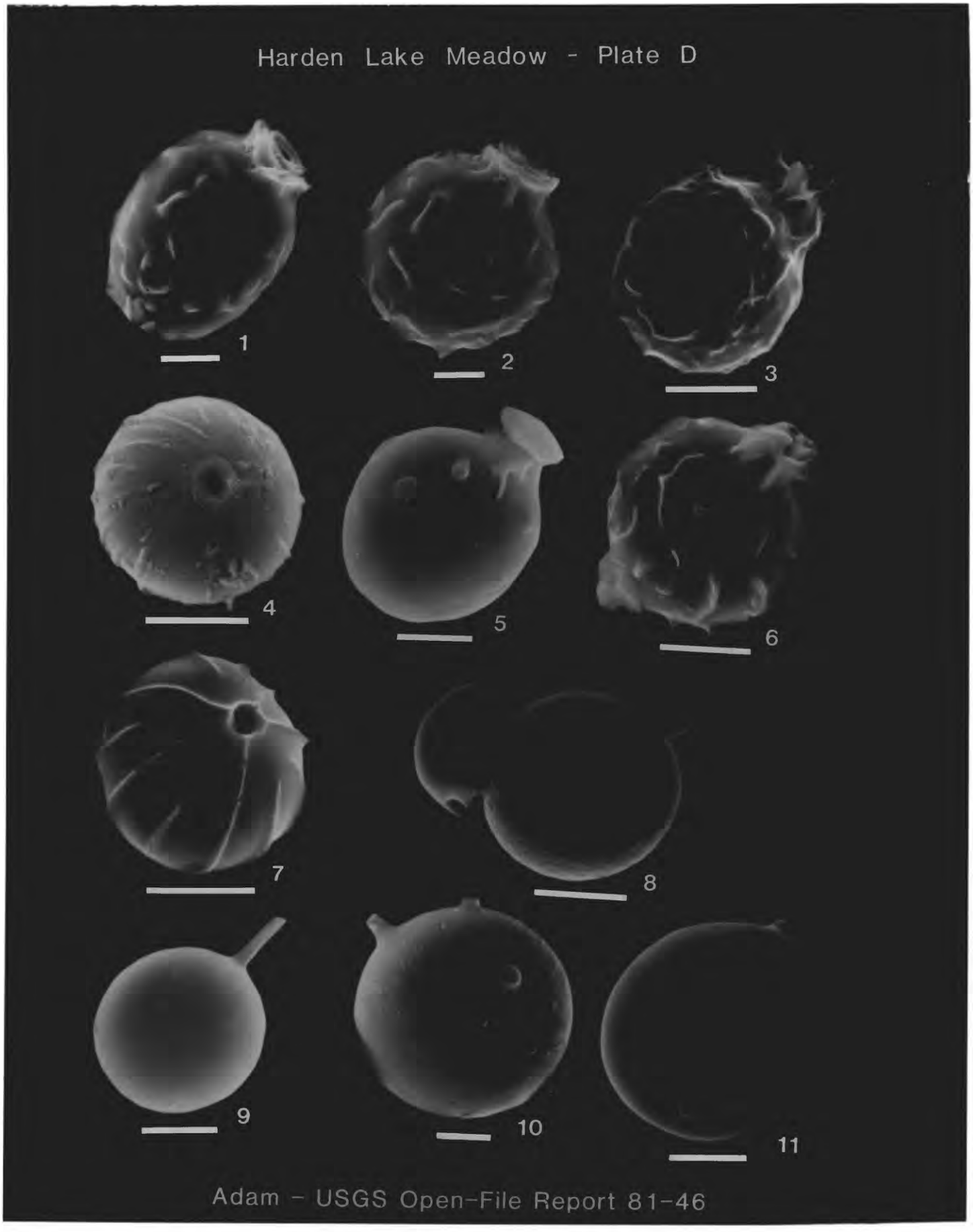
7 - Type 276

8 - Type 277
(with a Type 264 attached at left)

9 - Type 298(?)

10 - Type 298(?)

11 - Type 2


Harden Lake Meadow - Plate D
1
2
3
4
5
6
7
8
9
10
11
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Harden Lake Meadow, Plate E
Sample 115, taken from modern surface
scale bar = 3 micrometers

1 - Type 279

2 - Type 206

3 - Type 334(?)
(aperture not visible)

4 - Type 155

5 - Type 155
(with adhering debris - aperture not visible)

6 - Type 155
(aperture not visible)

7 - Type 155

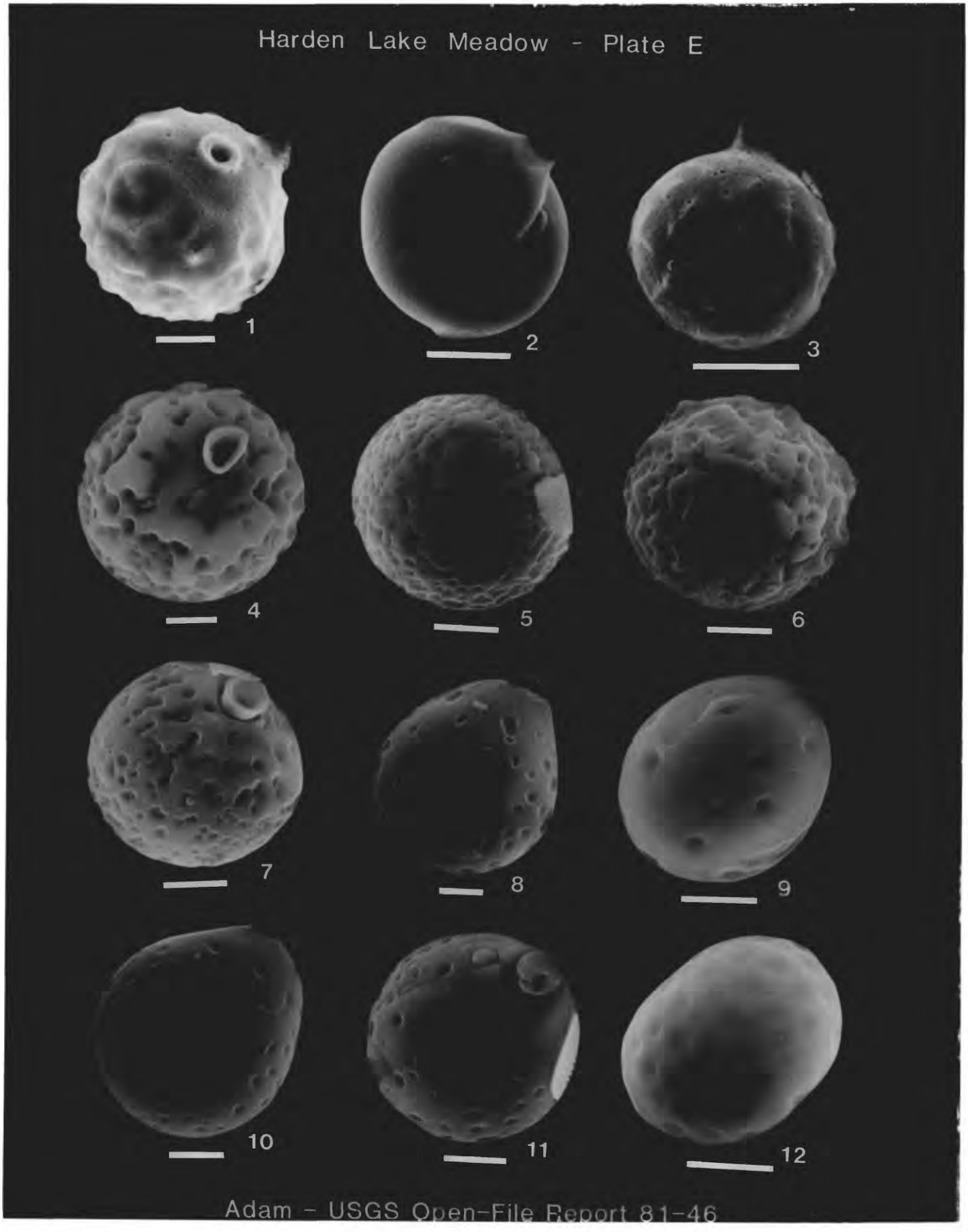
8 - Type 161

9 - Type 161

10 - Type 161

11 - Type 161
(bright patch at right is debris)

12 - Type 161(?)


Harden Lake Meadow - Plate E
1
2
3
4
5
6
7
8
9
10
11
12
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Harden Lake Meadow, Plate F
Sample 117, taken from a depth of 36 cm
scale bar = 3 micrometers

1 - Type 161

2 - Type 334

3 - Type 155(?)

4 - Type 6

5 - Type 200

6 - Type 155

7 - Type 335

8 - Type 335

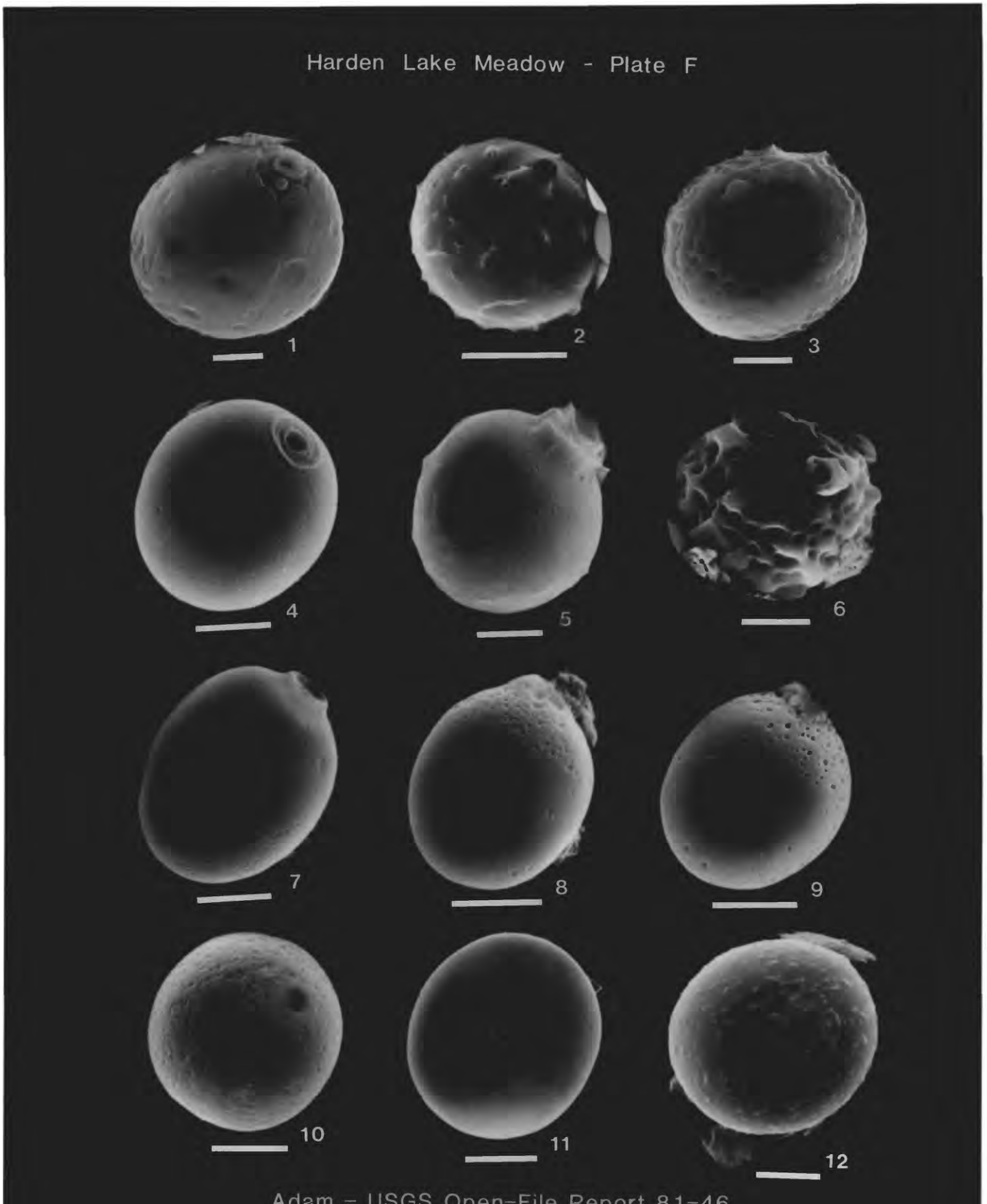
9 - Type 335

10 - Type 51

11 - Type 51

12 - Type 372

Harden Lake Meadow - Plate F



Adam – USGS Open-File Report 81-46

Harden Lake Meadow, Plate G
Sample 117, taken from a depth of 36 cm
scale bar = 3 micrometers

1 - Type 156

2 - Type 156

3 - Type 156

4 - Type 156

5 - Type 2

6 - Type 159

7 - Type 2

8 - Type 2

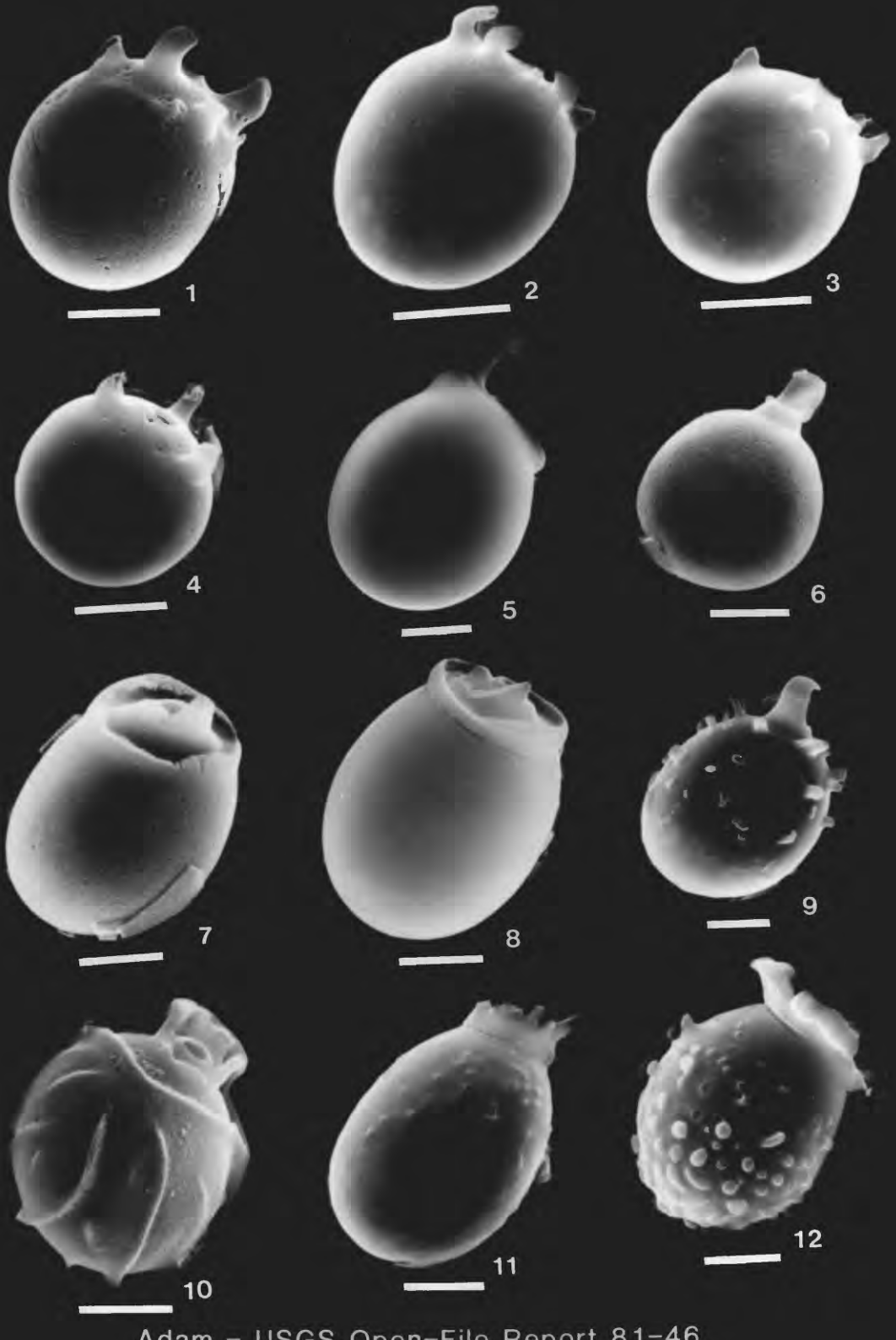
9 - Type 373

10 - Type 337

11 - Type 338

12 - Type 36

Harden Lake Meadow - Plate G



Adam - USGS Open-File Report 81-46

Harden Lake Meadow, Plate H
Sample 117, taken from a depth of 36 cm
scale bar = 3 micrometers

1 - Type 342

2 - Type 343

3 - Type 344

4 - Type 345

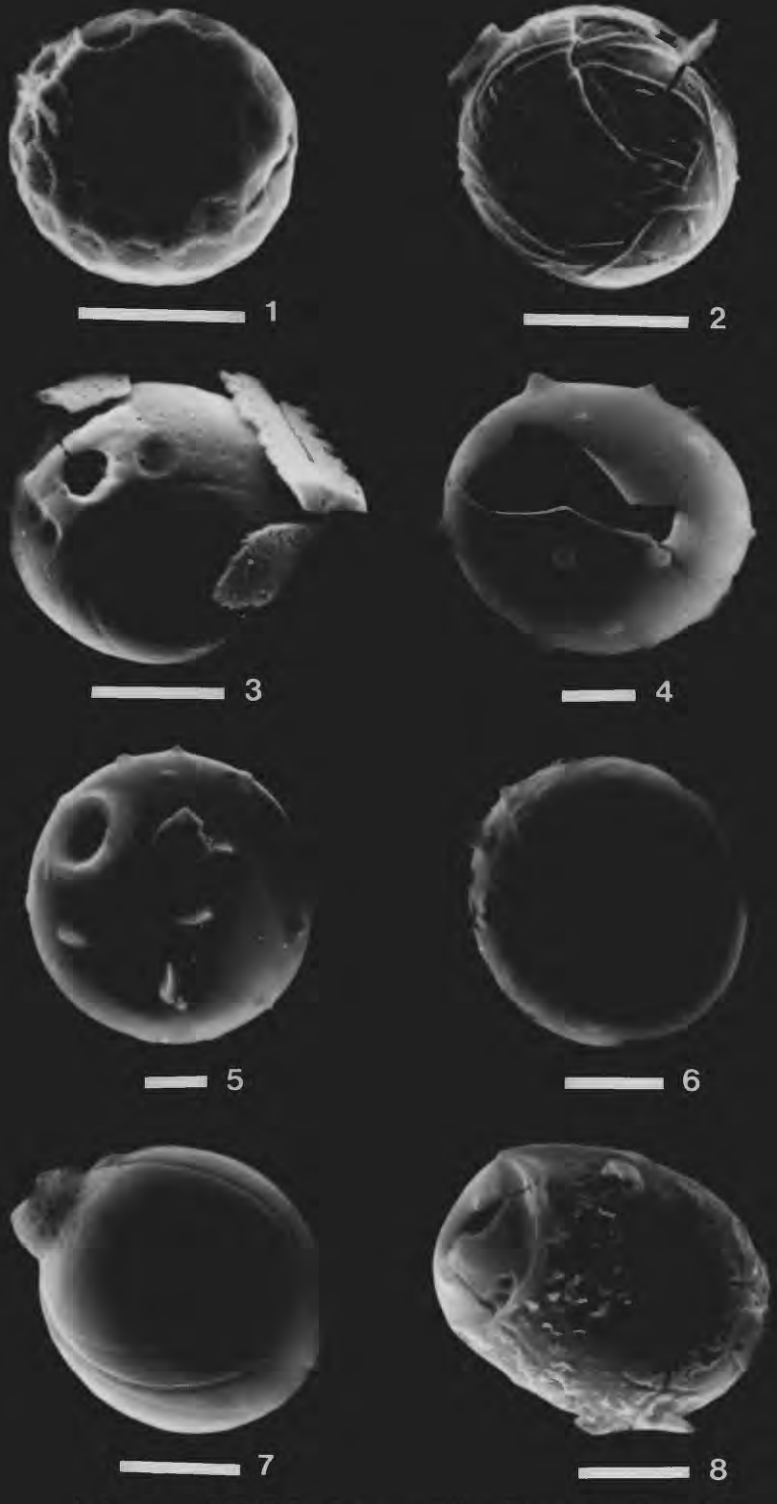
5 - Type 346

6 - Type 347

7 - Type 348

8 - Type 376(?)

HARDEN LAKE MEADOW PLATE H



Adam – USGS Open-File Report 81-46

Harden Lake Meadow, Plate I
Sample 117, taken from a depth of 36 cm
scale bar = 3 micrometers

1 - Type 18

2 - Type 18

3 - Type 18

4 - Type 339

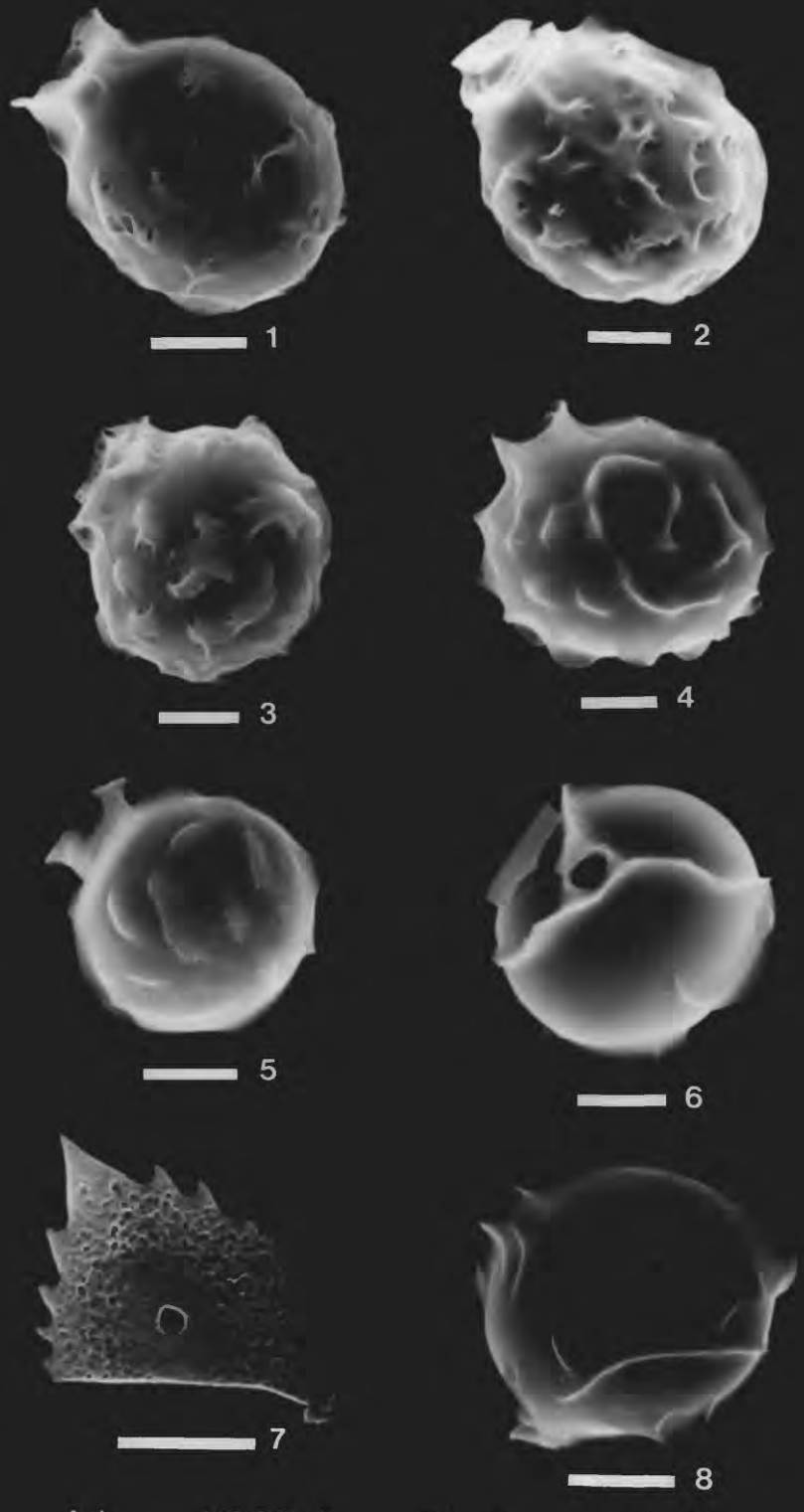
5 - Type 340

6 - Type 206

7 - Rhizopod scale
(cf. Euglypha acanthophora in Grospietsch, 1980, Plate 21J, fig. 9)

8 - Type 341

HARDEN LAKE MEADOW PLATE I



Adam - USGS Open-File Report 81-46

APPENDIX A

PREVIOUS REPORTS IN THIS SERIES

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

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Adam, David P., and Mahood, Albert D., 1979, Chrysomonad cysts from Upper Echo Lake, El Dorado County, California: U. S. Geological Survey Open-file Report Number 79-1461, 21 p. + 12 plates.

Adam, David P., and Mehringer, Peter J., Jr., 1980, Modern and Holocene chrysomonad cysts from Lost Trail Pass Bog, Montana: U. S. Geological Survey Open-file Report Number 80-797, 13 p. + 5 plates.

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Adam, David P., and Mahood, Albert D., 1980, Scanning electron micrographs of chrysomonad cysts from Suzie Lake, El Dorado County, California: U. S. Geological Survey Open-File Report Number 80-1250, 11 p., including 2 plates.

Adam, David P., and Mahood, Albert D., 1981, Scanning electron micrographs of chrysomonad cysts from Lake Aloha, El Dorado County, California: U. S. Geological Survey Open-File Report Number 81-45, 12 p., including 3 plates.