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Lake Baikal Diatom Taxonomy Workshop

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Of the 31 photographs taken during the workshop, 22 were considered good for conveying the concepts of the taxa considered during the meeting. These are attached separately as hard copy (Appendix 1). In future, these can be supplied on CD-ROM (or individual ones, if institutions have the available hardware to read such files and software to view and print the images properly. Currently, images are stored in TIFF format, though they can be converted to other formats (such as JPEG) at the ECRC.

1. Introduction (Rick Battarbee)

Following a welcome to the ECRC, Rick Battarbee went on to stress the importance of quality assurance in environmental science. It is a fundamental principle of science that results are reproducible. Standardisation of methods is an important element in achieving this objective. Water chemistry has long practised analytical quality control (AQC) within and between laboratories. For biology, taxonomic quality control (TQC) is more recent but an equally important issue, especially in international studies involving shared material. This is particularly true for Lake Baikal diatom studies where teams in the USA, Russia, UK, Japan and others are working on major projects based on diatom remains in long and short sediment cores. This workshop marks the first real attempt to introduce taxonomic control into these projects.

For TQC there are no absolute standards but results can be co-ordinated and harmonised by mutual agreement and identifications checked where appropriate with 'type' material conserved in museum herbaria. Nevertheless, there are specific issues that require attention before TQC can be put into practise:

1. **Synonyms**: agreement to use the same names

2. **Taxonomic discrimination**: agreement to use the same level of taxonomic splitting or lumping of taxa. To what level can taxa be separated? This is an especially important question for fossil material: there is a need to consider how different states of preservation for each taxon can be recognised in a standardised, reproducible way.

3. **Laboratory conventions** need to be harmonised: counting cells or valves, colonies or individuals, how are broken valves counted?

4. **Mistakes**: these inevitably occur and mechanisms should be agreed whereby they can be recognised and corrected.

5. **Real problems**: these arise where the literature is confused or where taxa are undescribed. Some of these can be resolved during workshops but some may need clarifying by more research. Temporary names and images can serve to differentiate forms pending in-depth taxonomic research.

Procedures: Co-ordinated international and national workshops are needed to identify problems and issues so that consensus can be achieved for identification of previously described or temporarily-named taxa occurring in the research material available. New or amended descriptions with photographs should be assembled into an atlas or iconograph series. The effectiveness of the agreements and conventions reached should be assessed by joint inter-laboratory analysis of unprovenanced test material. Only from the results of such 'blind' counting can inter-laboratory analyses be shown to have comparable TQC. This procedure has been practised before in other international diatom studies, see Kreiser & Battarbee (1988) and

Munro *et al.* (1990), and offers an effective way of testing workshop generated taxonomic protocols (see section 7 and Appendix 2).

2. Taxonomic sessions

A. *Cyclotella* spp. (Roger Flower)

Cyclotella minuta/ornata/baicalensis : There is an urgent need to decide on the taxonomic differentiation (though not necessarily the biological truth of such splits) of the so called "*C. minuta*-group" in Lake Baikal. The primary aim of this task is to aid palaeoecological interpretation of sediment records.

Across the whole size range of these endemic *Cyclotella* taxa, Yelena Likhoshway and others consider that intermediate forms exist between all the morpho-types. This may be so but since the 'morph-types' can be recognised, it was agreed to split the taxa for palaeoecological interpretation. This pending further work on the biological validity of these forms using SEM and culture studies. The following agreements were made:

C. minuta: elliptical to round valves up to 40 µm in diameter, usually less than 15 processes in central area. Intermediates from 30-40 µm diameter - but agree to separate larger forms as follows: *C. minuta f. ornata* above 40 µm and *C. minuta f. minuta* below 40 µm. It was agreed to look into the problem of discrimination of taxa in the 30-40 µm range. Above 80 µm, it was agreed to call these forms fall into *C. baicalensis.* This latter taxon is also differentiated by fewer thickened costae (< 10 per valve) that are usually asymmetric (restricted to one side of the valve only). Galina Khursevich noted that *Cyclotella baicalensis*-type taxa in geologically old sediment tend to have fewer central area fultuportulae, thickened costae are fewer and again usually distributed asymmetrically.

DNA sequencing work is in progress at the Limnological Institute (LI) and results will be used to assess the biological validity of the above taxonomic splits. Results may indicate morpho-species if not actual species.

So far, three morphotypes can be recognised based *inter alia* on size classification . David Jewson in his monitoring programme also identifies two *Cyclotella* size groupings in Lake Baikal separated by time (seasonal). The three morphotypes identified above were agreed upon. The LI laboratory will do some gene sequencing on the morphotypes to see if they are indeed different species.

The issue of *Cyclotella* preservation was raised. Taxonomic difficulties may arise with dissolved valves: without the costae, central areas may look similar.

Preservation issues (David Ryves)

David Ryves stressed the importance of separating valves into dissolution categories ("stages"), based on morphological appearance under light microscopy (LM). There are, for example, four recognisable stages of preservation for *Cyclotella*. Samples from different environments were compared in LM during this workshop session where it was noted that turbidites have different preservation signals.

To quantify down core preservation the simplest method is to take the ratio of pristine to dissolved valves. This is quick to do. This pristine : non-pristine ratio or diatom dissolution index (DDI) approach was first noted in Flower & Likhoshway (1993). In some sediment cores, sections where diatom concentrations are low tend to have poor preservation of valves. A spatial map of preservation in Baikal would be useful (and possible; where DDI is measured for surface sediments). **It was agreed to do % pristine : non-pristine in routine analysis.** It was recommended to compare preservation in inter-stadial and stadial periods where anecdotal evidence suggested preservation was possibly better in 'warm' periods. David Ryves to provide a description of dissolution stages of the main taxa encountered in sediments (see section 4). The four stages of dissolution of *C. minuta* are given in Flower (1993a).

It is possible to separate valves and cells with protoplast but this is only applicable to trap and surface sediment material (this was not done for trap material & surface sediments studied so far at ECRC).

Separating stages in SEM may need further criteria - possibility of an "ultra-pristine" ("stage 0") form for fresh valves (with no pre-treatment with oxidising agents, the "living" surface may be preserved in fresh and some trap material). Under LM, however, this detail cannot be seen and the distinction cannot be made within stage 1 valves which are accorded 'pristine' status in routine counting.

<u>Problems</u>: separating taxa in very poor preservation states is difficult but relative size (and shape for more elliptical central areas) and number of the central area processes are the best guides to taxon identification.

Breakage was not specifically discussed but in undisturbed sediments valve thinning by dissolution may promote breakage during preparation/sampling.

David Jewson talked from an "ecologist's point of view" noting that competition occurs between *C. minuta*-group and *A. baicalensis*. He has tried to grow in culture 45 isolates, 15 µm to above 105 µm cell size diameters and asked the question 'What simple feature can be used to separate the sister taxa?'. Following Flower (1993b), he concluded the ratio of radial striae to costae would be a good guide. *C. baicalensis* can occur down to 40 µm, *C. ornata* up to 90 µm. Although one *C. minuta* of 52 µm diameter was noted in culture. for practical purposes, an upper size limit of 40 µm should be adhered to for field studies of this taxon.

Seasonal changes: are the morphological features flexible? This has not yet been tested but, in on-going experiments where re-isolation of cells is practised frequently so that size range remains 'natural', it is hoped that culture studies will yield results relevant to the lake populations.

Auxospores are poorly silicified and probably only occasionally preserved in sediment . It was proposed to check auxospores found in traps (*Aulacoseira* or *Cyclotella* auxospores).

Some culture-derived evidence so far that taxa are different is that *C. minuta* has a higher temperature tolerance than *C. ornata*.

B. *Aulacoseira* spp.: (Yelena Likhoshway & David Jewson)

A. baicalensis & *A. islandica* are the focus of on-going international studies. The taxa are separated by the number of areolae and the number of rows in 10 µm (see below). Characteristics of resting stages: *A. islandica* has bullet-shaped resting spores while the longer thickened cells of *A. baicalensis* represent the resting stages. There appear to be rows of rimoportulae on the valve sides, and it was speculated what purpose these might serve. David Jewson noted that *A. baicalensis* has lower relative growth rate in culture.

A. granulata is occasionally found with a different form of both linking spines (branched) and rimoportulae. Together with *A. subarctica*, *A. ambigua* (typical) and *A. volgensis* (spiralled striae), these taxa are often associated with shallow bays in Lake Baikal, rather than the open water.

David Jewson noted that *A. islandica* grows from spores in autumn in Chivyrkuy Bay.

Babanazarova *et al* (1996) found than areolar density is 250-500 per 100 μm^2 for *A islandica* but less for *A. baicalensis* where the density is usually less than 100 for the same area.

Data to distinguish taxa are given in Babanazarova *et al.* (1996). The following are based on these:

A. baicalensis Spring populations: Cell diameter, 9-34 µm, areolae, 8-11 rows/10 µm; 4-13 areolae/10 µm of row; diameter: 9-34 µm, length: 10-30 µm
Summer and winter populations: number of rows of areolae 7-9 rows/10 µm ; 3-8 areolae/10 µm; cell diameter: 9.5-25 µm; cell length: 18-70 µm
Overall ranges (from this paper & literature): 6.5-11 rows in 10 µm; 3-13 areolae in 10 µm; cell diameter: 6-37 µm; cell length: 10-72 µm.

Baikalian *A. baicalensis* In this taxon the areolae can vary within one chain of valves and differ in winter and spring (finer) populations. Resting cells: these have thick walls, 3-8 areolae in 10 µm. Cells are longer and a size cut-off is difficult to define but these resting stage cells are frequently greater than 50 µm long.

Baikalian *A. islandica* (=*A. skvortzowii* but will probably be renamed *A. islandica* forma *spora*) Diameter: 5-19 µm, 8-36 µm long (mantle height); 14-18 rows in 10 µm, 16-24 areolae in 10 µm along a single row. Sometimes extreme cells can fall outside these ranges.

This taxon does not seem to occur in most Pleistocene sediments but some occur in the early Pleistocene. (*A. subarctica* also occurs in old sediments and this has a deeper sulcus and stronger spines. In Miocene deposits two species occur, including *A. preislandica v. tunka*, but more investigation is needed.

A. islandica has been examined from various locations in Baikal (modern, fossil and from sediment traps) and we recommend the use of the name *A. islandica* but specify that it is the form that produces spores (hence "forma *spora*"). A comparison was also made with *A. islandica* from Northern Ireland.

It was noted that some *A. islandica* cells possess domed cell ends in their vegetative state.

Saturday April 25th

C. *Stephanodiscus* spp. (Anson Mackay & Galina Khursevich)

RECENT SEDIMENTS (Anson Mackay)

In the last few hundred years of the sediment record *Stephanodiscus* spp. increase in some cores . This is particularly so for some short cores from the Academician Ridge area. There is a ca. 17th century peak in *S. cf. parvus* in several cores. This taxon has been called *S. parvus* and *S. binderanus* elsewhere - what is the identity of this taxon?

S. binderanus v. baicalensis (Genkal & Popovskaya 1990) - this has a central process whereas it is believed that the nominate variety does not. Hence, a new species will be proposed (*S. meyerii* Genkal & Popovskaya in press) for this taxon. Its characteristics are: diameter 7.7 -12.3 µm; 12-14 spines/ridges in 10 µm; areolae 27-35 in 10 µm. One central area fultoportula with 2 satellite pores (laterisquamae). Short spines with 5 points, marginal fultoportulae (8-13/valve) have 3 satellite pores. One rimoportula (r/p) occurs on a ridge that also supports a fultoportula.

Diagnosis under LM: It is difficult to see branched spines in LM so use striations, process and deep mantle.

S. minutulus - from fossil Pleistocene material in Germany. From Khursevich (1989): valves are 4-10 µm diameter, very distinct undulation, areolae 30-35 in 10 µm striae have 2 or 3 rows near margin; 15 - 20 costae in 10 µm. One central fultoportula, one rimoportula on the mantle/face boundary, 2-3 areolae in mantle arranged in short rows. Spines on each costa on boundary.

S. cf. parvus Diameter 5-11 µm, areolae 25-30 in 10 µm. Fascicles only contain 2 rows of areolae at margin. Hyaline ridges divide face, costae 13-15 in 10 µm. 1 central area fultoportula; 1 rimoportula. Marginal fultoportulae under spines, 6 spines to one fultoportula, spines simple. Valve face flat. Mantle is short but of a depth sufficient to accommodate 4-5 areolae. More material needs to be examined under SEM and could well be related to *S. meyerii*. The literature is confused concerning *S. parvus* because of a problem with the original description. SEM photographs of *S. parvus* (e.g. Anderson 1990) show valves with simple spines and very short mantle zone. Unfortunately in sedimentary material from Lake Baikal, the mantle area of these species are often not preserved.

Using material from BAIK25:

Stephanodiscus sp. 1 = *S. obscura*? Another undescribed *Stephanodiscus*-like taxon has been identified in THIS short core. *Stephanodiscus* sp. 1 = *S. obscura* has a diameter 8-12 µm, with unistriate rows of areolae, 1 or 2 central area fultuportulae, spines compound, convex valves. 14 striae in 10 µm; 22 spines in 10 µm. Awaiting confirmation in SEM.

Using older material from longer cores:

Galina Khursevich described *S. exiguus*, a form with short cylindrical cells, inter-locking valves, and a flat valve face. 3.8 -12.3 µm in diameter; 10-15 areolae in 10 µm, in uniseriate striae. Interstriae 8-10 in 10 µm. There is a single central fultoportula on valve face. Internally slit near valve mantle boundary. Marginal fultoportulae are located at the base of hyaline strips beneath every second or third, rarely every fourth spine. Spines are forked or finger-branched. Mantle from 0.7-5 µm deep. Coarse areolae of valve face (cf. *S. binderanus* which has bi- or tri- radiate striae and ca. 10 spines in 10 µm). Similar to Anson Mackay's *Stephanodiscus* sp. 3. Flatness of valve face not a good diagnostic feature of species. In press (Proceedings of the XIV Diatom Symposium, Japan 1996). *Stephanodiscus baicalensis* was also described from Pleistocene sediments, but this form has no valve face fascicular structure.

The issue of whether some of these taxa can be placed legitimately in the *Stephanodiscus* genus was raised by Roger Flower. It was generally agreed that some newly described species would probably need to be placed in new genera. One taxon, *S. inconspicuus*, has already moved out into a new genus (see *Crateriportula*, Flower & Håkansson 1994). However, it was agreed that for the purposes of taxonomic harmonisation, the workshop participants would retain the use of '*Stephanodiscus*' sensu lato as a genus complex. For the present, any splitting of this genus for Baikalian species is deferred or left to other specialists in diatom taxonomy.

Summary:

For practical diatom analysis a robust way of splitting taxa is required. This can be achieved by recognising key diagnostic features:

For the *S. cf. parvus/binderanus/meyerii* separation, it is suggested that the mantle, processes and spines are useful distinguishing features, at least in fresh material.

(A) **long mantle** - if it has a central process and branched spines, then *S. meyerii (= binderanus v. baicalensis*; for photo see figs. in Genkal & Popovskaya 1990); if no central process, then *S. binderanus v. binderanus* (see Round 1972; Genkal & Popovskaya 1990).

(B) **short mantle**: if has a conspicuous fultoportula, simple spines, then *S. cf. parvus* see photo in Figs. 1-4 p.378 (Krammer & Lange-Bertalot *Susswasserflora* 2/3); Plate 44 Fig. 4 Khursevich (1989); if no central fultoportula, then *S. hantzschii* - derived from Krammer & Lange-Bertalot *Susswasserflora* 2/3. See *S. minutulus*: Khursevich (1989) Plate 40, figs.1-6.

Recommendations:

More LM and SEM work on the *S. binderanus* group is needed. Yelena Likhoshway will contribute more photographs for next workshop.

"*S. parvus*" (as we have it in Baikal material) has a higher mantle than *S. parvus* (*sensu* Krammer & Lange-Bertalot *Susswasserflora* 2/3) and it was agreed to call these forms *S. cf. parvus* (it has the essential feature of an offset central strutted process), pending further work.

PLEISTOCENE AND EARLY HOLOCENE TAXA (Galina Khursevich)

There are at least 3 groups of *Stephanodiscus* taxa (all endemic, all extinct) that occur in Baikal sediment - all have an unusual rimoportula external opening without tubular extension (rare in *Stephanodiscus*).

S. grandis

High mantle (5-10 µm); poorly developed fascicles but areolae more or less cover valve face. Several rimoportulae (4-8 per valve) with no external tubules; very many marginal processes not connected to spines. Several (>10) central processes (fultoportulae). Diameter: 35-125 (rarely to 140) µm, 10-16 areolae/10 µm; rows of areolae do not continue onto mantle - also unusual for *Stephanodiscus*.

S. grandis var. entis was found only in one minor section of one long core. Hyaline ribs extend to mantle, these support the rimoportulae & marginal fultoportulae. Otherwise, similar to the nominate variety.

S. immensus, similarly, has rimoportulae with no tube and an indistinct fascicle structure. Found in Armenia from upper Pliocene, lower Pleistocene.

S. carconeiformis (25-41 µm diameter)

Western USA type material of *S. carconensis* was studied by GK: differences exist between this and the Baikal form. Julius *et al.* (1997) published two varieties of this latter species. It is however thought unlikely that *S. carconensis* is found in Baikal. For example, there are wedge-like multiseriate fascicles going from the centre in *S. carconensis* while *S. carconeiformis* has the areolar fascicles only in submarginal zone of the valve face. Costae are dichotomously branched in *S. carconeiformis*. *S. carconeiformis* has 2 or 3 rimoportulae, and central fultoportulae with 2 satellite pores occur near the centre. *S. carconensis* possesses one rimoportula and central fultoportulae with 3 satellite pores. Costae 4-6 in 10 µm in *S. carconeiformis* against 1-2, rarely 3 in 10 µm in *S. carconensis*.

Also Françoise Gasse's large African *Stephanodiscus* species differ too (Gasse 1986). *S. carconeiformis* has interfascicles from centre to mantle (more organised than *S. grandis*) and these split further near to mantle (additional hyaline areas between fascicles near edge). *S. carconensis* & var. occur in Lake Biwa sediments (and others). Likhoshway (1996) describes *S. khurseviczae* that differs by having coarser valve face areolae.

S. formosus (= S. bellus) - (12-25 µm diameter) has distinct interfascicles to centre.

S. formosus v. minor (9-16 µm diameter) - only a few central processes; in sediment may have all intermediate forms (may be all same). This variety has a more or less structureless central area; the nominate var. has areolae in middle, and hyaline area similar to nominate (areolae end half way down mantle).

S. formosus var. *formosus* and *S. formosus* var. *minor* differ from *S. carconensis* var. *pusilla* and *S. carconensis* var. *minor* by the presence of multiseriate areolar fascicles only in submarginal zone of the valve face too, as well as by the larger number of costae in 10 µm (5-8 in 10 µm against 3-4 costae in 10 µm in *S. carconensis* var. *pusilla*).

S. carconeiformis co-exists & co-varies with *S. grandis* and is also found with *S. formosus*.

S. flabellatus - (22-50 µm diameter) was described in Loginova & Khursevich (1986). It is more characteristic for the Upper Pleistocene sediments of Lake Baikal. Uniseriate striae from centre become fan-shaped (multiseriate) in the sub-marginal zone; in this zone also additional hyaline areas (inter-costal ridges) develop. No central processes observed. The rimoportula has a distinct external tubule opening.

S. flabellatus was described in Loginova & Khursevich (1986). It is more characteristic for the Upper Pleistocene sediments of Lake Baikal.

S. flabellatus v. distinctus: (14-38 µm diameter) has several central fultoportulae with 2-3 satellite pores and these can form in sub-marginal zones, along fascicles, or be grouped into a ring. Similar fan-shaped fascicles in sub-marginal areas. On examining type of the nominate form, forms with and without extra sub-marginal hyaline areas were noted. This taxon is described in the Proceedings of the XIV Diatom Symposium, Japan 1996. *S. flabellatus* var. *distinctus* occurs in both Upper and Middle Pleistocene sediments.

All of the above disappear taxa before the LGM, except for the nominate form of *S. flabellatus*. This species survived until around the end of Pleistocene/early Holocene. Photographs of the above key taxa will be published in the Proceedings of the XIV Diatom Symposium, Japan 1996.

Svetlana Vorobyova noted that the range of sizes of these *Stephanodiscus* taxa is stable with time in the Pleistocene cores.

Large *Stephanodiscus* taxa also occur in Pliocene fresh water sediments of the Black Sea where rapid *Stephanodiscus/Cyclostephanos* evolution occurs and speciation rate is very fast. All the taxa are different from those found in the Baikal flora but a study of the relationships between the two floras would be useful.

The first recorded *Cyclotella* spp. occur in late Miocene deposits (French Massif Central); again these are not the same but are closely related to some early Baikalian taxa. Pliocene and upper Miocene sediments from USA and France do have fossil taxa similar to, but probably not identical to, some Baikal taxa. *Cyclotella* is probably absent in Baikal in the Eocene when *Aulacoseira* taxa are common. The 5m year BDP cores from Academician's Ridge (into Pliocene) are now exceeded by longer cores that extend to the Miocene period.

Stephanodiscus agreements

	[illegible] μm	[illegible] μm	[illegible] μm	[illegible]	[illegible]	[illegible]	[illegible]	S/C	[illegible]
S. cf. parvus	5-11	25-30	13-15	flat	conic	1; 2 sp	3-6 spine	S	Y; need SEM
S. meyerii	7-12	27-35	12-14	flat	finger-branch	1; 2 sp	2 spines	C	Y
S. binderanus				flat		N		C	N
S. 'obscura'				flat		1			Y; need SEM
S. exiguus (extinct)	3.8-12.3	10-15 (20)	8-10	flat	finger-branch	1; 2 sp	2-3 (4) spines	C	Y
S. inconspicuus	4-10	20-40	8-20	mainly flat	conic	1; 2 sp (1-3 sp)	2-3 (4) spines	S	Y
S. baicalensis v. baicalensis	5-10	4-12	NO STRIAE	flat	conic	1; 2 sp	3-4 spines	S	N
S. baicalensis v. concinnis	5-12	12-16	8-10	mainly flat	conic	1; 2-3sp	2-3 spines	S	N

S/C = Solitary cells or Colonial form

References & notes

- *S. parvus*: Stoermer & Håkannson 1984 (but only 3 photographs are acceptable!). Need SEMs (but see Anderson 1990)
- *S. meyerii*: Genkal & Popovskaya in press (*S. binderanus v. baicalensis* Genkal & Popovskaya 1990)
- *S. binderanus*: Round. See also Khursevich (1989)
- *S. obscura*: no reference on going; pictures to be added to workshop results soon
- *S. exiguus*: Khursevich in Proceedings of the XIV International Diatom Symposium, Japan 1996
- *S. inconspicuus*: must be renamed as not characteristic of *Stephanodiscus* (Round) - Pomazkina & Makarova, but not issue here, so for time being will be called *S. inconspicuus*. Genus of *Stephanodiscus* needs revising or amending
- *S. baicalensis v. baicalensis*: in press Likhoshway, Pomazkina & Sherbakov (*Diatom Research*). Pleistocene to present; occurs in benthos
- *S. baicalensis v. concinnis*: in press Likhoshway, Pomazkina & Sherbakov (*Diatom Research*)
- Species that form long chains, such as *S. meyerii* & *S. exiguus* may actually be related to *Aulacoseira* and could perhaps be called *Stephanoseira*

Monday April 27th 1998

D. *Synedra* group (David Williams)

David Williams introduced a discussion on *Synedra* in general, and those in Lake Baikal in particular. Only a relatively small subset of these forms will likely be encountered in Baikal sediment.

A resume of the group was given, emphasising that *Synedra* is split from *Fragilaria* by copular structure: *Synedra* has closed copulae, *Fragilaria* has open copulae. Lange-Bertalot moved many *Synedra* to *Fragilaria* but in 1991 he proposed a new subgenus *Alterasynedra*; this is almost identical to Williams & Round definition of the genus *Synedra*.

Synedra acus ***sensu lato*** is common in Lake Baikal (cf. copula structure) and elsewhere. Hustedt recognised several varieties of this taxon (*Synedra acus v. acus*, *radians*, & *angustissima*) mainly on the basis of size (apical shape is mainly used for species separations). The var. '*radians*' may be a *Fragilaria* because it has open copulae. A slide of Kutzing's *S. acus* type material was examined during the workshop and the following noted:

S. acus: type material 11-12 striae/10 µm; 82 µm long; not more than 5 µm width. A problem is that at least 4 species of *Synedra* exist on the type slide!

S. acus v. radians: use Hustedt, Krammer & Lange-Bertalot concepts (not type material) as the type material could be confusing. It was agreed to retain this taxon within *Synedra* until SEM work is carried out on the copulae in particular.

Genkal's Atlas (in press) considers the planktonic *S. acus* complex and uses a wide striae density to distinguish v. *radians*. It was however agreed to separate the finely striated form (<18 in 10 µm) as 'fo. *pusilla*' from the variety *radians*. *S. acus* var. *acus* is shorter and coarser and usually benthic in habit. The var. *angustissima* is retained for those with very long cells.

Synedra ulna var. *danica* is planktonic but is robust and has different apices.

Synedra species from Lake Baikal material are summarised as follows:

Taxon	Habitat	Length (µm)	Width (µm)	Striae in 10 µm	Ends
Group I					
S. acus v. acus	plankton/benthic	90-250	5	10-22	Taper
S. acus v. radians (fo. radians)	plankton	c. 140-290	2-4	12-16	Taper
S. ulna v. danica	plankton	235-442	8-10	8-10	Abrupt
Group II					
S. acus v. radians (fo. pusilla)	plankton	c. 140-290	2-2.5	18-22	Taper
S. acus v. angustissima	plankton	>300	2-4	12-18	Taper

The gradually tapering ends of *S. acus* & vars. contrast with the shoulder of *S. ulna* forms - this is a key to differentiating *S. ulna* from the coarser forms of *S. acus*. Whenever possible, look at life-form in fresh material, and need to look at the copulae under SEM. Concerns were voiced about splitting group II entirely on length, as this separation is somewhat permeable in practice and other criteria should be considered.

Related taxa:

A very common benthic araphid diatom is *Fragilaria vaucheriae*, however this taxon probably has closed copulae and should be placed in *Synedra*. The form in Baikal is not quite the same as the cosmopolitan taxon of this name, it is similar to *S. mazumensis*. It was agreed to call it *S. cf. vaucheriae* temporarily (has non-typical central area) and is referred to as the "Baikalsee sippen" in Lange-Bertalot's flora (see: Krammer & Lange-Bertalot *Susswasserflora* 2/3, plate 112, figs. 3-8; predominantly benthic). Work in progress as part of the DARWIN Project will give the Baikal taxon a new species name.

3. Taxonomic Quality Control

One or more duplicate samples of Baikal material (sediment or fresh material) was provided to each laboratory (ECRC, LI and Minsk) for slide preparation (using standard local methods) and counting. Analysis of these two samples will be used as a test of whether these "theoretical" taxonomic agreements made during the 1998 workshop can be applied consistently between laboratories in practice. This exercise should include enumeration of the *Cyclotella*, *Aulacoseira*, *Stephanodiscus* & *Synedra* taxa discussed during the workshop as well as assessments of dissolution states for *Cyclotella* and *Aulacoseira* taxa (see below). Counts of 300-350 valves should be made for each sample, and results (raw data) sent to ECRC (or collected from the LI in summer 1998) for comparison between our laboratories and graphical presentation. Amendments to these agreements suggested during this workshop can be addressed at future meetings on the basis of this exercise, and tested by further re-counting as necessary as we strive to reach the ultimate goal of taxonomic harmonisation. Appendix 2 gives two examples of TQC exercises conducted by the ECRC for acid water diatoms.

4. Diatom dissolution protocol for Baikal material

Diatom dissolution is an underestimated problem in all aquatic environments (fresh, saline and marine). This is particularly true in Lake Baikal sediments, where such a long water column makes dissolution an important aspect of diatom taphonomy in sediments. This was first recognised by Flower & Likhoshway (1993). Pristine diatom valves are generally the exception in sediment samples and even in some trap material.

It can be demonstrated that certain taxa (e.g. *Nitzschia acicularis*) disappear completely in the water column. Other taxa are appreciably dissolved as they descend through the water column, and little generally reach surface sediments (e.g. *Synedra acus v. radians fo. pusilla*, *Stephanodiscus meyerii* = *S. binderanus v. baicalensis*). Dissolution however affects all taxa, and other more robust forms (*Aulacoseira baicalensis, A. islandica {v. helvetica}* spores, and *Cyclotella* taxa) are also dissolved, but less dramatically.

Dissolution deserves consideration for a variety of reasons. From a purely taxonomic viewpoint, valve degradation and corrosion will create uncertainty in identification, particularly of finer forms. More insidious from a palaeoenvironmental point of view is the differential dissolution of diatom taxa mentioned above. This affects the interpretation of fossil and sub-fossil (surface sediment) assemblages by affecting the absolute populations and so relative proportions of sedimenting valves. Differential diatom dissolution can blur the relationships between living diatom crops and environmental parameters (including climatic variables), creating sedimentary assemblages for which there are no contemporary analogues in living communities.

Many turbidite deposits have different taphonomic (as well as lithological and diatom compositional) signatures from other sediments, and dissolution indices can aid in identification of these facies in sediment sequences. Processes affecting dissolution rates may also be different between glacial and interglacial states of the lake, which could be reflected in the dissolution state of sedimentary assemblages within an undisturbed core.

The simplest way to treat dissolution is to recognise a pristine state for valves of each major taxon (called stage 1) and provide a ratio (or Diatom Dissolution Index, DDI) for assemblages which is the ratio of pristine valves to all valves. This index varies between 1 (for perfectly preserved assemblages with no dissolved diatoms) and 0 (for very badly dissolved samples) and is developed from ideas presented in Flower & Likhoshway (1993). Samples can be compared from different environments and facies with this index, but taxa can be compared within a sample as well (for example, a mixture of well preserved and badly dissolved valves may indicate an input of reworked valves in the sample).

In general, the relative susceptibility of taxa to dissolution is influenced by the surface area to volume ratio of silica wall, low ratios typifying robust and higher values associated with more susceptible (finer) forms. Within a valve, fine structures (with higher surface area to volume ratios) disappear first (e.g. satellite pores, and vela within areolae), creating taxonomic problems if identification is based on these finer details. Central processes and areolae within striae, however, tend to become enlarged, and often more noticeable, though they also act as epicentres of dissolution and provide lines of fracture (particularly if they coalesce) which enhance valve destruction in the latter stages of dissolution. For common Baikal taxa, the pristine state (stage 1) is separated from dissolved (stage 2 and higher) forms as outlined below under phase-contrast LM.

Aulacoseira spp. *(A. baicalensis/islandica* - vegetative & spores)

Stage 2 and above: Areolae on the mantle are enlarged and may coalesce, silica wall is distinctly thinner for all but the thickest *A. baicalensis* forms. Spines often dissolved. Fine valves (*A. islandica* vegetative cells) split easily along a longitudinal line of areolae (along a stria). When this is complete, the valve opens out, the cylindrical valve shape becoming a flat rectangular form ("mantle sheet"). Deciding on how large such a rectangular area has to be to be counted as a "valve" may need thought; as these "mantle sheets" often split further along longitudinal striae into thinner rectangular segments (and a valve with diameter D and length L if opened out will produce a sheet of length L and height ΠD). Valve faces may bind one end of valve, producing a conical form, but on further dissolution are lost and tend to dissolve rapidly (esp. *A. islandica*).

Cyclotella minuta-group (*C. minuta/ornata/baicalensis*)

Stage 2 and above The main stages are shown in Flower (1993a). From dissolution stage 2 there is visible loss of valve structure. Intercostal areas dissolve before marginal rim, which on further dissolution is lost. The costae are then shortened often irregularly (as weakened costae break off), until finally only a vestigial central area remains. Identification from this state may be difficult as the size of the central area may not always be a good indication of the diameter of the pristine valve. Any undulation of the central area in the pristine valve is often less pronounced by the final stages. Central processes may become more noticeable as they are enlarged, and satellite pores are often absent. The distribution (if not number) of central processes may be the only reliable diagnostic feature of the final stage (though elliptical shape, if present, is often maintained until the latter stages).

Stephanodiscus spp.

Stage 2 and above: Areolae are enlarged and may coalesce, although margin may initially remain. Spines are unevenly preserved even in the earliest stages of dissolution (long spines tend to weaken and break quickly). Once the spines and margin are lost, valves dissolve quickly towards central area. Undulations of central areas are less noticeable in the latter stages. Central processes are enlarged and become more noticeable although fine structures (e.g. satellite pores) are lost. It is often difficult to identify taxa from corroded central areas despite distinct differences in the margin (e.g. mantle depth) or size in the pristine valve if the pattern and density of areolation the central area are similar. Fine and small *Stephanodiscus* taxa tend to disappear quickly once dissolution begins.

Synedra spp.

Stage 2 and above: Striae chambers coalesce and dissolve at valve margins, though valve apices are initially often distinct, giving the valve the impression of a "backbone" effect. As dissolution progresses, valves dissolve towards the centre from the apices. Often, the more fragile and thinner forms will break, and in this case counting is best made on the apices, each being counted as a half valve. There is usually enough of the valve to determine the dissolution stage of the entire valve. Valves also tend to become noticeably thinner, and often will appear contorted or bent, with or without breaking up. This indicates that the striae chambers are to a large extent open at the valve margins, allowing the valve some degree of "articulation" along the central (longitudinal or apical) axis. Pristine valves are rarely thin enough to permit such flexure.

For the present purposes of TQC inter-laboratory calibration exercise it is recommended that only the proportion of pristine (stage 1) valves are calculated for the two planktonic genera: *Aulacoseira* and *Cyclotella*.

5. DARWIN Project

The last half day of the workshop was reserved for matters arising from the ongoing DARWIN Project on benthic diatoms in Lake Baikal. A first year report was received from Dr Likhoshway for 1997/98. This was accepted with some comments on further work. The provision of DARWIN facilities at the Limnological Institute was welcomed. Almost all equipment is now in place but the acquisition of the DARWIN microscope is not yet complete.

It was recommended that data should be reported as graphs of the % frequency of common taxa according to depth and to season. This would help interpretation of similar graphs of biomass. The sample count size was discussed and reducing the number of individuals (valves) counted per sample was recommended; the relationship between number counted and number of species found should be explored but for routine counting it is usually acceptable to count 500 valves per sample.

The value of analysing the floristic data in year 3 of the project was discussed, especially of using CANOCO software to examine the distribution of taxa with environmental variables. We suggested that CANOCO should be purchased through DARWIN or BICER. Collection of as much environmental data as possible will be valuable (address for purchase supplied).

Transect field work should be undertaken until late August 1998. Using floristic information we should then select the best site for future monitoring work in the light of biodiversity and environmental change. One transect sampling should be carried out in the 'optimum' season and location in 1999 as part of a long term monitoring programme.

Non-transect DARWIN field work in 1998 will be in 18th-28th June and will take about one week. David Ryves provided a page of an example (test2.wks) of the format that should be adopted in Excel spreadsheets of DARWIN data (for TILIA, CANOCO etc.). Species (each with an unique 8 alphanumeric character code) should be set up in columns, and samples (also up to 8 alphanumeric characters) as the rows. **All counts should be given as raw numbers** (not transformed to percentages etc.). A list of names for these codes should also be supplied as a separate table, for both samples and species.

6. Future plans

The extent to which the agreed taxonomic decisions could be effectively applied and followed by different laboratories would determine the success of this workshop, and the need for another. This will be largely evaluated on the results of the TQC exercise. The electronic images taken during the conference will be circulated to participants electronically as *.tif files and/or as hard copy produced at ECRC (with a hard copy catalogue established at the ECRC). A future workshop could perhaps focus more on the fresh and living plankton communities (sampled from the water column and traps, as well as in culture) but not to the exclusion of the sediments.

David Williams offered to arrange a DARWIN Project benthic diatom workshop for next year subject to funding. The venue, scope and participants have yet to be decided. Sources of funding need to be examined.

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Baikal Taxonomy Workshop Photographs Catalogue
April 24th - 27th 1998, ECRC, UCL

All images are stored as *.tif files, at 300 dpi (or above), with the Image Grabber package, and generally taken under DIC. They are in the **D:\Baikal\workshop** directory on the UCL image analysis PC.

No.	Filename	Brief description	Reference
1	BK003.TIF	*Cyclotella baicalensis*	
2	BK004.TIF	*Cyclotella minuta f. ornata*	
3	BK005.TIF	*Cyclotella minuta f. minuta*	
4	BK006.TIF	*Aulacoseira baicalensis*	
5	BK010.TIF	*Aulacoseira baicalensis* focus A	
6	BK011.TIF	*Aulacoseira baicalensis* focus B	
7	BK012.TIF	*Aulacoseira baicalensis*	
8	BK015.TIF	*Aulacoseira islandica*	
9	BK014.TIF	*Synedra acus* - type material	
10	BK007.TIF	*Aulacoseira islandica* half spore	
11	BK022.TIF	*Stephanodiscus cf. parvus*	
12	BK023.TIF	*Stephanodiscus cf. parvus*	
13	BK025.TIF	*Stephanodiscus meyerii*	
14	BK027.TIF	*Stephanodiscus meyerii*	
15	BK030.TIF	*Stephanodiscus obscura?*	
16	BK029.TIF	*Stephanodiscus exiguus*	
17	BK028.TIF	*Stephanodiscus exiguus*	
18	BK024.TIF	*Stephanodiscus inconspicuus*	
19	BK016.TIF	*Synedra acus* - type material	
20	BK021.TIF	*Synedra vaucheriae*	
21	BK020.TIF	*Synedra acus/radians*	
22	BK002.TIF	*Synedra acus var. radians*	
23	BK001.TIF	*Aulacoseira islandica*	●
24	BK008.TIF	*Aulacoseira islandica* collapsed veg. cell	●
25	BK009.TIF	*Aulacoseira islandica*	●
26	BK013.TIF	*Aulacoseira islandica*	●
27	BK017.TIF	*Synedra acus* - type material	●
28	BK018.TIF	*Synedra radians*	●
29	BK019.TIF	*Synedra radians*	●
30	BK026.TIF	*Stephanodiscus meyerii*	●
31	BK031.TIF	*Stephanodiscus obscura?*	●

22 images are thus accepted as part of the workshop output, with a further 9 (denoted ●) as reference images (and not included with the report). All 31 images are archived at the ECRC and can be viewed as necessary. These will be kept as TIFF files, and hard copy made for distribution with the report, until enough are acquired to be put on a CD-ROM and sent out as a single disc.

Baikal Taxonomy Workshop Photographs Catalogue
April 24th - 27th 1998, ECRC, UCL

Figure 1.

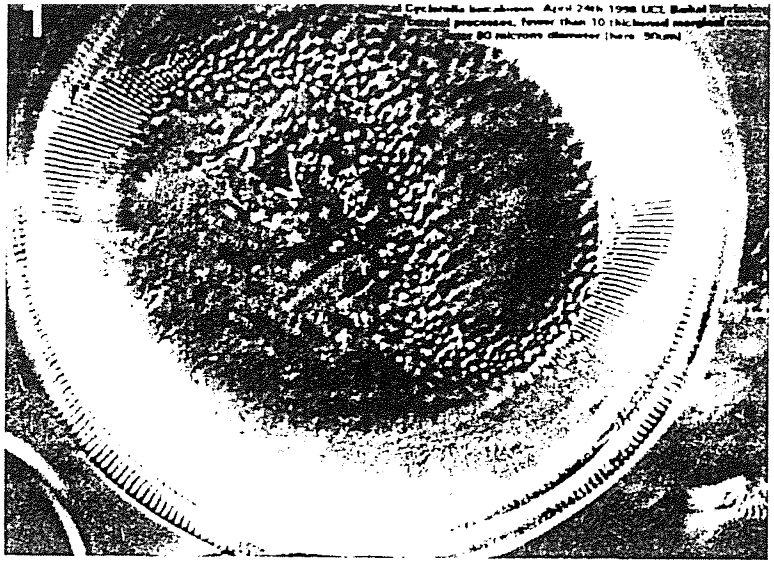
Typical *Cyclotella baicalensis*. Over 50 central processes, fewer than 10 thickened marginal costae, over 80 µm diameter (here, 90 µm).

Figure 2.

Typical *Cyclotella ornata*. Usually less than 50 central processes, many thickened marginal costae, between 40-80 µm diameter (here, 60 µm).

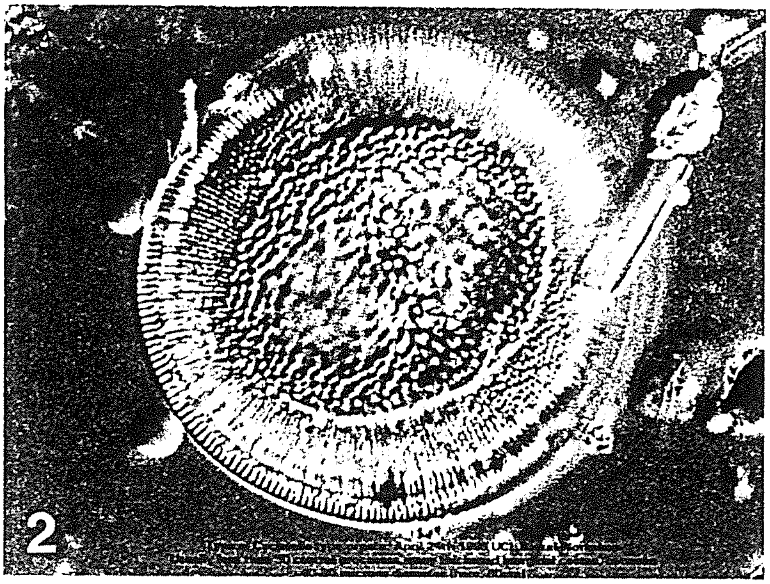
Figure 3.

Typical *Cyclotella* type *minuta*. Usually less than 15 central processes, thickened marginal costae present in larger valves up to 40 µm diameter (here, 38 µm).



1

[illegible] Cyclotella baicalensis. April 24th 1998 UCL Baikal Workshop
[illegible] central processes, fewer than 10 thickened marginal costae
[illegible] than 80 microns diameter (here 50um)



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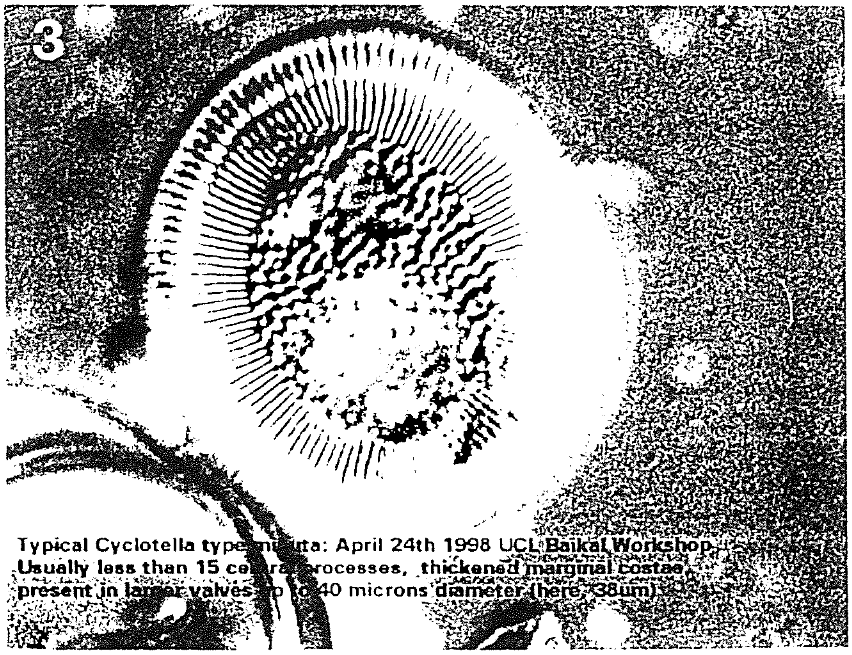


3

Typical Cyclotella type minuta: April 24th 1998 UCL Baikal Workshop.
Usually less than 15 central processes, thickened marginal costae
present in larger valves up to 40 microns diameter (here, 38um)

Figure 4.

Typical *Aulacoseira baicalensis* (May/June). Valve 37 µm long, width 12 µm; 10 rows of areolae/10 µm; 6 areolae along 10 µm of row.

Figure 5 - focus A.

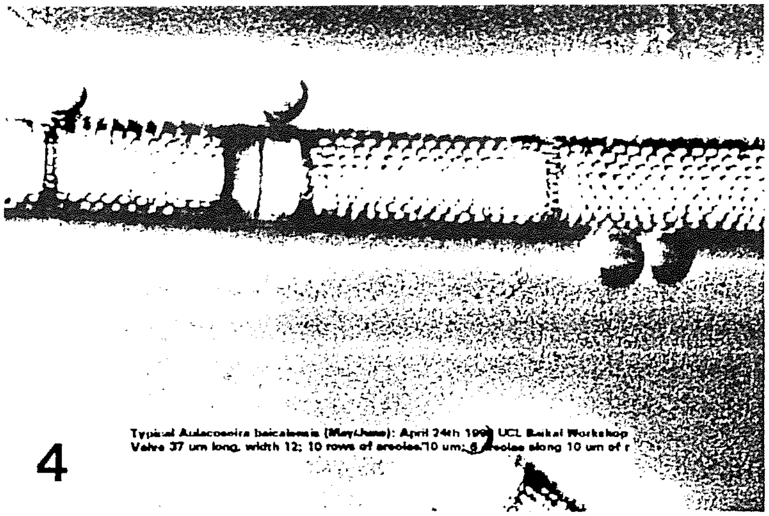
Aulacoseira baicalensis resting valve (medium). From sediment (BAIK 32: 1.4 - 1.6 cm). 38 µm long; 9 µm wide. Valve surface focus of fig. 6.

Figure 6 - focus B.

Aulacoseira baicalensis resting valve (medium). From sediment (BAIK 32: 1.4 - 1.6 cm). 38 µm long; 9 µm wide. Mid-valve focus of fig. 5.

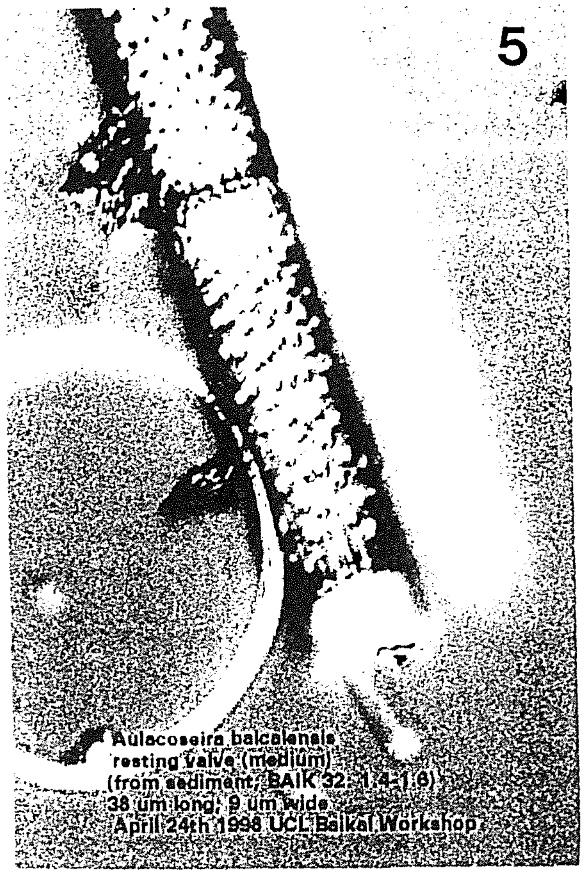
Figure 7.

Aulacoseira baicalensis. Length 20 µm. Trap material - note girdle bands.



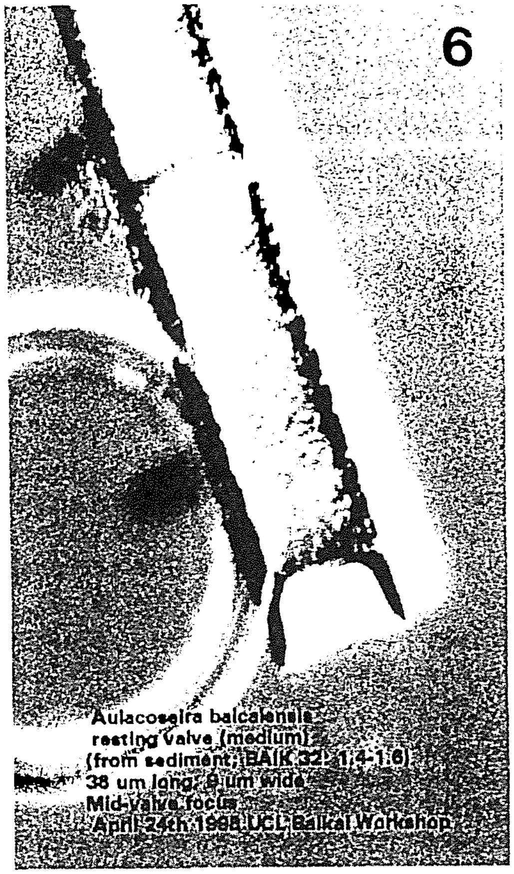
4

Typical Aulacoseira baicalensis (May/June): April 24th 199[illegible] UCL Baikal Workshop
Valve 37 um long, width 12; 10 rows of areolae/10 um; 6 areolae along 10 um of r



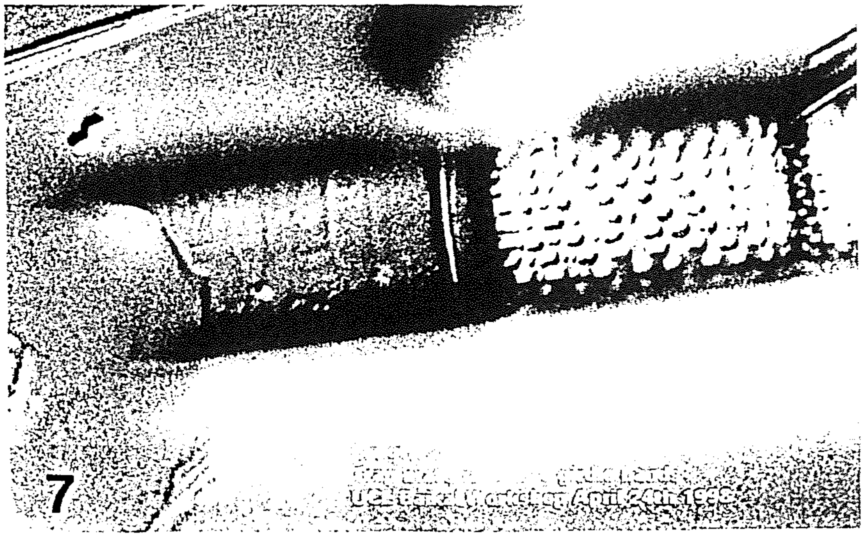
5

Aulacoseira baicalensis
resting valve (medium)
(from sediment, BAIK 32, 1.4-1.6)
38 um long, 9 um wide
April 24th 1998 UCL Baikal Workshop



6

Aulacoseira baicalensis
resting valve (medium)
(from sediment, BAIK 32, 1.4-1.6)
38 um long, 9 um wide
Mid-valve focus
April 24th 1998 UCL Baikal Workshop



7

[illegible]
UCL Baikal Workshop April 24th 1998

Figure 8.

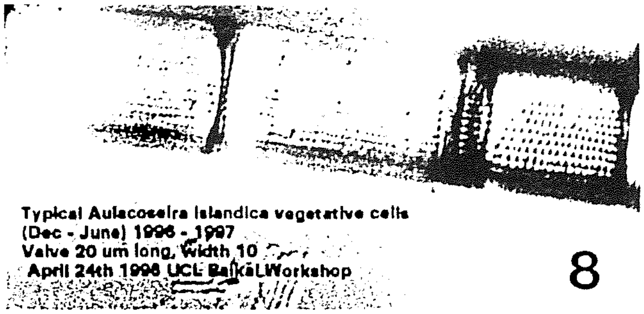
Typical *Aulacoseira islandica* vegetative cell (with a spore valve attached on right). Open trap material, December 1996 - June 1997. Valve 20 µm long, width 10 µm.

Figure 9.

Aulacoseira islandica (spores and vegetative valves). Open trap material, December 1996 - June 1997. Vegetative valves: 15 µm long, 7.5 µm wide.

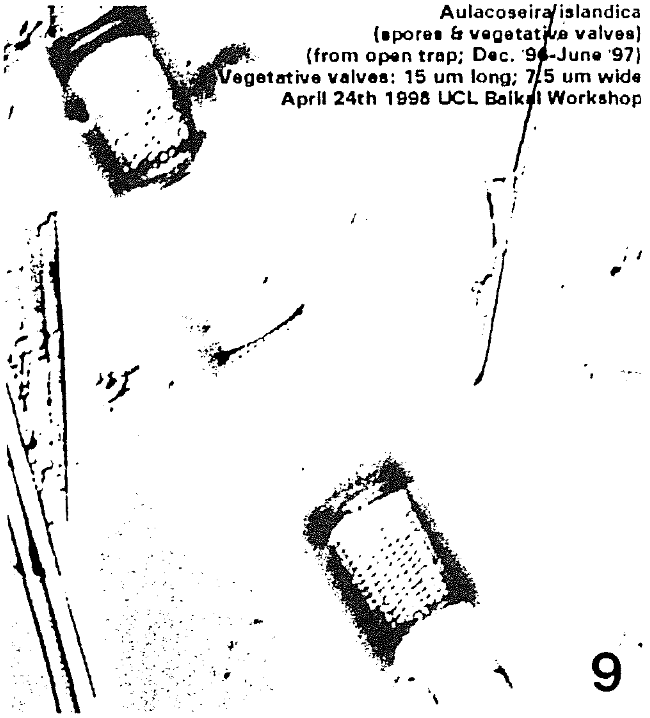
Figure 10.

Typical *Aulacoseira islandica* spore (from open trap, December 1996 - June 1997). Valve 15 µm long, width 12 µm.



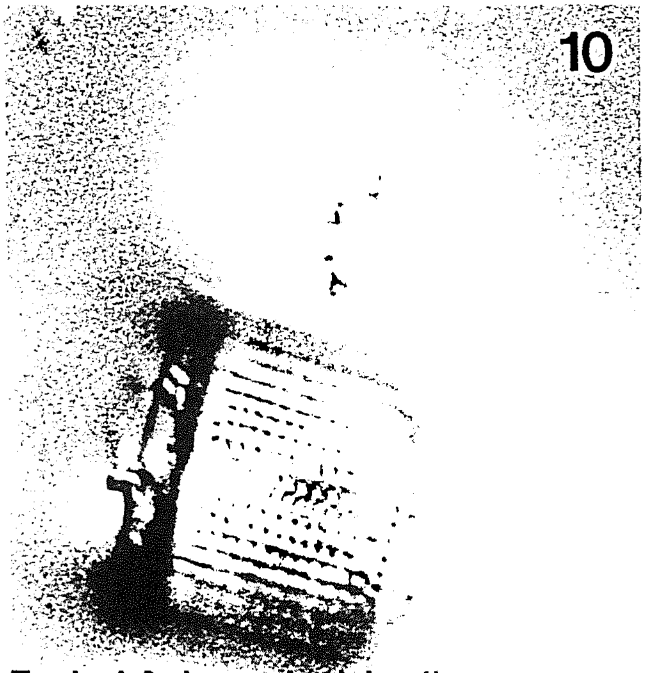
Typical Aulacoseira islandica vegetative cells
(Dec - June) 1996 - 1997
Valve 20 um long, Width 10
April 24th 1998 UCL BaikalWorkshop

8



Aulacoseira islandica
(spores & vegetative valves)
(from open trap; Dec. '96-June '97)
Vegetative valves: 15 um long; 7.5 um wide
April 24th 1998 UCL Baikal Workshop

9



10

Typical Aulacoseira islandica spore
(Dec - June) 1996 - 1997
Valve 15 um long, width 12
April 24th 1998 UCL Baikal Workshop

Figure 11.

Stephanodiscus cf. parvus. Diameter 6 µm. From sediment: BAIK 25: 10 - 11 cm.

Figure 12.

Stephanodiscus cf. parvus. Diameter 7 µm. From sediment: BAIK 25: 10 - 11 cm.

Figure 13.

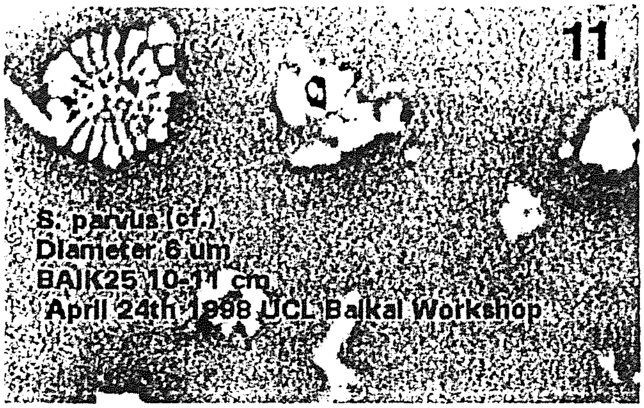
Stephanodiscus meyerii (*S. binderanus* var. *baicalensis*). Diameter 8µm. From sediment, BAIK 25: 10 - 11 cm.

Figure 14.

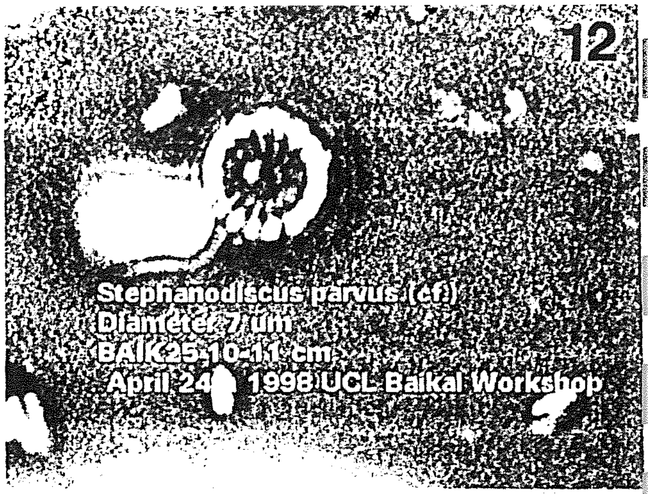
Stephanodiscus meyerii (*S. binderanus* var. *baicalensis*). Diameter 9 µm. From sediment, BAIK 25: 10 - 11 cm.

Figure 15.

Stephanodiscus obscura? Diameter 10 µm. Striae: 14 in 10 µm, spines: 22 in 10 µm. From sediment, BAIK 25: 10 - 11 cm.


11

S. parvus (cf.)
Diameter 6 um
BAIK25 10-11 cm
April 24th 1998 UCL Baikal Workshop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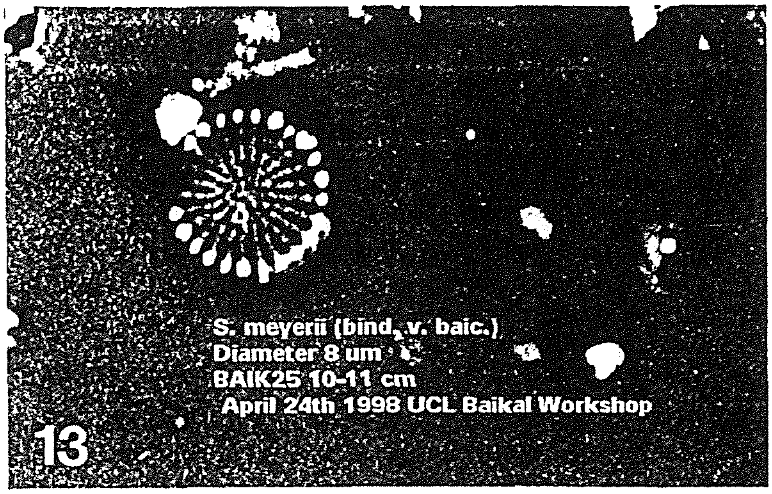
Stephanodiscus parvus (cf.)
Diameter 7 um
BAIK25 10-11 cm
April 24[illegible] 1998 UCL Baikal Workshop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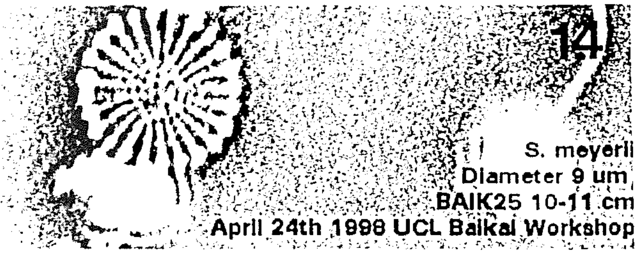
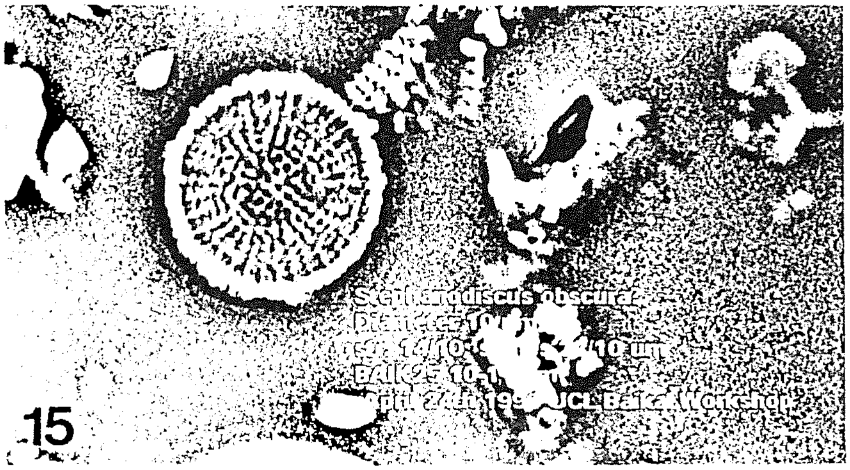
S. meyerii (bind. v. baic.)
Diameter 8 um
BAIK25 10-11 cm
April 24th 1998 UCL Baikal Workshop


14

S. meyerii
Diameter 9 um
BAIK25 10-11 cm
April 24th 1998 UCL Baikal Workshop


15

Stephanodiscus obscura?
Diameter 10 [illegible]
[illegible] 14/10 [illegible] 10 um
BAIK25 10-1[illegible]
April 24th 199[illegible] UCL Baikal Workshop

Figure 16.

Stephanodiscus exiguus (Khurs.). Diameter 7 µm (mantle view). Pleistocene sediment.

Figure 17.

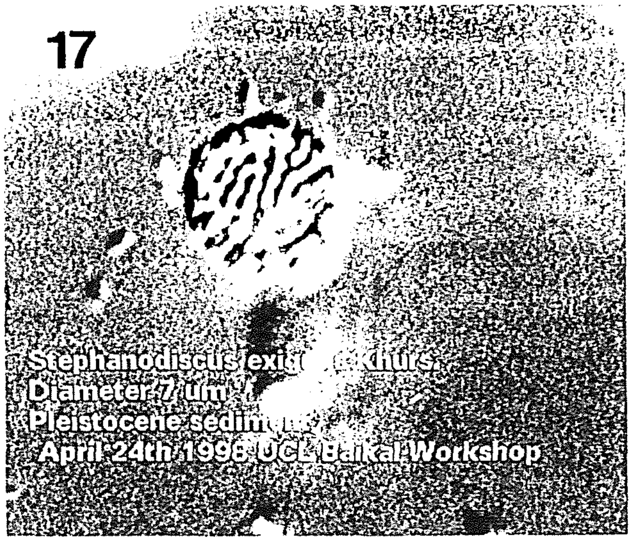
Stephanodiscus exiguus (Khurs.). Diameter 7 µm. Pleistocene sediment.

Figure 18.

Stephanodiscus inconspicuus. Diameter 8 µm. From sediment (BAIK 25: 10 - 11 cm).

16

17


Stephanodiscus exig Khurs.
Diameter 7 um
Pleistocene sedim
April 24th 1998 UCL Baikal Workshop

18

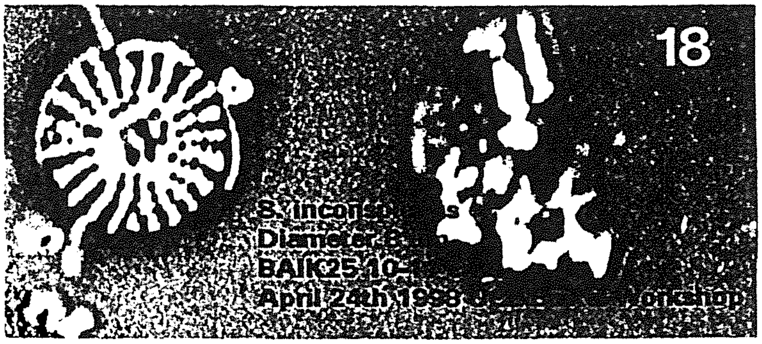

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Figure 19.

Synedra acus. Type material from the Kützing collection (British Museum). Length 82 µm; width 5 µm; striae: 11/10 µm.

Figure 20.

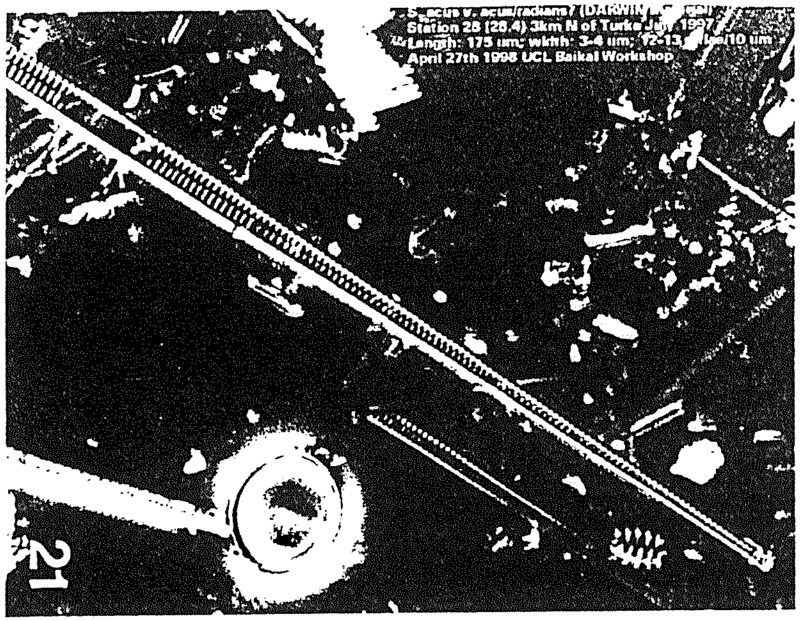
Synedra cf. vaucheriae (DARWIN material). Station 2, Goloustny, June 1997. Length: 35 µm; width: 4 µm; striae: 10-11/10 µm

Figure 21.

Synedra acus var. *acus/radians*? (DARWIN material). Station 28 (28.4), 3 km N of Turka, July 1997. Length: 175 µm; width: 3-4 µm; striae: 12-13/10 µm.

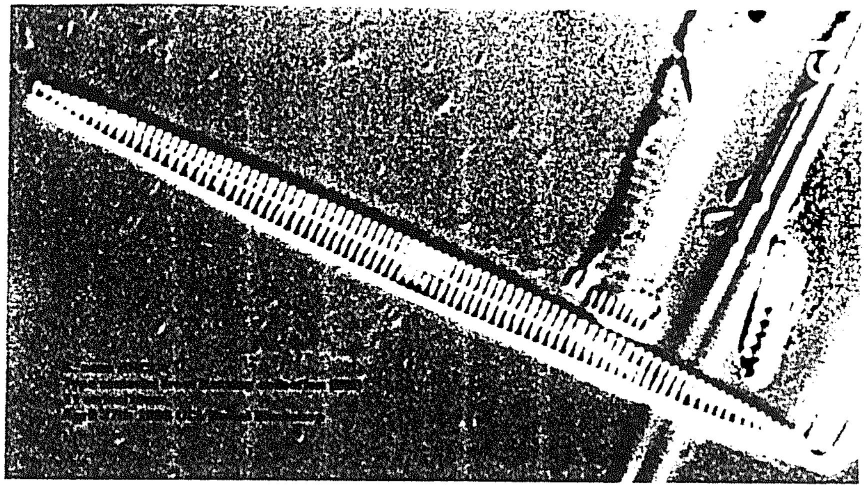
Figure 22.

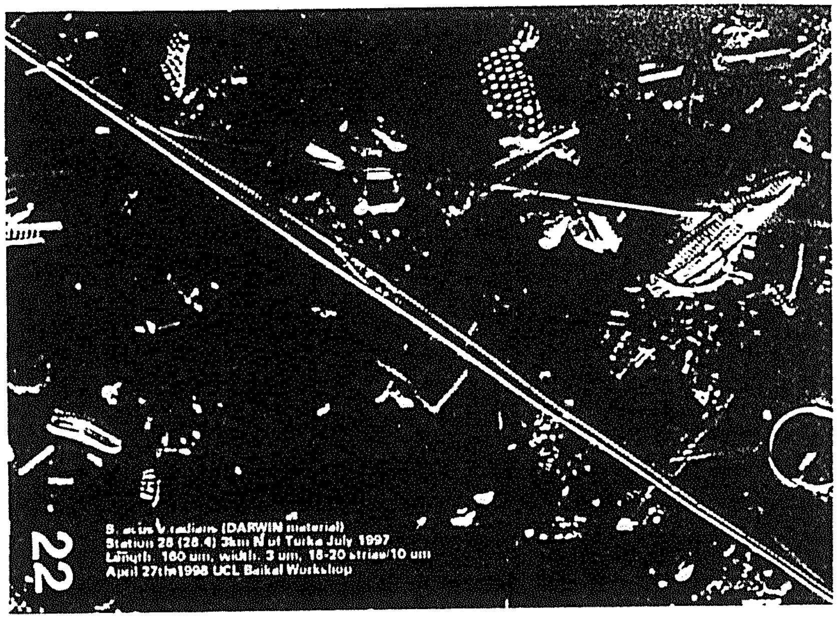
Synedra acus var. *radians*? (DARWIN material). Station 28 (28.4), 3 km N of Turka, July 1997. Length: 160 µm; width: 3 µm; striae: 18-20/10 µm.



21

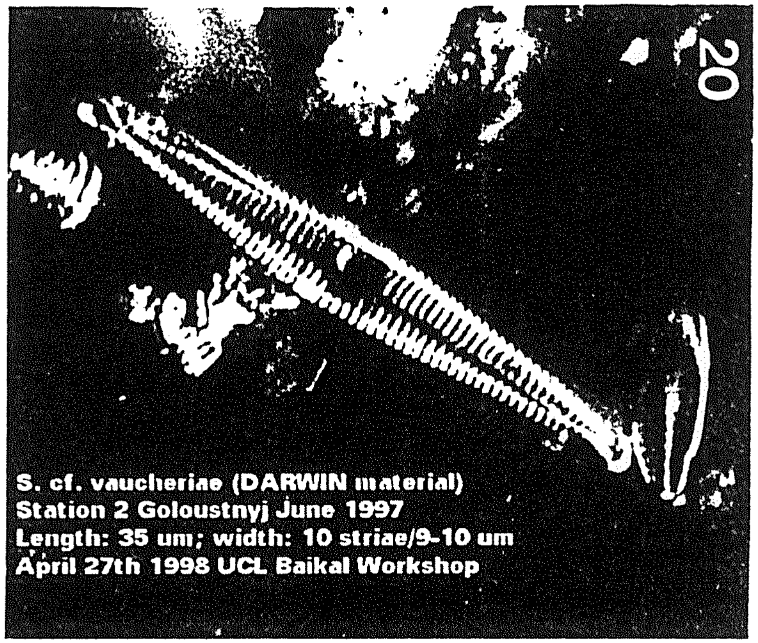
S. acus v. acus/radians? (DARWIN [illegible])
Station 28 (28.4) 3km N of Turka July 1997
Length: 175 um; width: 3-4 um; 12-13 striae/10 um
April 27th 1998 UCL Baikal Workshop





22

S. acus v. radians (DARWIN material)
Station 28 (28.4) 3km N of Turka July 1997
Length: 160 um; width: 3 um; 18-20 striae/10 um
April 27th 1998 UCL Baikal Workshop



20

S. cf. vaucheriae (DARWIN material)
Station 2 Goloustnyj June 1997
Length: 35 um; width: 10 striae/9-10 um
April 27th 1998 UCL Baikal Workshop

Appendix 2

Baikal Taxonomy Workshop - TQC references
April 24th - 27th 1998, ECRC, UCL

Phil. Trans. R. Soc. Lond. B 327, 257–261 (1990)
Printed in Great Britain

Diatom quality control and data handling

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The diatom data used for reconstructing pH within the Surface Water Acidification Project (SWAP) came from several different laboratories. The laboratories used agreed nomenclature and standardized identifications by using quality control techniques. A diatom database (DISCO) stored and processed counts and site information.

1. INTRODUCTION

The diatom section of the Surface Water Acidification Project (SWAP) Palaeolimnology Programme brought together data from many sources. One of the aims of the project was to construct a single large pH calibration dataset, by combining modern lake pH values with modern surface-sediment diatom assemblages and to use the calibration to reconstruct past lake pH values from the assemblages in sediment cores. However, reconstructions based on small regional subsets of chemical and diatom data from several laboratories must be combined in a way that resolves any differences in taxonomy or analytical technique, and selected extracts from this large combined dataset must be created in a form that can be read by the computer programs performing the calibration and reconstruction.

2. STANDARDIZATION OF DIATOM TAXONOMY

Because there is considerable variation in practice between diatomists in different laboratories it is essential in cooperative projects to establish agreed protocols for diatom taxonomy and nomenclature. In the SWAP project, diatomists from Norway, Sweden and the U.K. adopted an approach to diatom harmonization similar to that developed by diatomists involved in the Paleoecological Investigation of Recent Lake Acidification (PIRLA) project in the U.S.A. (Charles *et al.* 1987). This has included the use of taxonomic workshops, diatom slide exchange and the circulation of agreed taxonomic protocols both within SWAP and between the SWAP and PIRLA schemes.

(*a*) *Initial identification of problem areas*

The first SWAP diatom taxonomy workshop was held in March 1987. In preparation for this, each of the four laboratories involved circulated diatom slides and accompanying count sheets for three sediment samples to each of the other laboratories, choosing samples representing the range of soft-water floras encountered within SWAP. Each laboratory provided counts from all 12 slides and the results were compared at the taxonomy workshop. Figure 1*a* summarizes the results of one of these slides (Lingmoor Tarn), demonstrating the three main problems encountered: differences in nomenclature, splitting versus amalgamation of taxa and differing criteria used in the identification of a taxon. Figure 1*b* shows the result after revision at the workshop.

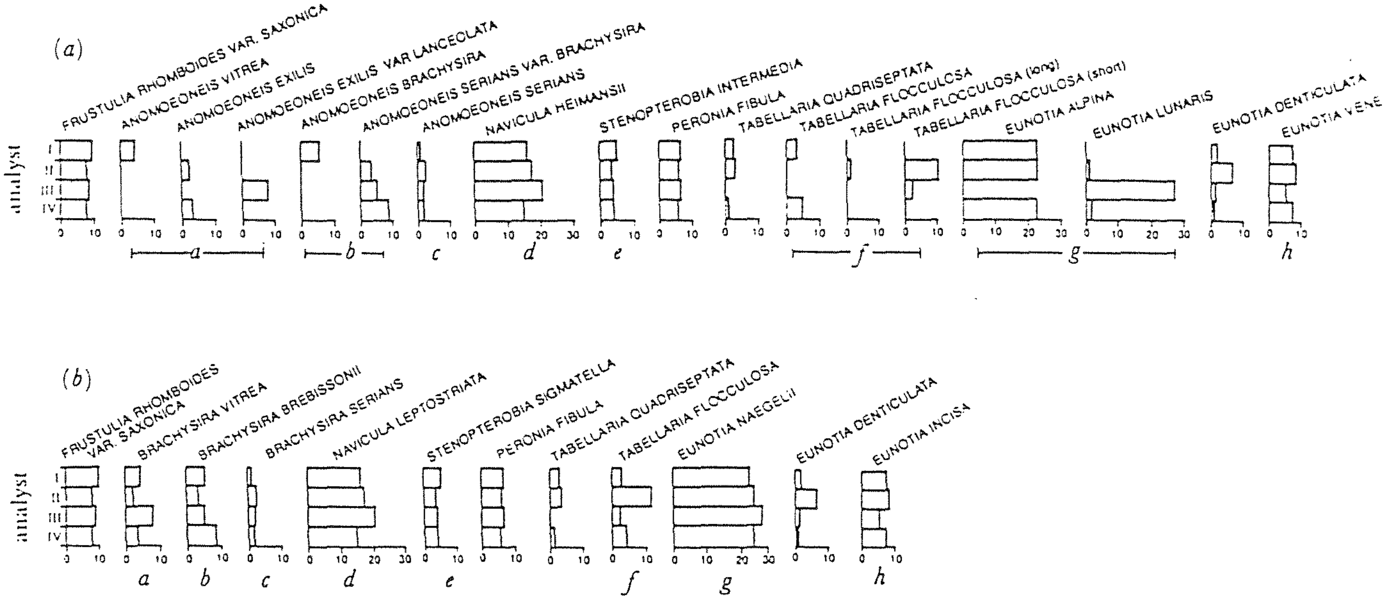


FIGURE 1. (*a*) Dominant taxa in the Lingmoor Tarn slide illustrating problems of nomenclature in groups *a*, *b*, *c*, *d*, *e*, *g*, *h*, problems of splitting versus amalgamation in groups *a*, *f* and the use of differing identification criteria in group *g*; (*b*) dominant taxa in the Lingmoor Tarn slide after full taxonomic and nomenclatural revision. (Horizontal scale is percentage occurrence.)

The agreements from the workshop were circulated to all the workshop participants in a SWAP taxonomic guide. Nomenclature was based on the Checklist of British diatoms (Hartley 1986), which formed the framework for a coded checklist of British diatoms (Williams *et al.* 1988). The SWAP taxonomic guide also included agreements on definitions for boundaries between certain species and their varieties, in some cases following inspection of type material. If possible, published descriptions were referred to. Failing this, the criteria for identification were agreed between the participants.

(*b*) *Applying and refining the SWAP taxonomic guide*

To test the 1987 workshop protocols three slides from lake sediment samples representing the range of pH values encountered within SWAP (one sample from each of the ranges pH < 5, pH 5–6 and pH > 6) were circulated to all SWAP diatomists, who counted the slides without prior access to the countsheets of other diatomists. The results were discussed at a workshop in July 1988.

Many potential problems had been avoided by following the protocols agreed at the previous workshop. However, because of the inclusion of taxa additional to those already encountered, some further problems were raised. Most of these were resolved and a revised edition of the SWAP taxonomic guide was circulated to all diatomists. This workshop also produced a guide for the handling of unknown diatoms.

A major problem encountered at the 1988 workshop was one of identification within the genus *Aulacoseira*. This genus presents particular taxonomic problems because of the difficulties of matching girdle (side) views of the diatom valves with valve (front) views.

(*c*) *Focusing on problems within the genus* Aulacoseira

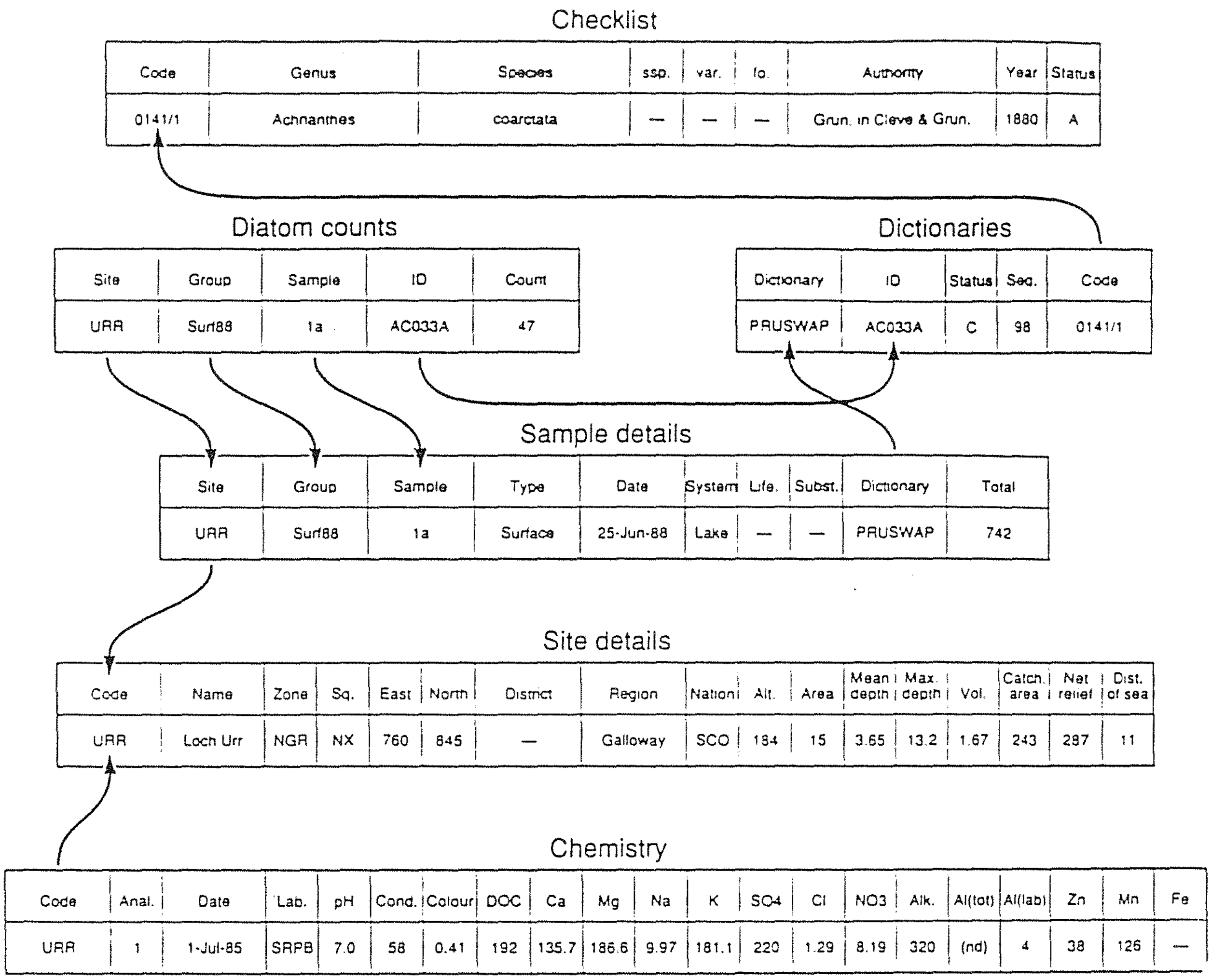
As a result of the 1988 workshop it was decided to concentrate on the taxonomy of the *Aulacoseira* genus. Three samples containing *Aulacoseira* were selected from SWAP sites and slides were circulated to all SWAP diatomists, who counted 300 valves of *Aulacoseira* from each slide and discussed the results at the diatom workshop in February 1989. There were no problems with the most abundant *Aulacoseira* taxa, such as *A. lirata* and *A. distans* var. *nivalis*. For the less abundant taxa, e.g. *A. lirata* var. *alpigena*, *A. subarctica* and *A. subborealis*, definitions were agreed by using either published definitions or criteria agreed at the workshop. Previously counted surface and core samples containing the problematic *Aulacoseira* taxa were consequently recounted.

This series of workshops and quality control exercises has enabled all diatom data generated within SWAP to be compatible between laboratories and to be suitable for storage and manipulation in a computerized database.

3. THE COMPUTER DATABASE

The diatom database (DISCO) at University College London combines archives of diatom counts, chemical analyses and catchment descriptions for several projects, including SWAP. It uses the commercial program ORACLE and the standard database language SQL. Diatom counts, taxonomic information and chemistry can be entered on or retrieved from the database, by filling out entries on forms that appear on the computer screen. The PIRLA project also required a large computer database (Ahmad & Charles 1988). It also uses a commercial program (SIR) and stores data from many other sources (including chemical analyses and chrysophyte counts). However most of the PIRLA database is hierarchic, with the diatom counts at a lower level in the hierarchy than the site information, whereas DISCO is a relational database, consisting of tables of data with no pre-established structure. The data themselves are used to connect the different tables. Figure 2 shows how common site and sample codes can link different tables to establish a structure similar to the PIRLA database. Many other arrangements are possible.

The database includes the version of the Hartley (1986) diatom checklist coded by Williams *et al.* (1988). Williams' coding scheme allocates a code to each taxon on the list by using a number to represent the original name of the taxon. This does not encode any information about the genus or species name, so the codes are suited to following a taxon through revisions of nomenclature. Some names do not fit this scheme: names of valid taxa that have not been



Checklist

Code	Genus	Species	ssp.	var.	fo.	Authority	Year	Status
0141/1	Achnanthes	coarctata	—	—	—	Grun. in Cleve & Grun.	1880	A

Diatom counts

Site	Group	Sample	ID	Count
URR	Surf88	1a	AC033A	47

Dictionaries

Dictionary	ID	Status	Seq.	Code
PRUSWAP	AC033A	C	98	0141/1

Sample details

Site	Group	Sample	Type	Date	System	Life.	Subst.	Dictionary	Total
URR	Surf88	1a	Surface	25-Jun-88	Lake	—	—	PRUSWAP	742

Site details

Code	Name	Zone	Sq.	East	North	District	Region	Nation	Alt.	Area	Mean depth	Max. depth	Vol.	Catch. area	Net relief	Dist. of sea
URR	Loch Urr	NGR	NX	760	845	—	Galloway	SCO	184	15	3.65	13.2	1.67	243	287	11

Chemistry

Code	Anal.	Date	Lab.	pH	Cond.	Colour	DOC	Ca	Mg	Na	K	SO4	Cl	NO3	Alk.	Al(tot)	Al(lab)	Zn	Mn	Fe
URR	1	1-Jul-85	SRPB	7.0	58	0.41	192	135.7	186.6	9.97	181.1	220	1.29	8.19	320	(nd)	4	38	126	—

FIGURE 2. The rectangles represent entries in various database tables, the arrows show how common entries can connect the tables. Other connections are possible.

recorded in Britain (so Hartley excluded them), names that refer to aggregate taxonomic categories that do not have any place in a checklist of single taxa (such as *Navicula* spp.) and names needed for newly discovered taxa, or taxa that diatomists can recognize consistently but cannot identify as any checklist entry. It includes these in a supplementary code list. The database also stores tables of chemical analyses for calibration data set values that were used for improving reconstruction methods (Birks *et al.*, this symposium). So far only pH is used, but other data are included, such as: conductivity, colour, dissolved organic carbon, Ca^{2+}, Mg^{2+}, Na^+, K^+, SO_4^{2-}, Cl^-, NO_3^-, alkalinity, Al (total), Al (labile), Zn, Mn, Fe, Cu, Pb, dissolved SiO_2 and total P. These will be used for future development of diatom-based reconstruction methods.

4. Data processing

Diatomists submitting counts to the database provided an outline code dictionary for their data. The dictionary was checked to ensure that it contained valid checklist or supplementary list codes, and was compared to previous lists from the same laboratory. The counts were then converted to percentages of the total number of diatoms counted in each sample; any amalgamations and other re-definitions of taxa were performed. The database also provided a list of the more frequently occurring taxa for each group of samples, defined as those present in at least two of the samples and having a frequency of more than 1% in at least one sample. These lists were compared to help identify unresolved taxonomic problems.

The SWAP calibration data-set was created by merging full sets of surface sediment percentages in this way for the regional datasets from Scotland, Wales, Cumbria, Norway and Sweden. All the aggregates to genus level and above (e.g. *Navicula* spp.) were deleted and the remainder of this list was used to select the taxa to be exported to the calibration programs. The core percentages were then exported to the reconstruction programs as a series of individual site datasets.

The chemical values added to the database were screened in several stages. The program for adding new values included simple checks on the range of the values for various determinands. At least two people checked a complete paper listing of the database values against the original laboratory report. The values were standardized (zero mean, standard deviation = 1), by using both site and regional means, and values outside the range ±2 were noted. In some cases histograms of the distributions were plotted as a further check, as the values for some determinands were not normally distributed. Values of pH were excluded from the data-set only if they were extremely discordant (such as a value of 3.6 from Llyn Bugeilyn whose other pH values were 5.0, 4.6 and 5.1), or if exceptional conductivity and ionic concentration values suggested that they were influenced by a sea-salt event. Geometric mean pH values were used for calibration (arithmetic means of H^+ concentrations). The groups of analyses used to calculate the means were matched with the calibration dataset to ensure that re-sampled sites (which had two sets of diatom assemblages) had two sets of pH values. The sampling date for the chemistry was normally within three years of the diatom sampling date.

The database will allow further exploration of diatom–water-quality data as samples from a wider range of environmental gradients are included and the full range of chemical data is screened in the same way as the pH values.

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ANALYTICAL QUALITY CONTROL (AQC) IN DIATOM ANALYSIS

Annette Kreiser & Richard W. Battarbee

Proceedings of Nordic Diatomist Meeting, Stockholm, 1987. University of Stockholm, Department of Quaternary Research (USDQR) Report 12, 1988, pp. 41 - 44.

NORDIC DIATOMIST MEETING STOCKHOLM ·87

The taxonomic concepts used by diatomists frequently vary between laboratories. Diatomists working within the Surface Water Acidification Project (SWAP) are attempting to harmonize approaches to the taxonomy of acid water floras. In an analytical quality control (AQC) exercise replicate slides were counted and the results compared. Here we present the results of canonical variate analysis, used to examine the degree of similarity between the separate diatom counts. Examples of the problems raised and the agreements reached are discussed.

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INTRODUCTION

Despite the general availability of major diatom floras, (e.g. Hustedt 1930-1966, Cleve-Euler 1951-1955, Patrick & Reimer 1966, 1975) there can be considerable variation in taxonomic and nomenclatural usage between diatomists in different laboratories. Floras differ in their definitions and use of names. Diatomists develop laboratory-based concepts for inter- and intra-specific taxonomic division and errors can easily be made. Such differences can hinder the comparison of data between laboratories and, in situations where diatoms are used as environmental indicators, misleading conclusions can arise.

In recent years, in response to the importance of diatom analysis in lake acidification studies, it has become essential for inter-laboratory protocols to be established and for taxonomic harmonization to be made with great care. In the USA, diatomists involved in the Palaeoecological Investigation of Recent Lake Acidification (PIRLA) project (Charles et al. 1987) have developed a rigorous system of taxonomic control (Kingston 1986) including the production of an iconograph series for diatoms from soft-water environments, regular workshops and the exchange of slides between laboratories.

In the European SWAP project (Battarbee & Renberg 1985) diatomists from Norway, Sweden and the UK have been attempting a similar harmonization, based on workshops and the exchange of slides. Links with the PIRLA project have been maintained through the presence of John Kingston at the workshops.

SLIDE EXCHANGE AND AQC

Each of the five diatom laboratories involved in the SWAP project circulated slides from three samples to the other laboratories, prior to a workshop held at University College London in March, 1987. The slides were chosen to represent the range of floras encountered in the acid water sites being studied by each laboratory. Count sheets were supplied with each slide. All slides were then recounted and the results submitted to UCL before the workshop. Table 1 lists the samples analysed with the number of diatom valves counted by each laboratory.

Fig. 1 shows the range of values and names for the dominant species at one site, Lingmoor Tarn. This analysis provided examples of the three main problems that arose.

i) Nomenclature. In this analysis there was a problem within the genus *Anomoeoneis* with both former and revised names being allocated to the same taxon in two cases. *Anomoeoneis vitrea* (Grun.) Ross was used by laboratory 1, and *A. exilis* Cleve, including the variety *lanceolata*, was used by laboratories 2, 3 and 4 for the same diatom. Likewise *A. brachysira* (Breb.) Grunow and *A. serians* var. *brachysira* (Breb.) Cleve were both applied to the same taxon. These two taxa have now been transferred to the genus *Brachysira*, *A. vitrea* becoming *B. vitrea* (Grun.) Ross and *A. brachysira* becoming *B. brebissonii* Ross.

ii) Splitting and amalgamation of taxa. *Anomoeoneis exilis* variety *lanceolata* was split from the nominate by one laboratory. This has also been transferred to the genus *Brachysira* as *B. vitrea* var. *lanceolata* and it was agreed that all laboratories should attempt to differentiate the lanceolate variety from the nominate.

iii) Identification. The criteria used to separate *Eunotia alpina* (Naeg.) Hustedt from *E. lunaris* (Ehr.) Grunow differed between laboratories. A mutually agreed list of criteria was drawn up to differentiate the two taxa. The revised names for *E. alpina* and *E. lunaris* are *E. naegelii* Migula and *E. curvata* (Kütz.) Lagerstedt respectively.

Despite these differences, Fig. 1 shows that the proportion of the most abundant taxa varied little between the laboratories. Comparisons of results from the other slides exchanged (Table 1) showed

TABLE 1. Slides analysed with the diatom counts for each slide.

Site Code	Site Names and Core Sample Depths	Laboratory 1	2	3	4	5
A	Round Loch of Glenhead 1-2 cm	496	193	164	512	•
B	Round Loch of Glenhead 43-44 cm	518	203	169	528	•
C	Llyn cwm Mynach 2-3 cm	536	198	165	522	•
D	Low Tarn surface sample	283	492	125	542	•
E	Scoat Tarn 80 cm	266	491	128	491	•
F	Lingmoor Tarn surface sample	444	501	150	500	•
G	Lilla Öresjön 6 cm	408	204	455	•	•
H	Lilla Öresjön 30 cm	465	•	417	•	•
J	Jon-Svenstjörn surface sample	434	•	402	•	•
K	Gulspettsvatn 4-5 cm	424	199	•	533	•
L	Verevatn 1.5 cm	411	•	219	495	•
M	Verevatn 19.5 cm	371	201	156	475	•
N	Tveitå surface sample	•	185	85	500	501
O	Tveitå 24 cm	•	200	293	531	551
P	Tveitå 37 cm	•	•	106	396	500

• data not available

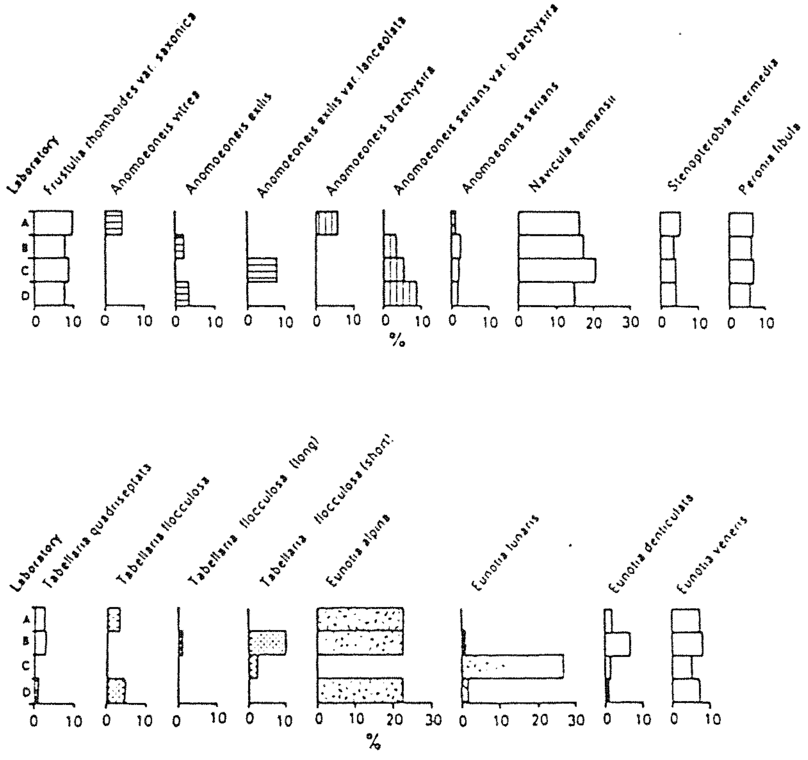

Fig. 1. Percentage abundances of the dominant diatom taxa in the Lingmoor Tarn slides. The shaded values denote problematic taxa.

a similar range of discrepancies and agreements. In order to provide some measure of similarity between the counts for each slide, canonical variate analysis (CANVAR) was used. Only taxa with abundances >5% were selected and these taxa were further screened for the use of synonyms. Any inconsistances in the original data resulting from problems of nomenclature are therefore omitted. The remaining 29 taxa were used for the analysis. The results are shown in Fig. 2. It can be seen that the counts for each slide plot together indicating little within-sample variation. There is also some grouping of certain slides, e.g. A, K, G and M, due to floristic similarities between samples.

AGREEMENTS

The following measures to improve standardization have been implemented:

i) A central taxonomic list containing all species (computer coded) commonly found by diatomists within the SWAP project has been compiled.

ii) Nomenclature is now standardized within the group, based on the British diatom checklist (Hartley 1986).

iii) Agreements have been reached on common definitions for the boundaries between certain species and their varieties. If possible published sources are to be used to solve taxonomic problems. Failing this, criteria for identification should be agreed between the participants.

iv) The agreements reached are to be firmly established in the correct historical framework by reference to type material and collections, with the cooperation of the British Museum (Natural History).

v) Further exchange of slides, photographs and descriptions will continue, with particular emphasis on problem areas within the *Aulacoseira*, *Eunotia* and *Navicula* genera.

vi) Future AQC exercises will be carried out without the assistance of count sheet.

CONCLUSION

Many potential sources of taxonomic error can be eradicated as a result of workshops and an AQC exercise. Multivariate analysis (e.g. CANVAR) can be used to illustrate the degree of taxonomic and statistical variability between laboratories. Revision of taxonomy occurs continually and checklists and databases need to be regularly updated. National and International meetings should be used to report on further changes.

ACKNOWLEDGEMENTS

We would like to thank Tony Stevenson for his help with the computing, and also all participants of the SWAP diatom workshop for providing the diatom data. Funding was provided by the Royal Society (SWAP).

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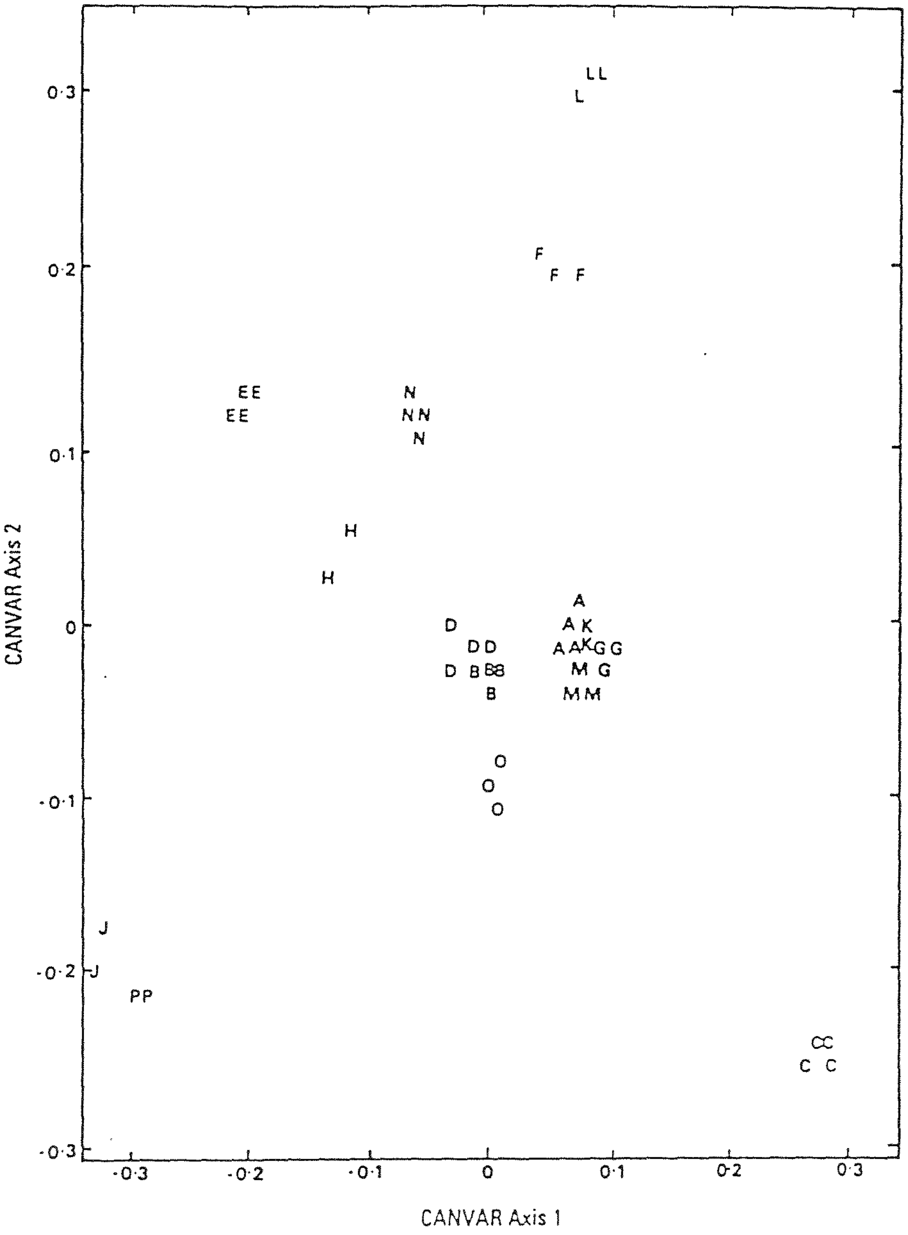

FIG. 2. Canonical variate analysis of the slides analysed.

Slide code letters are as listed in Table 1.