DISPLAY ONLY

ISSN 1366-7300

ECRC

ENVIRONMENTAL CHANGE RESEARCH CENTRE

University College London

RESEARCH REPORT

No. 52

NERC - GEOPASS Mid Project Review: GR3/10529: minutes of Workshop 1

A.W. Mackay

May 1998

Environmental Change Research Centre
University College London
26 Bedford Way
London
WC1H 0AP

ECRC Research Report of Mid-term Workshop

6th - 8th April, 1998

CONTENTS

1. INTRODUCTION

The mid-term project review meeting took place at the Environmental Change Research Centre, UCL between 6th - 8th April inclusive. All but one of the active participants in the project were present:

Prof. Rick Battarbee (RWB): Principal Investigator
Dr. Roger Flower (RJF): Principal Investigator
Dr. David Jewson (DJ): Principal Investigator
Dr. Dave Ryves (DBR): PDRA
Dr. Anson Mackay (AWM): Associated personnel
Dr. Mike Sturm (MS): Senior Visiting Fellow
Dr. Joan Lees (JL): Associated personnel

Apologies: Dr Anna Kuzmina (Senior Visiting Fellow)

Day 1 of the meeting was used as an opportunity for the project team to update each other on work progress to date, and to exhange & harmonise data already collected.

Day 2 focused on the NERC proposal, specifically what we have acheived so far, and what remains to be done to fulfill project requirements.

Day 3 focused firstly on what types of data would need to be collected to create a diatom transfer function for Lake Baikal. In the afternoon, new ideas for future projects and co-operation were discussed between the 4 groups: ECRC, University of Ulster, EAWAG & the Limnological Institute at Irkutsk.

2. PROGRESS REPORTS

2.1 Phytoplankton Monitoring Programme (DJ)

The phytoplankton monitoring programme has been operating for a total of 5 years now, and is revealing patterns in the data. Phytoplankton abundances in 1994 are similar to those in 1997, and likewise for 1995 & 1998, although each year still has it own peculiarities. For example, severe storms in November 1997 resulted in many 'edge' diatoms appearing at the base sampling site.

Monitoring, together with culturing work done at UU, is now showing some very interesting results in terms of the growth and life cycles of the major endemic diatom species:

- This spring large *Cyclotella baicalensis* - type valves (*c.* 110 µm diameter) are about the only diatom species left in the upper sediment layers as almost all other species were grazed by *Epischura* and, to a lesser degree, rotifers. Although the taxonomy between *C. baicalensis* and *C. ornata* has been problematic, culturing work is showing that these 2 species have different temperature optima. (To date, DJ has 7 - 8 spp of Baikal diatoms in culture now). Experiments have now shown that the third, and the most common *Cyclotella* spp., *C. minuta*, can survive temperatures of up to 10 - 12 ºC. In 1997, *C. minuta* managed to grow under the ice, providing a large innoculum for the autumn season, but as it turned out, there was no special bloom of this species, suggesting that its growth was curbed by nutrient limitations.

- *Aulacoseira. baicalensis* tends to avoid summer water stratification with its low P & Si values, and valves begin to sink. As the *Aulacoseira* grows, *C. minuta* declines, but then starts to grow again as temperatures increase. *Aulacoseira* abundances are actually controlled by *Epischura*, who in turn produce young dependant on how much food is around. Therefore, as *Aulacoseira* increases, *Epischura* increase, which in turn causes the diatom to decrease. The *Epischura* follow their food source down the water column, then as ice grows, the *Epischura* swim back up again and concentrate their feeding under the ice.

- It is important to record *Aulacoseira* valve length *vs* number: under the ice, valves have thin walls and are generally short, m = 17 - 18 µm. In June, when summer stratification occurs, valve length increases to 40 - 60 µm, but these cells only have a limited lifetime, indicative of prevailing environmental conditions, of which cell length indicates mutual exclusive populations. In the traps, the thin walled cells disappear, which may explain the fall in silica from the lower traps by 50%.

- *Aulacoseira* can grow in very low levels of silica, but as silica becomes limiting, it cannot grow the thicker longer cell types. In general, *A. baicalensis* can divide once every 4 days, whilst *Stephanodiscus binderanus* & *Nitzschia acicularis* can divide every day.

- Final aims are to take numbers of valves in the water column, and integrate for precise times that the traps were exposed, even doing this crop by crop. Maximum numbers would be expected to be found in traps, especially over a 1 year cycle. The properties of these species should be noted, such

as total numbers in column, and then properties expected in the surface sediments estimated. If numbers do correlate, then this will be the first time that this exercise will have been successful.

- DJ pointed out that palaeolimnologists often talk about diatom spp. disappearing in profiles. However, these plots are usually on linear scales. Attempts should be made to plot stratigraphical data on a log scale too, which may demonstrate that diatoms are almost always constantly present, albeit at very low concentrations. For example, in 1996, although this was not a Melosira year, *log* graphs show that growth rates in this year were as high for Melosira years, but just that the initial innoculum was lower.

- Data should be analysed in as many forms as possible, such as nos., volumes, concentrations, as all forms provide valuable information.

2.2 Sediment traps (MS)

In the summer 1997, we found that there was a vast amount of material deposited in the sequence trap in the south basin, with fluxes up to 5000 mg m^{-2} (from *c.* 200 mg m^{-2}). These large fluxes co-incide with a *Melosira* year.

There is no evidence of resuspension, thus contradicting Grachev *et al.*'s focusing theory, which suggests that one would expect to see differing fluxes in the upper & lower traps, but this tends not to be the case. The data do show that *perhaps* some resuspension may occur in the lower 5 m, but again, our diatom data tend to show that different crops can explain differences in fluxes.

During March - July, very little material was deposited in the higher trap at 100 m, where trap material mass increases, perhaps due to flocculation of material rather than natural settling. In all traps, there is no evidence of faecal pellets, unless they were subjected to taphonomic processes.

Trap material was examined using EDS analyses. In the upper traps, silica was found to dominate in all samples. Aluminium was also found to be important as a background signal of mineralogical properties, especially clastic material. Calcium is also present, and represents mineral debris into the lake by river input. In the lower traps, lots of carbonate appears to be present, e.g. in Spring 1996; argonite is also present, but this is usually formed by chemical equilibrium calibrations which are impossible in Baikal; under the ice in 1997, there is an increase in silicate feldspars.

It is extremely unlikely that this carbonate is due to resuspension, and is more likely to be due to biological processes. SEM pictures show concentrations of calcium carbonate up to 60 - 70% of all sediment, which look like small scales. Jewson suggests that perhaps they have come from Protozoa, of which 15 new species have recently been described. Overall however, its source is as yet unknown, but as calcium carbonate increases, silica is diluted in concentration.

Organic carbon contents were compared In the open traps, between December 1995 - June 1996. Reduced C/N ratios in July - December maybe due to shallower water species, such as *Synedra* dominating traps, i.e. non planktonic taxa. In the surface layers in summer, picoplankton increase and recycle nitrogen thereby reducing C/N ration.

2.3 Temperature profiles (MS)

T fluctuations in the upper 130 m were greater than at 1290 m & 1390 m. However, if we expand 1290 m & 1390 m at a higher resolution, and we see 'chimney structures' or thermal bars. The data show that a thermal bar that is present during June at 130 m which is not apparent lower down the water column. Furthermore, a thermal bar at 1290 m is not apparent in the surface waters. The 'chimney' structures in winter can be linked to 130 m and lower sensors; these however cannot be true thermal bars because of the differing densities in the water column.

Current flows at this time in January 1996 increase too, indicating a high speed, low temperature event. In January 1997, this event was more pronounced and occurs just before ice formation. There may therefore be a link to storminess, which in 1997 was extremely bad. Further, there is evidence of a cold layer over the whole bottom of the south basin in Jan 1997, but thermal bars show more patchy temperatures.

From work to date, two main conclusions can be drawn now:

1. enormous sinking speeds of over 100 m per day
2. resuspension of focusing of sediments is not significant

2.4 Diatom analyses in traps (DBR)

December 1995 - June 1996.

N. acicularis can be present in traps in vast quantities, but is not present in either the surface sediments or in the sediment column. DDI analyses suggest the dissolution in the water column is only very slight, and that dissolution is occurring at the sediment - surface water interface.

There is an increase in the number of valves in the bottom most trap which is only 3 m above the surface - this is mirrored by a small increase in dry matter weight. It was discussed whether this could be due to resuspension. However, Jewson shows a 10 fold increase in empty islandica valves reaching the bottom at that time, i.e. this increase that Ryves noticed can be explained by an pulse of old crops settling, rather than resuspension.

June 1996 - December 1996

This period is dominated by *S. acus*. Again there is a small increase in flux in the bottom trap, which is confirmed by Sturm results. Low numbers of acus were recorded in the surface waters because this species was already dropping down the water column.

Sequencing traps

Sequencing traps for December 1995 - November 1997 were analysed, and DBR presented results. It was suggested to Ryves that he present the data horizontally first. From the data, *S. binderanus* appears to sink before *Synedra* but they bloom at the same time. It could be that *S. binderanus* sinks faster due to the long chains that it forms, within one month. Further, DDI analyses suggests that as *Synedra* sinks, they dissolve, which Jewson can confirm.

The afternoon was spent by MS, DJ & DBR exchanging data etc.

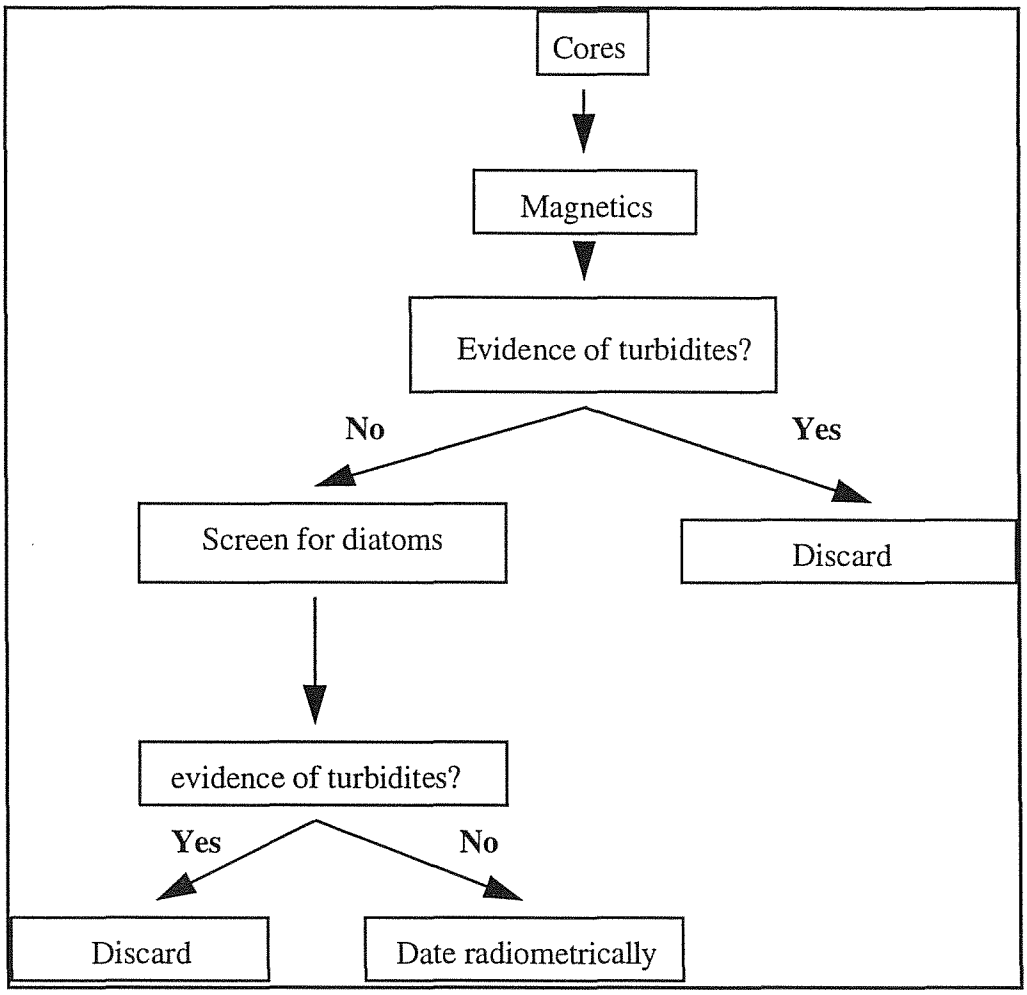
3. ACHIEVEMENTS

Day 2 of the workshop focused on the objectives that were set out in the NERC proposal - what we have achieved so far in this context, and what now needs to be done over the final year of the contract.

Screening as many cores as possible for diatom evidence of turbidites is extremely time consuming and labour intensive. We therefore decided to incorporate into the programme a further screening process,

eliminating cores firstly on the basis of magnetics and photography (Fig. 1). Cores within transects where no obvious turbidites are present, were then screened for diatoms.

Figure 1: Core screenig procedure for turbidites



The Swiss GEOPASS project has already examined 3 regions of Lake Baikal in detail:

- south of the north basin (Zavarotnya region)
- Academician ridge
- south basin

To effectively determine regions where turbidites may or may not be present, many cores in a relatively small area ought to be examined. For example, Marc de Batiste in Belgium took lots of cores in the Zavarotnya sub basin, which is very tectonic, including core numbers 72, 73, 74, 79, 106, 107, 71, 76. He found that the cores were very different with differing old surfaces.

Two transects were selected as being suitable for analyses for this project. The first transect is in the south eastern side of the north basin, the Zavarotnya transect (cores 75, 79, 80 & 81). Core 79 has evidence of a turbidite, whereas numbers 80 and 81 do not. Core 80 will form the basis of a dissertation by the MRes student Mark Bangs. This will leave 78 still to count, which has evidence of a small turbidite. In the south basin, another possible transect is 45, 43, 44, 112, 113 & 114, although 45 & 112 did not contain that years *Aulacoseira* bloom on the surface sediment. Core no. 43 has already been counted by AK, and for the purpose of the transect, 114 should be counted in full, and 113 screened for diatoms.

One further area to be explored is a ridge area just to the north of the Ridge, where core nos. 65 & 69 and 108 & 109 have been collected. Each of these core pairs, i.e. 65- 69 and 108-109 are replicates. It is recommended that we count for diatoms 69 & 109. It was decided, that should Joan have the time, that she measures these 2 cores too, as well as remeasuring 65 and 108 & 75. Remeasuring 65 & 108 will enable Joan to see what effects of storing cores for 2 years will have on magnetic measurements.

3.1 Paper writing

Sturm has a couple of papers that he has to write to fulfil GEOPASS requirements:

1. dramatic particle fluxes
2. spatial patterns of recent sedimentary processes

These can fit into the series of papers planed from the joint NERC-GEOPASS team (see Table below). The papers can be written in 3 phases:

Phase 1:

- a first paper should be a rapid short communication, and be written asap.

Phase 2:

- a trilogy of 3 papers to be submitted to *L&O*. First drafts for these should be ready at SIL 1998.

Phase 3:

- these will be written as results are collated, e.g. once envirtonmental data have been collected, and Mark Bangs has completed his MRes dissertation.

All the papers will have Russian and Swiss collaborators - details are not provided in the table below, but should be taken as read.

No	Lead Author	Description	Other Authors	Journal
1	Sturm	rapid communication inc. traps speed of settling etc.	DJ/DBR	*Science/L&O*
2	Jewson	6 spp paper	MS/DBR	*L&O*
3	Sturm	trap paper, esp. masses, chemistries, resuspension, thermal bars, SEM work etc	DJ/DBR	*L&O*
4	Ryves	trap paper based on diatoms & flux calculations	DJ/MS	*L&O*
5	Battarbee	link phytoplankton, traps, surface sediments & lower sediments numerically 1996 - 1997	DBR/DJ/MS/RJF/ AWM	*L&O/JOPL*
6	Mackay	transfer function paper	DBR/DJ	*L&O*
7	Battarbee	trubidites for palaeolimnologists	RJF/MS/JL	*JOPL*
8	Sturm	spatial patterns of turbidites, basins, shoulders etc.		*??*
9	Bangs	Zavarotnya transect - evidence of turbidites, via diatoms, dating etc.	AWM/RJF/MS/JL/MB	*JOPL*

4. TRANSFER FUNCTIONS

In order for a diatom transfer function to be formulated, as many variables as possible for as many sites in Baikal need to be collated, including picoplankton & zooplankton. This will be done in conjunction with Nick and Liba Granin, using some of the excess monies from BICER ($4000) to do further sampling in the northern basin, e.g. spring peak, autumn mixing, ice on + one other period. Monies will also be made available from a new INTAS grant of 60K ecu. This money will be used to look at spatial variation between on-shore & off-shore diatoms, e.g. gyres, thermal bars. This data can also be used for the transfer function. Two stations will be planned, one to the north, and one to the south of the Zavarotnya transect.

Morphologies of valves need to counted, and an agreed strategy between DJ & DBR has been agreed. Length measurements will also confirm what is in the water column, and if the traps are actually trapping what is in the water, i.e. assessing the reliability of the traps.

DJ has counted valve lengths in the surface sediments collected by MS in 1993. We now need to do same measurements in all our surface sediments. Need also to calculate Cyc/Aul ratios & resting - vegetative cell ratios.

- Water temperatures are not really needed, and crude data should suffice

- Mean surface water temps within grid squares, thereby allowing us to tell when stratification starts and sinking of diatoms begins.

- All the data collected should be smoothed, so therefore look for data 88-93, 92-96 & 93-97.

- Albedo measurements can be got from Frank.Peters@eawag.ch, who has data for 10-15 years. Is it possible to model snow cover over the last 100 years by using met office data. Over 100 years, work out variability of snow cover.

- In general, over the Holocene there have not been that many changes to Baikal, e.g. circulation patterns, but could this be true for the chemistry?

- David Livingstone discovered that February temperatures seemed to trigger ice cover duration, and linked this to North Atlantic Oscillations (NAO)

- Circulation: gyres are important in terms of distance from Selenga, and data may be gotten from the review book by Shimaraev *et al.* It will be difficult to measure, but perhaps some modelling can be done using ice cover, i.e. clear ice is indicative of high pressure, and snow covered ice indicative of low pressure, with a gradient in between. Circulation is most important during Spring.

- Other parameters can include distance from the Selenga - figures may have to be weighted to compensate for % age flow, and distribution through thermal bars.

- Chemical e.g. silica & conductivity and biological data are also important. Picoplankton data may be assessed indirectly through draw down in N/P ratios, data for which exists since 1990. Afanasaeva has spatial data on zooplankton, but need to be careful of how s/he is approached.

5. FUTURE WORK

Sturm has a deadline for GEOPASS on 30-Sep-98, and will apply for a new grant in April 1999. MS would like to co-operate with Ulster, UCL & LIN, especially in terms of biological and physical measurements, and the development of the transfer function. DJ will use the traps put out by MS to collect algae and link to physical analyses using thermistors. 2 sets of traps will be set up to (i) monitor physical material, and (ii) to monitor biological material.

The project will centre around circulation, especially geochemical processes from surface of Baikal through to the sediments, in the north and south basins. This project will not focus on coring work in 'prime' sites.

If this proposal is successful, then traps will be deployed in the summer of 1999, and the first samples ready by *c.* January 2000. The ECRC should therefore aim to apply for a new standard NERC grant in January 2000. This monitoring programme ought to incorporate modelling, e.g. knowledge of GCM predictions of GHG. We should also look to apply for EU funding, perhaps under Framework 5, using BICER to collate groups together.