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Your file Votre référence

Our file Notre référence

*Oboes Dan Shlyannov  
17.08.89.  
T.U. Harpov: b deuo  
*

Dr. Mikhail Grachev  
Institute of Limnology  
University of Irkutsk  
Irkutsk, USSR

7 July 1989

Dear Dr. Grachev:

Please excuse my tardiness in expressing my gratitude to you for the opportunity to carry out research on Lake Baikal. Your scientific staff and the crew of the VERESCHAGIN were a delight to work with, and I look forward to a chance to continue this work.

I think the work begun in 1988 will lead to a new understanding of convection in deep lakes. Already there are some practical applications. For example, in western Canada there are 9 lakes deeper than 300 m; some of these are very important because they are sites for spawning and early rearing of anadromous fish. Now, since these lakes are very oligotrophic, the government has a program to artificially fertilize them with nutrients. It is clear that the proper management of the lake fertilization program requires an understanding of the seasonal mixing cycle, as there is quite a difference in the amount of costly fertilizer that required for a lake that mixes twice yearly as opposed to one that mixes on a longer time scale.

I have enclosed an outline of proposed work for cooperative studies on the physics of deep convection and lake climate in Lake Baikal. Tentatively, this work will begin in March or April of 1990. The proposal consists of three parts. The first is to obtain a much needed CTD survey of the lake during mid-winter; perhaps this survey could be repeated immediately prior to and after ice break-up. Data such as this would be invaluable in describing lake structure for the purpose of modelling. The second activity is to begin a long-term monitor of the lake as part of an international program involving other deep lakes. (To not include Baikal in such a project would be an obvious loss for the program!) An added benefit of this program is that it draws together limnologists from all over the world to discuss common problems associated with global change. The third part is to begin to model physical processes in Lake Baikal for eventual incorporation into a practical model of chemical and biological distributions. I propose to do this work in collaboration with colleagues at the Institute of Ocean Sciences and the Canada Centre for Inland Waters.

Please inform me as to your thoughts about this proposal; I am open to all suggestions. If you are supportive, I will begin at once to procure

the necessary financial support and field instrumentation. Hopefully, this work will lead to a long and fruitful collaboration and to many important discoveries.

Sincerely yours,

A handwritten signature in black ink, appearing to read 'Eddy Carmack', with a long horizontal flourish extending to the right.

Eddy Carmack

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# PROPOSAL FOR PHYSICAL LIMNOLOGY STUDIES ON LAKE BAIKAL (1990-91)

From

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## OBJECTIVE

To study physical processes associated with deep convection and mixing in Lake Baikal, and to apply these results to basic problems of biogeochemical transport and global change.

## ACTIVITIES

First, to carry out detailed conductivity/temperature/depth (CTD) surveys of Lake Baikal during the period of full winter ice cover (See Annex 1). This work would involve 2-4 Canadians and approximately 2 weeks of field work in March or April, 1990.

Second, to initiate a sustained measurement program as part of an international study of lake climate change (see Annex 2). This project involves the deployment of a long-term mooring consisting of a fixed thermistor chain (FTC) and a sequentially sampling sediment trap (SST). If arrangements can be made in time a test deployment could be made in 1990.

Third, to begin development of a time-dependent model of thermal structure and mixing based on the formulation of Paterson and Hamblin (1988), and including the effects of ice cover, geothermal heating, and a non-linear equation of state.

## PROCEDURES AND REQUIREMENTS

Canadians will provide the necessary instrumentation and equipment for field work, data analysis, and modelling; Soviets will provide logistics and field support. All travel and work will be carried out on a currency-free basis.

Data software, and computer models will be exchanged. Canadian and Soviet scientists will co-publish results. Technical expertise will be transferred through cooperation in field work.

Efforts will be made to arrange the exchange of students between Canadian and Soviet universities during summer break. Tentatively, the first exchange could take place in summer, 1990.

LAKE BAIKAL  
U.S.S.R

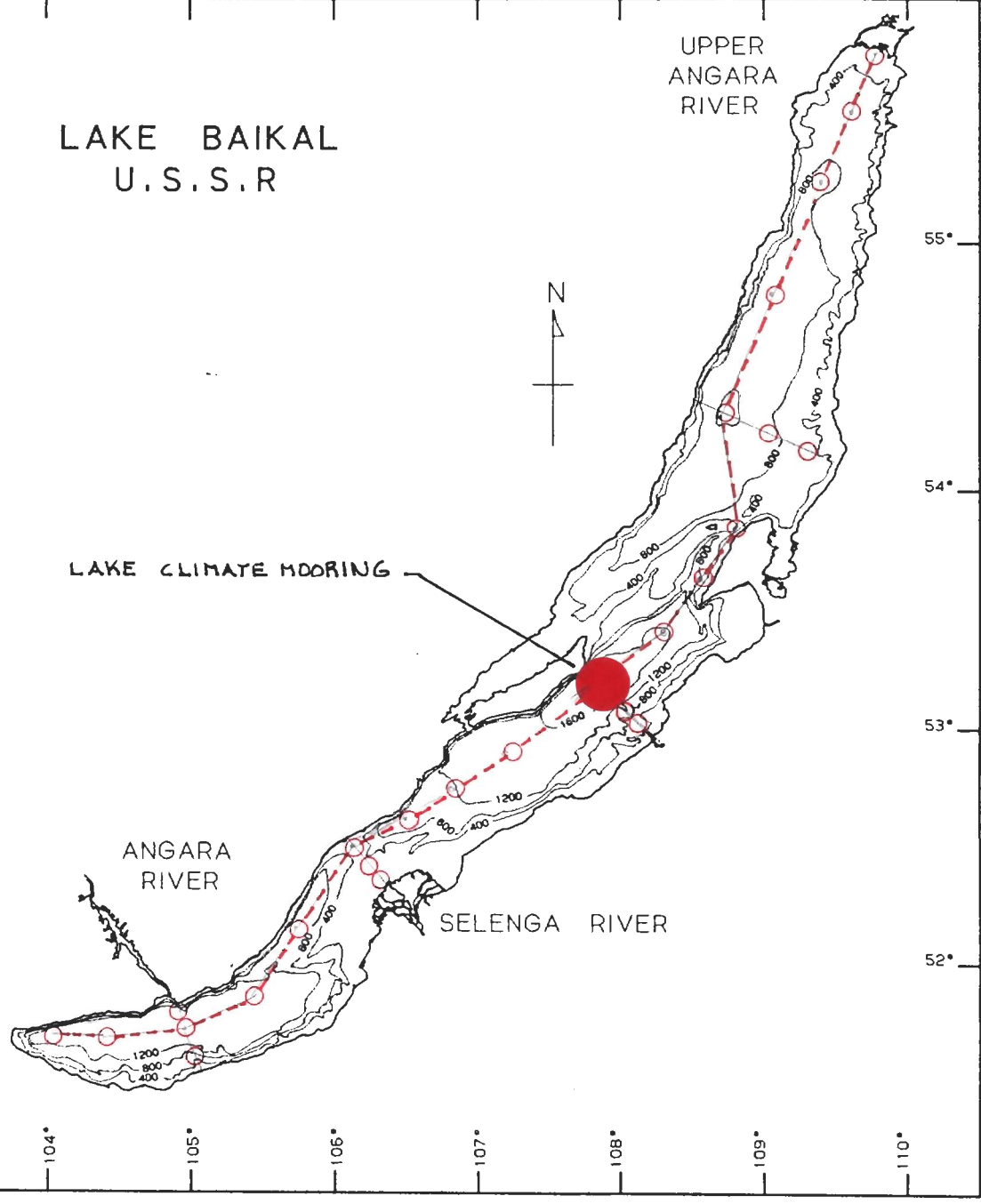
UPPER  
ANGARA  
RIVER



LAKE CLIMATE MOORING

ANGARA  
RIVER

SELENGA RIVER

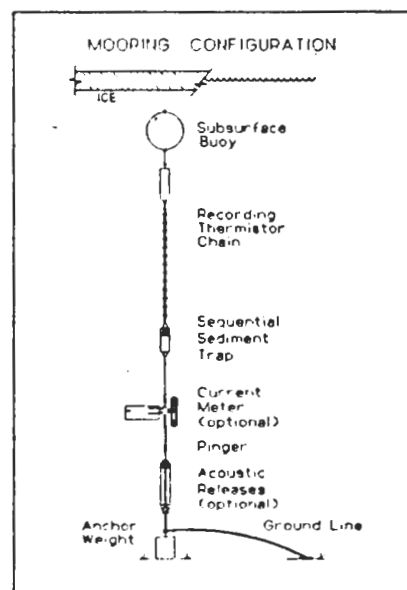
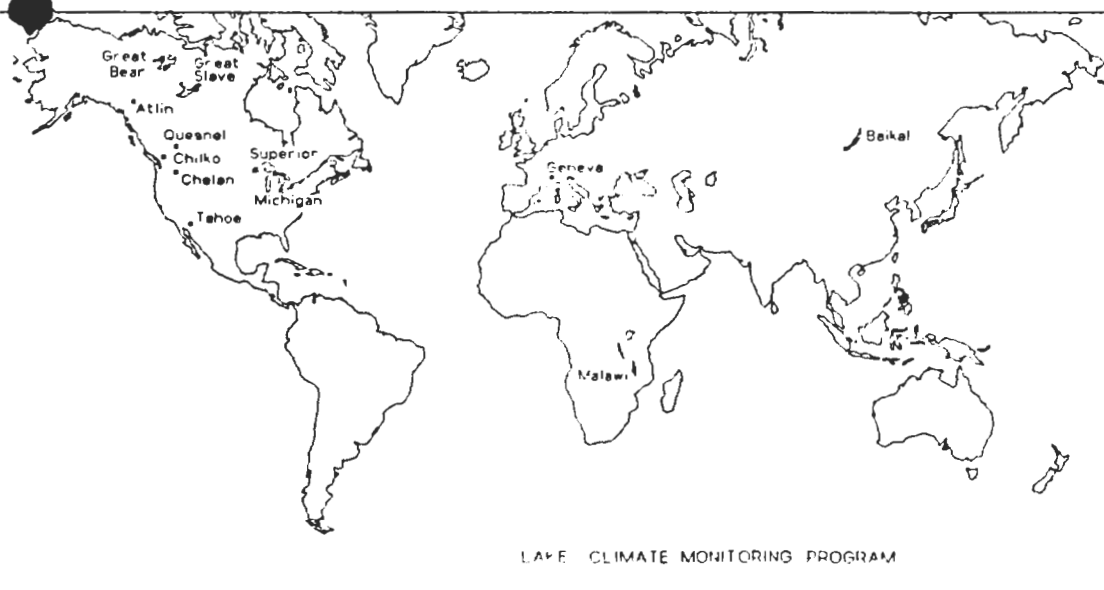


PROPOSED WINTER SURVEY

## LAKE CLIMATE MONITORING PROGRAM

Large, deep lakes offer a unique setting within which to monitor global change. They are found from polar to tropical regions, and thus form a kind of planetary thermometer that spans the full range of atmospheric and hydrologic settings. Their great volume acts to integrate the biological and physical effects of climate. They are of sufficient size to respond to all the basic physical forcing mechanisms that affect the world ocean, yet they are also closed systems, a feature which makes their study much simpler. It is anticipated that global warming will alter temperatures, the length of the stratified season, the depth of the mixed-layer, flushing and ventilation rates, the duration of ice cover, primary productivity, and plankton community structure.

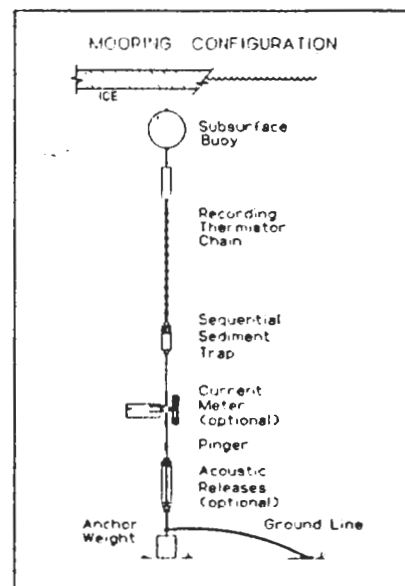
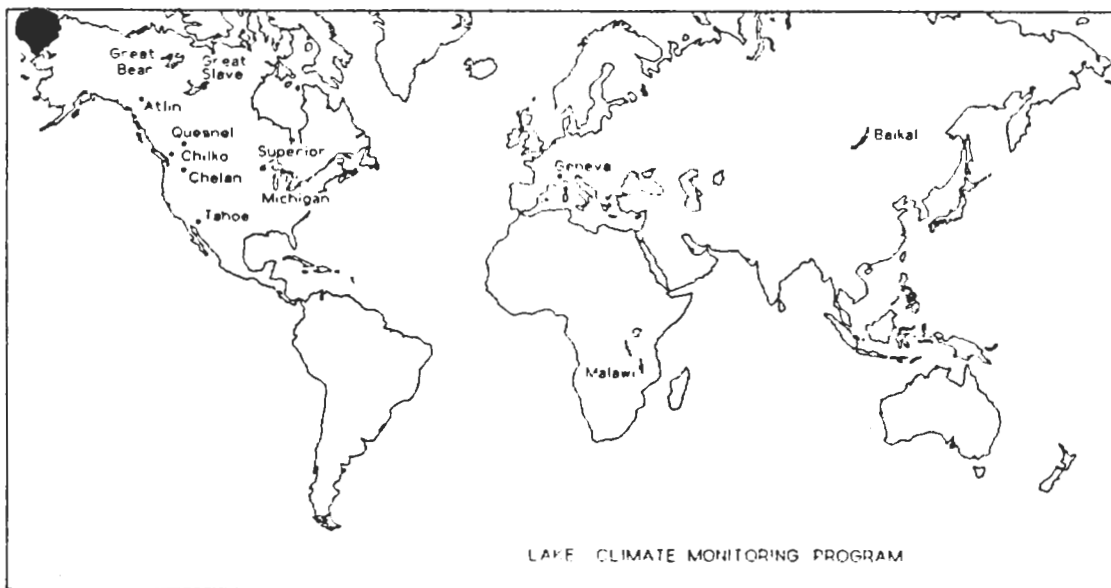
It is proposed here that a network of lake climate moorings be established in selected deep lakes of the world, and that these moorings be maintained into the next century. Twelve lakes are picked to both (a) cover as wide a latitude range as possible, and (b) encircle the world within the present day zone of seasonal snow and ice cover. The program would be run as a confederation; that is, member laboratories would agree to buy and maintain the basic mooring within a certain lake, knowing that all members have equal access to the data. To allow a meaningful comparison of data, a standard mooring design would be used in all lakes; this mooring consists of a thermistor chain, to obtain the thermal record, and a sequential sediment trap, to monitor carbon flux and community structure. To this bedrock program member laboratories will be encouraged to conduct other process oriented studies connected with climate change. Annual workshops will be held to exchange data and scientific results.



## LAKE CLIMATE MONITORING PROGRAM

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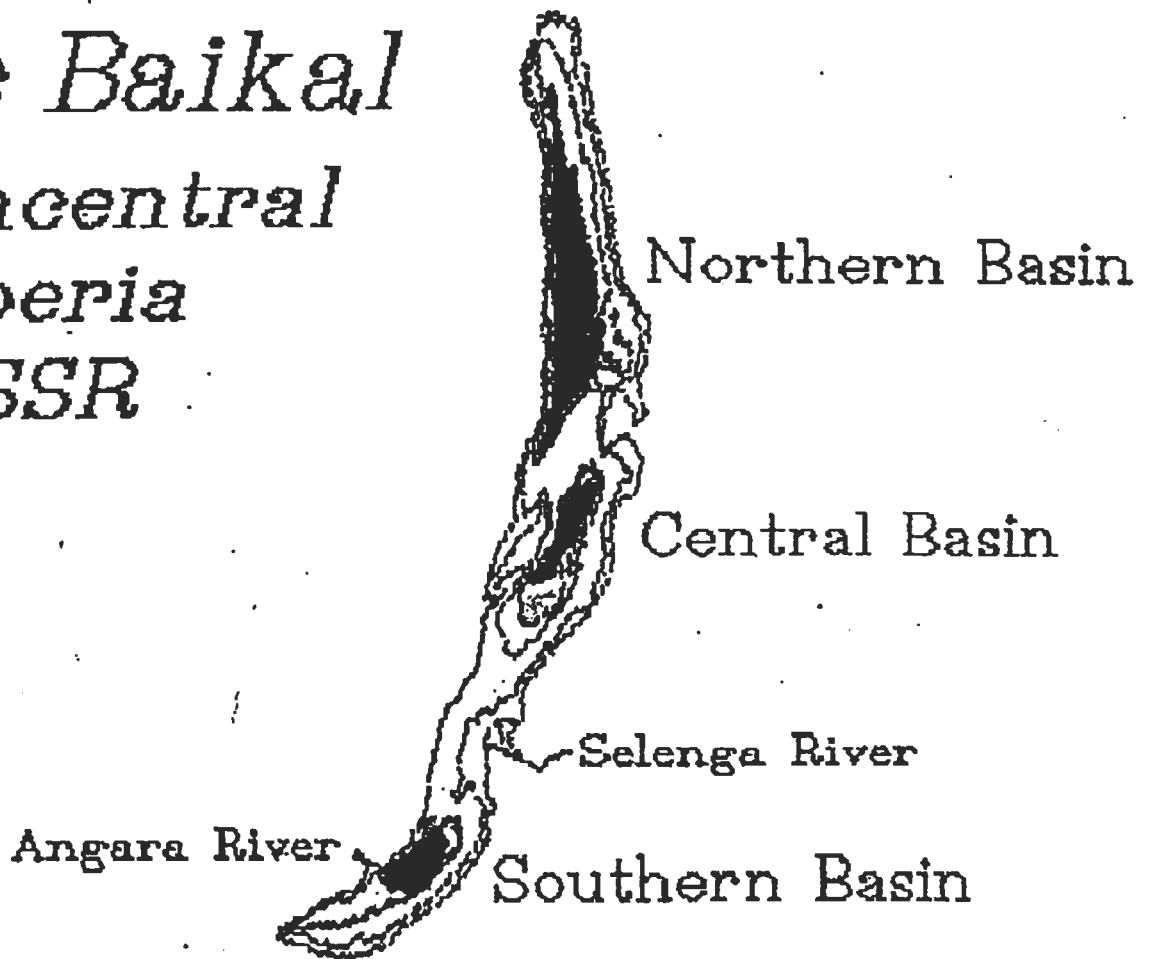


# *Lake Baikal*

*southcentral*

*Siberia*

*USSR*



## *Origin and History of Lake Baikal and its Sedimentary Record*

Proposal to the National Science Foundation

Douglas F. Williams

Kim D. Klitgord

Deborah Hutchinson-Gove

Paul P. Hearn, Jr.

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**PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION****DIVISION OF INTERNATIONAL PROGRAMS  
DIVISION OF THE EARTH SCIENCES  
DIVISION OF ATMOSPHERIC SCIENCES****ORIGIN AND TECTONIC HISTORY OF LAKE BAIKAL  
AND ITS SEDIMENTARY SECTION****Co-Principal Investigators:**

Douglas F. Williams, University of South Carolina  
Kim Klitgord, USGS-Woods Hole  
Deborah Hutchinson, USGS-Woods Hole  
Paul P. Hearn, Jr. USGS-Reston

**ABSTRACT**

Lake Baikal is the world's deepest lake, by volume the world's largest lake and certainly one of the oldest lake systems in the northern hemisphere. Lake Baikal occupies a central position in the Baikal Rift Zone (BRZ), southcentral Siberia, where active intracontinental extension is occurring today. The sediments within the Lake Baikal depression are estimated to be over 5 km thick. This proposal requests funding for a basic scientific investigation of the origin and tectonic history of Lake Baikal and its sedimentary section through the joint analysis of Soviet multichannel seismic (MCS) data, the first such data to be released to the western scientific community. In addition, the most recent history of Lake Baikal sediments will be examined by conducting sedimentological, geochemical and paleomagnetic studies of new piston cores collected summer 1989 by the Institute of Oceanology, Moscow. This new MCS and core material were collected as part of a five-year program by seven Soviet institutes to study the geodynamics and evolution of the Lake Baikal sedimentary system. The proposed cooperative study of Lake Baikal will be implemented Memorandum of Understanding (MOU) in Basic Scientific Research between the NSF and the USSR Academy of Sciences, and the MOU in Geoscience between the U.S. Geological Survey and the USSR Ministry of Geology. Information gained from this study will be of fundamental importance to understanding the tectono-stratigraphic evolution of Lake Baikal and the Baikal Rift Zone. By characterizing tectonic-sedimentary interactions and identifying useful climate proxies in Baikal sediments, the study will also lay an important foundation for future efforts to obtain long-term (10-20 Ma) records of climate change on the Asian continent.



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	A. Douglas F. Williams, University of South Carolina	
	B. Kim D. Klitgord, USGS-Woods Hole	
	C. Deborah Hutchinson, USGS-Woods Hole	
	D. Paul P. Hearn, Jr., USGS-Reston	
Appendix I.	Memorandum of Baikal Drilling Project Meetings, University of South Carolina, July 1989.	

Prof. W.A. Elders (40 京都大学 地江正治先生)  
40 都仁 東京

Dear Prof. Elders

① send more 19 pages.

*kijs*

## II. INTRODUCTION

The Baikal Rift Zone is actively extensional today and thus provides geoscientists with a prime opportunity to understand the mechanisms and processes involved in continental rifting. Lake Baikal occupies the deepest depressions of the rift zone. The thick lacustrine sequence of the lake (>5000 m) offers an unparalleled opportunity for studying of a long-term continental paleoclimatic record. The objectives of this proposal are to conduct a basic scientific investigation of the origin and tectonic history of this important Baikal rift-lake system through the joint analysis of the first Soviet multichannel seismic (MCS) data released to the western scientific community and newly collected piston cores. Our first examination of one line of the Baikal MCS data has yielded a highly interpretable profile with exciting geological information. We and our Soviet colleagues believe that processing of the remaining 1000 km of MCS data enable us to better define the geometry of the Baikal Rift Zone underlying Lake Baikal and the distribution of sedimentary units in Lake Baikal as a function of tectonic setting. The proposed MCS and piston core study will also lay an important foundation for future efforts to obtain long-term (10-20 Ma) records of climate change on the Asian continent.

### A. Regional Framework of Lake Baikal and the Baikal Rift Zone

More than 2,500 km in length, the Baikal Rift Zone (BRZ) is located in northwestern Mongolia to southeastern Siberia (97°E, 50°N to 120°E 57°N). The latest phase of rifting began in the middle Cenozoic after almost 150 m.y. of tectonic quiescence (Lipman et al., 1989). The BRZ separates the tectonically stable Siberian craton to the northwest from seismically active tectonic belts in Mongolia to the southeast. The rift zone consists of numerous fault-bounded troughs and depressions along the southern margin of the Siberian Plateau. Grabens of the rift are asymmetric (Abalakov, 1974), with the northern or western margin predominantly being the steepest, sloping gently to the southern or eastern margin.

At an elevation of 468 m above sea level, Lake Baikal occupies a series of linear depressions in the center of the Baikal Rift Zone (BRZ) (Figure 1) (Logatchev, 1968; Logatchev et al. 1974; Krylov et al. 1976; Logatchev et al., 1983). It is the world's deepest lake, by volume the world's largest lake and certainly one of the oldest lake systems in the northern hemisphere. Soviet single-channel seismic profiling surveys indicate that the Lake Baikal depression is divided into three evolving basins: Northern, Central and Southern (Figure 2) (Zorin, 1966; Zorin et al., 1977). Each basin has active sedimentation, differing levels of recent tectonic activity and

complex neotectonic structures (Figure 2) (Abalakov, 1974). Water depths in the central basin are the deepest (1622 m) compared with approximately 1400 m in the southern basin and 889 m in the northern basin (Nikolayev et al., 1985). The Academician Ridge including Olkhon Island separates the Northern and Central basins. Synrift volcanism occurs throughout the BRZ but has never been identified or sampled within the lake (Lipman et al., 1989).

The sediments of Lake Baikal are Neogene to Quaternary in age and range in thicknesses from 500 m to 5000 m (Nikolayev et al., 1985). Several borings made in the Selenga River Delta during the late 1950's penetrated 3000 m of Neogene to Recent deposits. Sediments are especially thick in the Selenga delta where the Selenga River empties into the southwestern part of Lake Baikal (Zamarayev et al., 1979). Except for the borings on the Selenga River Delta, much of what appears to be published in the literature about the composition and age of the deeply buried sediments of the Lake Baikal basins is based on interpretations of single-channel seismic profiles and correlation with exposures along the shores of Lake Baikal.

## B. Results to Date from Lake Baikal Multichannel Line #9

### 1. Background

During summer, 1989, the Institute of Oceanology of the USSR Academy of Sciences collected 15 lines of multichannel seismic reflection data (MCS) to provide regional coverage of Lake Baikal (Fig. 3). The data are part of a larger collaborative project of Soviet Institutions entitled "Paleolimnology and Deep-water Ecology of Lake Baikal". In order to determine the feasibility of processing the MCS data, Williams arbitrarily chose line 9 for test processing during his visit to the Soviet Union in August, 1989. On October 8, 1989, Ardis Savory, Vice President for Research at the University of South Carolina, returned from the Soviet Union with eight magnetic tapes of line 9, provided from the Institute of Oceanology. These data represent the first Soviet-collected MCS data to leave the Soviet Union for processing in the USA. The tapes were sent to Klitgord and Hutchinson on 15 October for processing at the USGS VAX/DISCO facility in Denver.

In the month available for processing prior to submission of this proposal, we have been able to generate a brute stack of Lake Baikal line 9 (Fig. 4). This brute stack shows clearly that the Baikal MCS data were collected satisfactorily, that the preliminary geological results are promising, and that the remaining 14 lines of MCS data, including one line which traverses the entire length of Lake Baikal, warrant processing.

## 2. Acquisition and Processing Parameters

Acquisition parameters for line 9 show a rather modest multichannel system: 1200-m-long streamer, 24 channels (50-m groups), 17-liter airgun source (about 1000 cubic inches), 50-m shot spacing yielding 12-fold data, 2-millisecond (ms) sample rate, and a recording length of 7 seconds (s) two-way travel time. The data were collected in standard SEG-B format that was easily read using standard DISCO input. Processing through the brute stack involved demultiplexing, editing, resampling to 4 ms, sort, deconvolution, velocity analysis, mute, normal-moveout correction, stack 12-fold, vertical stack adjacent traces, and display. This processing has not followed any special noise-reduction or signal enhancement techniques, and this first examination of the data will provide the basis for developing more appropriate processing parameters and strategies for final processing. Because of the preliminary nature of the processing, we have not performed any post-stack migration.

## 3. Preliminary Geological Interpretation of Baikal Line #9

Lake Baikal MCS line #9 trends northwest-southeast in central Lake Baikal, north of Olkhon Island (Fig. 3). The geological results from profile 9 (Fig. 4) are extremely promising. For example,

(a) The southern end of the Northern Basin is relatively shallow with less than about 300 m (0.4 s) of sedimentary fill (CDP 1 to CDP 500, S1 in Fig. 4).

(b) The details of the near trace, single-channel profile in this northern basin reveal a minor offset within the sedimentary section CDP 470, CDP 510, (Fig. 5). This offset suggests that minor active faulting is affecting this basin.

(c) The Academician Ridge is prominently displayed from CDP 500 to CDP 1100. The MCS data reveal that this ridge is partly a basement high (CDP 600 to CDP 750) and partly a thick sedimentary wedge (1.5 km, 1.8 s). The sedimentary section is underlain by very rough basement topography which probably consists of faulted blocks (CDP 750 to CDP 1100, S2 and S4, Fig. 6).

(d) A major normal fault, down to the southeast, occurs in the middle of the Academician Ridge (CDP 750).

(e) The lake depth increases rapidly southeast of the ridge and rises equally abruptly towards the eastern shore of the Central Basin (CDP 1100 to CDP 2400). The

intervening flat basin floor at CDP 1450 to CDP 1800 forms the northern portion of the Central Basin. Numerous reflector offsets occur at depth within the sedimentary section (Fig. 7). This suggests that, at least in this portion of Lake Baikal, the Central Basin is actively deforming along its edges in contrast to the Northern Basin is much less active.

(f) This line does not provide convincing evidence of half-graben structures or listric faulting, although the basin shape and basement depths are variable and complex.

#### 4. Preliminary Evidence for Deformation Episodes

The MCS data reveal at least two episodes of deformation within this portion of the BRZ. The youngest episode is the active faulting mentioned above along the edges of the Central Basin (Fig. 7). An older fault sequence can be identified within the deeper sediments beneath the Academician Ridge (CDP 750 to CDP 1100, S4 in Fig. 4) by offsets that fail to penetrate above about 1.2 s (Fig. 6). It is unclear on the MCS data whether the large fault at CDP 750, which is presumably related to the older faulting, is currently active. Although detailed processing of this area, including migration, is clearly needed, these preliminary results hint at progressive focusing of the active extension from the periphery towards the center of the lake. Results from the other multichannel seismic lines will be essential to clarify this process.

#### 5. Preliminary Stratigraphic Evidence From Baikal Line 9

The MCS data of profile 9 contain seismic stratigraphic information that should elucidate the evolution of the BRZ as well as the history of lake levels. For example,

a) Beneath the deepest portions of the Central Basin, a series of weak northwestward dipping reflectors are imaged in the brute stack that suggest a major unconformities (and rotation) in these older deposits (\* in Fig. 4, enlarged in Fig. 7). These dipping events may be part of a more chaotic, unlayered seismic sequence (S5 in Fig. 4, enlarged in Fig. 7). The sequence grades upward into and interfingers with the flat-lying well-laminated reflections that form the immediate subbottom unit of the Central Basin (S3, Fig. 4). These dipping events may also be evidence of the older ("slow rifting") phase of the rift development whereas the overlying flat deposits are part of the younger ("fast rifting") phase described by Logatchev and Zorin (1987). More processing to image these weak events is in order, as well as identifying them on other profiles and mapping their

distribution and geometry.

b) A second distinct break in the stratigraphic section occurs within the sediments that form the Academician Ridge (units S2 and S4 in Fig. 4, enlarged in Fig. 6). Below about 1.2 s, the sediments of unit S4 are faulted and dip gently to the southeast, especially from about CDP 950 to CDP 1100. The overlying reflectors are basically flat-lying, unfaulted, and much more transparent. The deeper unit indicates an older deformational event and perhaps an older deltaic unit, represented by the dipping (foreset?) reflectors. If confirmed with further processing, such features could be used to infer past drainage patterns in the lake and/or changes in lake levels during Lake Baikal's tectonic development and response to Neogene paleoclimate changes.

In summary, this first examination of MCS data from Lake Baikal has yielded a highly interpretable profile with exciting geological information. The standard acquisition format on the magnetic tapes is easy to incorporate into existing MCS processing packages, and strictly routine processing has demonstrated the feasibility of processing these Soviet-collected MCS data. Because Baikal line #9 was randomly chosen by Williams from the entire 15 line data set, it is reasonable to assume that line 9 is representative of the other 14 lines, rather than representing the best of this valuable MCS data from Lake Baikal.

## 6. Limitations of the Baikal MCS Lines

Having stated the above, it is important to discuss the limitations of the MCS data, for this first processing effort has clearly pointed to some deficiencies:

(1) The airgun source is dominated by a low-frequency (12.5Hz) peak, typical of a single large gun. Spectral analysis of randomly selected shot gathers shows the peak is consistent in the data; the spectrum drops rapidly (-30 dB down) to about 50 Hz, and then drops less rapidly (-60 dB down) to about 200 Hz. The dominance of the low frequency signal is the reason for resampling the data to 4 ms, as there is no loss of information by doing this, yet the data volume is reduced by 50 percent. This dominant low-frequency signal limits the resolution of the data: using the quarter wavelength rule, the resolution of a 12.5 Hz signal at water velocities is about 40 m; that of a 50 Hz signal is about 7.5 m. At best, these data will be of limited use for detailed stratigraphic correlation, though they are still appropriate for establishing the regional geologic framework. We have balanced the spectrum by

application of a deconvolution filter.

(2) The shot point navigation has not (yet) been supplied to us. Hence we only know in a general sense where these lines are located (fig. 3). This compromises our ability to map units and structures, but does not prevent us from using the data to define the gross structural and stratigraphic framework. Lack of navigation will also compromise our ability to tie the lines together with the single long profile that runs along the axis of the lake. We expect to get the navigation data from our Soviet colleagues with the rest of the field tapes. The quality of the navigation is also currently unknown.

(3) Observers logs were not provided for the data. We are currently unaware whether logs exist and are available, although we assume that they are. This omission did not seriously affect the processing of line 9 because there were no noise test or other non-data files on the field tapes. Careful monitoring of the near trace profile in the demultiplexing phase revealed that possible data gaps inferred from small discontinuities of the seismic section coincided with one to a few missing record numbers on the field tapes. Our assumption that one record number increment coincided with one 50-m shot appears to have been justified for line 9, and this will be our approach in processing the rest of the data if observer's logs are not available.

(4) The streamer sensitivity varies between channels, which can be seen by strong and weak groups of channels. This variation is consistent along the line but is not consistent with one or more bad gain channels. There were no dead channels and the variation was not characterized by excessively weak or strong channels, only moderately varying responses. This deficiency is most serious for true-amplitude processing, which we are not planning to do at this time. Our intention is to generate scaled sections, and this streamer response, while not ideal, is adequate for our purpose. The streamer length (1200m, far offset = 1570m) will also limit our ability to resolve velocities below about 2km).

### III. PROPOSAL OBJECTIVES .

#### A. Geophysical Objectives

Most interpretations about the tectonic evolution of Lake Baikal published by Soviet scientists in English have been based on single-channel seismic surveys conducted by the Geological Institute and Institute of Oceanology. These studies indicate that the sediment within the lake is probably in excess of 5,000 m, and represents 20 to 30 million years of Earth history (e.g., Nikolaev et al., 1985). It is well known, however, that interpretations of rifted basins based on single-channel profiles are limited, especially given the complexity of basement structures in the Lake Baikal depression (Lut, 1964; Florensov et al., 1978; Merklin et al., 1979; Vanyakin et al., 1980; Kalinin, and Sal'man, 1980; Kalinin et al., 1981). By processing the 15 Lake Baikal multichannel profiles collected by Soviet geophysicists this past summer, we expect to be able to significantly expand upon the preliminary interpretations possible to date from profile #9 by defining a) the geometry of the Baikal Rift Zone underlying Lake Baikal and b) the distribution of sedimentary units in Lake Baikal in a way that is not possible using only single-channel, generally low-penetration seismic data.

The objectives of our proposed geophysical work are to:

- (1) complete the processing of profile #9 and the remaining 14 MCS lines collected by the Institute of Oceanology;
- (2) describe the overall structural, stratigraphic, and tectonic framework of that portion of the BRZ occupied by Lake Baikal;
- (3) understand the rift architecture of Lake Baikal in the context of the surrounding regional geology and tectonics;
- (4) compare the architecture of this part of the BRZ to other well-studied continental rifts, such as the East Africa Rift System (Rosendahl, 1986), Rio Grande Rift (Lipman et al., 1989), the Basin and Range of the western U.S., and the Mesozoic rifted margin of the eastern U.S. (Klitgord et al., 1988).



## B. Geochemical, Paleomagnetic and Sedimentological Objectives

Previous work on piston cores by Soviet sedimentologists and geochemists has shown that the trace element composition and sedimentary facies of Lake Baikal are quite variable (Goldyrev, 1982) (Figures 8-14). Organic carbon contents in surface sediments range up to 1.5 to 2.5 percent (Figure 15) (Vykhristyuk, 1971). Little is known, however, about the absolute sediment accumulation rates in the three basins of Lake Baikal, nor how these variables change with time, climate, lake productivity and lake levels. In addition, very few if any piston cores from previous studies are available for further study because of the lack of archival facilities and an established sample distribution policy in many Soviet institutes.

It is therefore significant that we now have the opportunity of working on a newly collected set of Lake Baikal piston cores collected by the Institute of Oceanology, Moscow. These cores were collected during the 1989 field season when the 15 multichannel seismic profiles were shot in Lake Baikal. Many of the nearly 100 piston cores are 10 meters in length. Of course, cores with this limited length cannot be used to ground-truth the deep penetration MCS. However, recovery of 10 m sections offers the opportunity of examining changes in paleoclimate, sedimentation, lake levels and lake productivity at this important high latitude site in the northern hemisphere based on geochemical, paleomagnetic and sedimentological properties of Lake Baikal sediments. The time scales over which these variables can be studied in Lake Baikal will depend on the average sediment accumulation rates of the cores. It would be fortunate if we knew what those exact rates are at this time, but recovery of the last 1 million years might be possible if average accumulation rates are  $1 \text{ cm}/10^3 \text{ years}$ , the last 500,000 years at  $2 \text{ cm}/10^3 \text{ years}$  and the last 20,000 years if rates are as high as  $50 \text{ cm}/10^3 \text{ years}$ . Access to these core samples will also permit other US workers to conduct joint studies of the palynology and micropaleontology (diatoms) of Lake Baikal sediments although, none are planned at this time.

In August 1989 Williams and Hearn were able to obtain a few samples from one of the cores taken on the southern flank of the Academician Ridge for a preliminary geochemical study. CHN analyses performed during this last month reveal total organic carbon contents ranging from 1.41 to 0.24 percent and carbon/nitrogen ratios of 11.8 to 7.5 (Table 1). Carbon isotopic analyses of the organic carbon range from -25 to -20 per mil (PDB). We point out these preliminary values from the newly collected Lake Baikal cores because power spectral analysis of organic carbon contents and the  $\delta^{13}\text{C}$  of organic carbon in lacustrine sediments of Lake Biwa (Japan, as a western Pacific

continental paleoclimatic record) and Tulelake (northern California, as an eastern Pacific continental paleoclimatic record), suggest that temporal variations in TOC and  $\delta^{13}\text{C}$  of TOC during the Pleistocene may provide useful paleoclimate proxies in response to global climatic change (Figures 16-18). We report these limited data here only to indicate the potential for such studies in Lake Baikal and the need for further detailed studies of the new core material collected by our Soviet counterparts.

The objectives of this portion of this proposal are to collaborate with Soviet geoscientists on basic geochemical, paleoclimatic, paleomagnetic and sedimentological studies of these new Lake Baikal piston cores with the following questions in mind:

What are the best proxies for paleoclimatic reconstructions of Lake Baikal?

What are the best sedimentological and geochemical measures of late Pleistocene or Holocene lake levels in Baikal? How are lake level changes related to climate changes on the central Asian continent?

How are changes in secular variation, magnetic intensity and perhaps reversals of the earth's magnetic field recorded in Lake Baikal sediments? Can the magnetic properties of Lake Baikal sediments be used to provide a chronology of Baikal paleoenvironmental changes?

How have the productivity and preservation of organic carbon in Lake Baikal sediments changed on different time scales in the late Pleistocene? Have changes in these processes varied between the Northern, Central and Southern basins of Lake Baikal? How have either these lake-wide or basin specific changes responded to paleoclimate changes of the central Siberian region?

### C. International Considerations of the Proposed Work

On the basis of personal meetings over the last six months, we anticipate that the following Soviet geoscientists will be our primary counterparts who will be most actively involved in the proposed work and for whom funds are requested to visit the University of South Carolina and US Geological Survey during 1990. Of course involvement of other scientists in the USA and USSR will be sought and encouraged.

Professor Lev Zonenshain of the Institute of Oceanology, Moscow, is a key person to the proposed studies of the piston cores and MCS profiles. Zonenshain has an international

reputation for his active involvement for the past 20 years in studying the tectonic history of Lake Baikal within the broad context of the tectonic evolution of the Soviet Union, the Siberian Platform and the Baikal Rift Zone (BRZ). Three of the co-PIs (Hearn, Klitgord and Williams) have established close working relationships with Zonenshain through (a) the August 1989 USGS-USSR seismic profiling and submersible dive program of King's Trough, North Atlantic (Klitgord and Hearn), and (b) the July 1989 meetings at the University of South Carolina and August 1989 meetings in Moscow with Zonenshain to discuss the viability of a BAIKAL DRILLING PROJECT (BDP) and the joint processing and interpretation of the Soviet Lake Baikal MCS data (Williams and Hearn).

Professor Yuri Zorin of the Institute of the Earth's Crust, Irkutsk, will be mostly involved with the proposed studies of the MCS profiles. Zorin has an international reputation for his outstanding work with Prof. N. Logatchev on the geophysical and structural development of the Baikal Rift Zone (BRZ). He and Logatchev were also important participants in the US-USSR Rio Grande Rift-BRZ comparison study recently reported in EOS by Lipman, Logatchev, Zorin, et al. (1989). Zorin has also been involved as a chief representative of the Institute of the Earth's Crust in BDP planning meetings held in Irkutsk August 1989 with Hearn and Williams.

The participation of Professor Vadim Nikolaev of the Geological Institute, Moscow, will be important to the proposed studies of the MCS profiles. Nikolaev has published extensively on the sedimentary structure of Lake Baikal using single-channel seismic profiles. He participated in the summer 1989 acquisition of the MCS and is a geophysical member of the 5-year Soviet Lake Baikal Program. Hearn and Williams had the opportunity of meeting and becoming well acquainted with Nikolaev on board the RV Balkesh on Lake Baikal in August 1989. Since that meeting we have corresponded about collaborating on Lake Baikal seismic studies.

The expertise of all three Soviet geoscientists, coupled with the experience and background of the US co-PIs, is an essential component of this proposal. Visits by them to our US laboratories will enable us to work closely as a team on the interpretation of the geophysical, geochemical, paleomagnetic and sedimentological results arising from this study. They in turn can act effectively as go-betweens to the other Soviet scientists independently studying the Lake Baikal MCS and core materials. We look forward to writing joint manuscripts on the results and abstracts for presentations at national and international scientific meetings.

#### IV. PROPOSED WORK PLAN

##### A. Geophysical

The work plan for the geophysical studies consists of three parts: (1) Developing a processing strategy, (2) Processing the MCS data, and (3) Interpreting the MCS data with our Soviet colleagues.

##### Part 1. Development of a Processing Strategy

Developing a processing strategy is time consuming and iterative. Numerous tests and trials are required on selected portions of the MCS data to optimize processing parameters and improve efficiency. Once a strategy is developed, much of the rest of the MCS data can then be routinely processed (i.e., Part 2 of our work plan), adjusting parameters as appropriate to individual variations among the MCS lines.

Some of the processing strategy is already completed based on information obtained from constructing the brute stack of line 9. For example, a) resampling to 4ms (which still preserves the entire frequency range of the source, yet reduces the data volume by 50 percent) and b) applying a deconvolution operator early in the processing sequence (which sharpens the signal and balances the lop-sided spectrum by adding higher frequencies).

The brute stack also shows the need for additional special processing. For example, a) steeply dipping noise trains near the eastern shoreline can probably be eliminated by a pre-stack F-K filter; b) peg-leg multiples (i.e., reverberations between layers other than the water layer) require additional deconvolution and filtering tests to fully attenuate them; c) frequent and careful velocity analyses and mute picks will be essential to accommodate the large and rapid lateral variations in lake depth, structure, and stacking velocity; d) post-stack migration is clearly needed for resolution of fault dip and basement geometry. Some preliminary depth conversion may be possible in regions of good velocity resolution (i.e., shallow water depths)

We expect that a processing strategy based on MCS line 9 will be fully developed prior to the June 1 start-up date for the proposal. This will be done independently by Hutchinson and Klitgord as they finish processing line 9. Hence the most difficult part of processing the MCS data - defining the order and type of processing operations - is being provided by USGS at no charge to NSF.

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## Part 2. Actual Processing the MCS Data

The second part of our work plan is to process the remaining 14 MCS lines collected from Lake Baikal by our Soviet colleagues. This processing will involve (a) shipping or otherwise transferring the field tapes from the Soviet Union to the United States, (b) processing the MCS data using the strategy developed in the final processing of line 9, with processing parameters adjusted to suit individual lines, and (c) producing final digital (i.e., magnetic tape) and visual (i.e., mylar film) copies of the data for archiving by Soviet and U.S. scientists. Final form of the data will probably include 12-fold scaled stacks, migrated scaled stacks, and, if quality of the velocity data quality permits, scaled depth sections.

We propose that all processing be done on the USGS VAX/DISCO computer located in Denver, Colorado. This facility is accessible with remote plotting from Woods Hole, Mass. (location of Klitgord and Hutchinson). Our request to NSF for support is for expendables related to the processing (tapes, paper, film, etc.), for a low-level technician who would be hired by University of South Carolina (and temporarily located in Woods Hole to help with the more mundane aspects of the processing), and for travel funds for this technician to travel to the processing center in Denver. The USGS would supply the computer time, operator time, system support and salary support of Hutchinson and Klitgord to oversee the processing of the data.

## Part 3. . Interpretation of the Baikal MCS data with our Soviet colleagues.

The final aspect of the work plan is to interpret the data with our Soviet colleagues. This is described more fully elsewhere in the proposal and will involve working with the Soviet scientists in any of our joint locations (South Carolina, Woods Hole, Denver, or Washington) as appropriate progress is made on the project.

Our intention is to include the Soviet scientists in as many phases of the geophysical study as possible and practical, including the processing phase, although the reality of number crunching large amounts of data on a computer with which the Soviets are largely not familiar will probably limit their actual participation to discussions of the processing parameters and their effects on the data. Proper interpretation of the data will require time and mutual interaction: for us to learn the backbone of the Baikal geology and geophysics from our Soviet counterparts; for them to understand the idiosyncrasies of their valuable data set. Hence we are requesting that the travel for the participating scientists from the USSR include visits in excess of 4 weeks.

## B. Geochemical, Paleomagnetic and Sedimentological Work Plan

Our work plan for this phase is as follows:

Hearn and Williams will begin sampling some of the piston cores for geochemical and paleomagnetic analyses during our next visit to the Soviet Union in January 1990. Due to our limited time in Moscow, our sampling will be limited probably to 3-5 cores at a 5 cm interval. Cubic (8 cm<sup>3</sup>) plastic demagnetized paleomagnetic boxes will be used. Additional boxes will be left with Soviet technicians so that 10-20 additional cores can be sampled in our absence. Professor Ken Verosub (University of California, Davis) has agreed to perform paleomagnetic measurements of these cores given his long-standing and well recognized contributions in the magnetic properties of lacustrine sediments. Cores for sampling will be selected to represent the major depositional portions of the southern and central basins, including the Academician Ridge and margins of the Selenga River Delta (Figure 19).

Following the paleomagnetic measurements (inclination, total remanent magnetism, magnetic intensity, etc.), the samples will be split according to the following protocol:

- 25% for carbon-hydrogen-nitrogen analyses (TOC, TON, C/N ratios)
- 25% for  $\delta^{13}\text{C}$  and selected  $\delta^{15}\text{N}$  analyses of the organic fraction
- 25% for sedimentological analyses (clay mineralogy, grain size, etc.) by our Soviet counterparts
- 25% for archive (future unanticipated studies such as micropaleontological and palynological studies, etc.)

To obtain some preliminary time control, larger sediment samples will be taken in two cores for 10 bulk organic radiocarbon analyses and 2 accelerator mass spectrometer C-14 determinations. We realize that this limited amount of dating will provide only a cursory handle on accumulation rates at this time, but these data will at least point us in the direction for future dating.

Geochemical analyses of the organic matter (TOC, TON, C/N ratios) will be performed on a Perkin Elmer 2400 CHN Elemental Analyzer at the University of South Carolina.

Stable carbon ( $\delta^{13}\text{C}$ ) and selected nitrogen ( $\delta^{15}\text{N}$ ) isotopic analyses will be made using standard combustion techniques. The purified CO<sub>2</sub> and N<sub>2</sub> gases will be analysed on a VG Isogas SIRA 24 Isotope Ratio Mass Spectrometer in the Stable Isotope laboratory at the University of South Carolina.

In addition to the analyses described above, Soviet sedimentologists under the direction of Alexander Lisitzen (Inst. Oceanology, Moscow) are also studying the same piston cores. The combined data will be used to examine the questions concerning changes in organic productivity and preservation in the different regions of the southern and central basins.

### C. Project Responsibilities

This project will definitely need to be a "team-effort" but Williams will be responsible for the overall coordination of the project on the US side, while Zonenshain will coordinate the Soviet participation. Williams and Hearn will work together with Zonenshain and his colleagues on the geochemistry and sedimentology of the piston cores. Klitgord and Hutchinson will be responsible for the geophysical processing on the US side, working most closely with Zorin and Nickolaev and their Soviet colleagues.

### D. Tentative Schedule for Visits of Soviet Counterparts

Collaboration between the US and Soviet teams is an essential and exciting component of this study. We tentatively envision the following schedule for visits of our Soviet colleagues:

Jan. 1990 - Williams and Hearn obtain samples from 1-2 piston cores during their planned visit to Moscow-Irkutsk for discussions about Lake Baikal planning meeting; it may also be possible to return with MCS from 1 or 2 lines.

July 1990 - transferral of complete magnetic tape set from USSR to USA and receipt of remaining piston core samples.

July-Dec. - establishment of brute stacks for the 14 of 15 Baikal MCS lines; geochemical work-up in USA; sedimentological analyses in Institute of Oceanology, Moscow.

Jan - Feb 1991 - Zorin and Nickolaev visit Klitgord and Hutchinson in Woods Hole; Zonenshain visits Williams at the University of South Carolina; Williams, Hearn and Zonenshain join the geophysical team in Woods Hole for joint discussions. Abstracts for spring AGU meeting and preliminary drafts of manuscripts are prepared.

Feb. - Soviet team return to USSR to report results to their colleagues and work on draft manuscripts.

May - June - Zonenshain, Zorin, Nickolaev return to USA to attend AGU meeting and complete manuscripts for publication.



## E. Facilities to Perform the Research

The USC Stable Isotope Laboratory (SIL) has two isotope ratio mass spectrometers to perform the isotope analyses of this project: a manual double collector VG 602D with upgraded electronics including a microprocessor and a computer automated VG SIRA 24 with small volume capabilities approaching 1-5  $\mu$ l CO<sub>2</sub>. The SIL has seven separate carbonate extraction lines as well as separate extraction lines for analyzing sea water, dissolved CO<sub>2</sub> in sea water, organic matter, and silicate rocks and minerals (under the direction of Dr. Debra Stakes).

Geochemical analyses of the organic matter (TOC, TON, C/N ratios) will be performed on a newly purchased (11/89) Perkin Elmer 2400 CHN Elemental Analyzer in Robert Thunell's lab at the University of South Carolina.

We also have ready access to the new USC Electron Microscopy Facility with its new JEOL SEM under the direction of renowned biomineralization expert Dr. Norimitsu Watabe, and to the Electron Microprobe Facility with an automated CAMECA probe directed by Drs. John Shervais and Debra Stakes.

For the MCS processing, the USGS Disco/Vax facility in Denver is well known. All necessary software and peripherals are available in Woods Hole for accessing output and plot routines from this facility.

In addition, both the USGS and USC facilities have ample PCs for wordprocessing and computer graphics for manuscript production.

## V. SIGNIFICANCE OF PROPOSED WORK

We anticipate many significant contributions from the proposed geophysical and sediment core research, not the least of which will be the first sharing of such a large data base on Lake Baikal between American and Soviet geoscientists. The Baikal region holds untold opportunities for exciting geoscience investigations (Lipman et al., 1989). Every successful activity under the new US-USSR Basic Sciences Agreement and the NSF-Soviet Academy of Sciences and USGS-USSR Ministry of Geology basic research agreements will help pave the way for further scientific exchanges between our two societies.

Processing the multichannel data from Lake Baikal contains numerous scientific firsts.

1. The proposed work involves the first MCS data collected in Lake Baikal, and therefore the first opportunity to image the deeper structure of the Lake Baikal and its overall stratigraphy - attainment of these important objectives has been elusive with analog single-channel profiling, which is all that is available in the English literature.

2. The proposed work represents the first opportunity for western scientists to evaluate an actual seismic data set from Lake Baikal, because previous publications, at least those available in English, show only interpretations, not actual data.

3. The BRZ is also one of the Earth's largest and most active Cenozoic rift systems. Understanding the processes by which continents fracture and break apart is a fundamental problem in the earth sciences. These MCS data offer the opportunity to at least begin obtaining an understanding of the three dimensional geometry of active faults within the lake. From this it may be possible to eventually achieve an understanding of the distributions of earthquakes and the earthquake risk in this part of the Soviet Union (earthquakes estimated to be about magnitude 8 have occurred in the BRZ during this century) (Lipman et al., 1989).

With regard to the sediment core studies, Lake Baikal occupies an important position in a climatically sensitive latitude of the northern hemisphere. Its sedimentary record offers the opportunity of recording the Asian continental response to climate change on different time scales. The proposed core studies will provide new information about the modern and late Pleistocene styles of sedimentation, organic productivity and preservation in Lake Baikal as a function of lake level, climate change and structural setting. While the limited length of the cores prevents direct comparison with the deep penetration MCS, the new core information will provide an important baseline for calibration of future high-resolution seismic surveys.

## VI. RELATIONSHIP OF THIS PROPOSAL TO OTHER BAIKAL INITIATIVES

### A. BAIKAL DRILLING PROJECT - BDP

A preliminary proposal for a joint drilling project in Lake Baikal was transmitted to the Soviet Ministry of Geology and Academy of Sciences in May, 1989, by Williams and Hearn. Both the Ministry and Academy responded favorably to the proposal, and designated a group of four scientists (one of which was Lev Zonenshain) to take part in exploratory discussions in July, following the 28th IGC meeting in Washington DC.

These July talks took place at the University of South Carolina, Columbia, and outlined the overall scientific objectives of the project, a long-range work plan, and potential problem areas (see Appendix I). This document established the basis for the next stage of discussions, which took place in August in the Soviet Union.

The Baikal Drilling Project (BDP) was initially proposed with the objective of drilling and coring the entire sequence of sediments (over 5000 m) in the deepest part of the lake (over 1500 m). Achieving this goal will require the use of a free-floating platform of some design capable of using DSDP/ODP type technology.

While obtaining a complete sequence of core remains an ultimate goal, the issues of cost, technical and logistical complexity, and restrictions on technology transfer require a stepwise approach which will produce a foundation for subsequent efforts. The current work plan for BDP consists of four elements:

Step 1. Joint study of existing multichannel seismic (MCS) data and piston cores.

Step 2. Joint collection of new MCS and piston cores.

Step 3. On-shore drilling and field studies of Baikal lacustrine basins.

Step 4. Shallow-penetration (500 m) deep-lake drilling from thickened ice platform.

This proposal to study the Soviet MCS tapes and piston cores from Lake Baikal represents the first step in the BDP work plan.

#### B. 5 YEAR BAIKAL RESEARCH PROGRAM OF THE SIBERIAN BRANCH OF THE USSR ACADEMY OF SCIENCES

This proposed research program is totally consistent with, and does not duplicate, the activities and goals of the 5-year Baikal Research Program underway under the auspices of the Siberian Branch of the Soviet Academy of Sciences.

#### C. RIO GRANDE-BAIKAL RIFT STUDY

The comparison of the Rio Grande-Baikal rift systems (Lipman et al., 1989) sponsored by the American and Soviet Academies of Sciences is a successful example of the scientific fruits to be gained by cooperative studies. This comparison study was an important field program to determine the general structural, seismological, volcanic and tectonic settings of the RGR and BRZ. Many of the participants in the RGR and BRZ study are actively involved in the planning of the BDP program described above.

The results of this proposal will build upon the joint BRZ-RGR field research in an important way by providing the offshore framework with which US and Soviet geoscientists

Draft Research Proposal for Joint USSR-US Studies  
on the  
Breeding and Acoustic Behavior of Baikal Seals, Phoca sibirica: use of  
multiple birth lairs by lactating females and pups.

by

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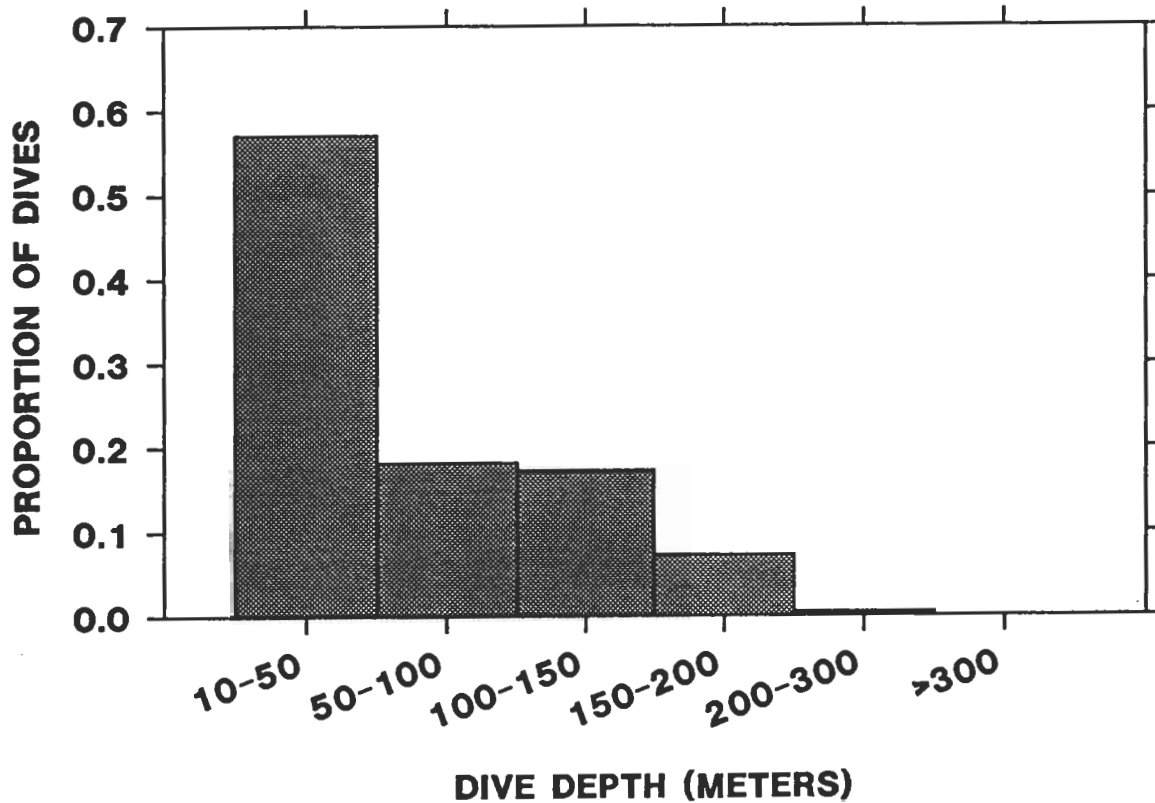
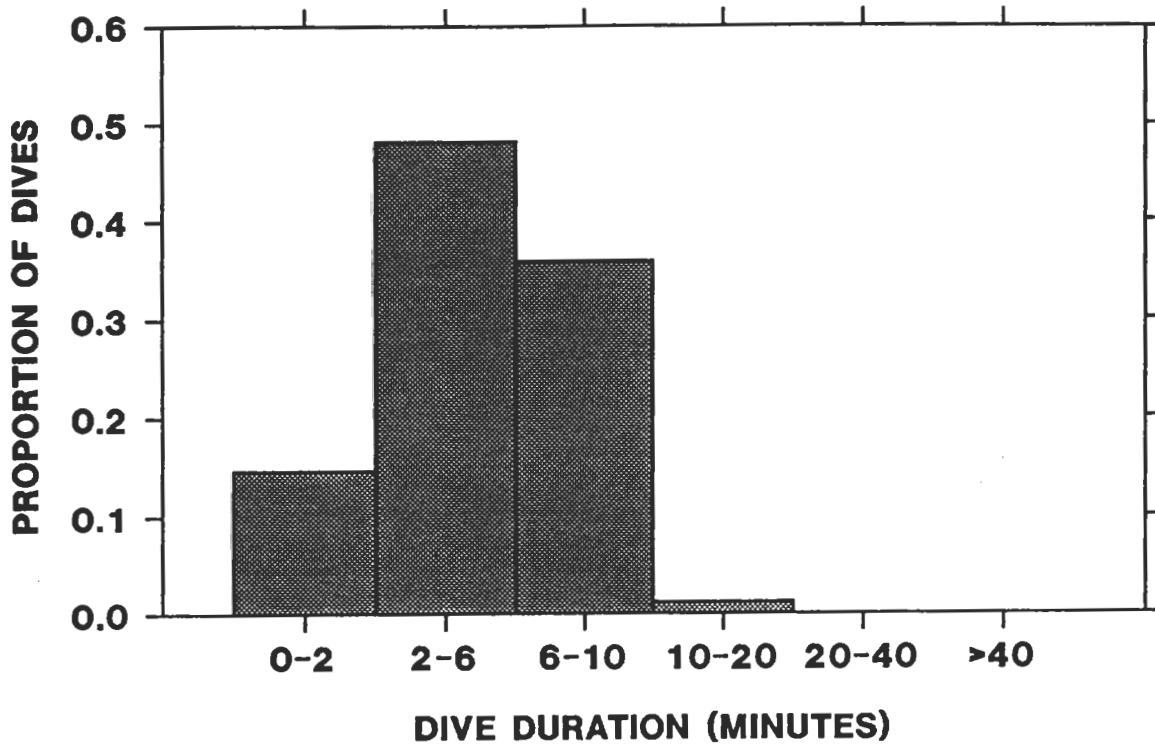
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The abundance of Baikal seals is currently estimated with systematic surveys (strip or line transects) of seals' breathing holes in late-winter or early spring. Most previous surveys have assumed that each seal, particularly lactating females, maintain only a single breathing hole. Recent studies

near the Ushkany Islands (A. Timonin, pers. comm.) suggest, however, that a female and her pup may construct several birth lairs and use three or more breathing holes during the 2.5-3 month nursing period. Thus, documentation of the birth-lair maintenance behavior of females is needed to calibrate the census method and to improve the accuracies of population estimates. We propose to use radio-telemetry and acoustic monitoring techniques to study the behavior and local movements of lactating females and pups from late-March through mid-April 1992. Daily radio-surveys will be made from a field ice-camp about 15 nm east of Okhorn Island to determine the number of birth lairs used by 15-20 mother-pup pairs and the patterns of their use. In addition, a smaller number of mother-pup pairs will be studied by placing radio-signal detectors in 10-15 birth lairs and VHF radio transmitters (unique frequencies for each seal) on several young pups in late March. The signal detectors will be linked to a central data recorder, by cable. Each time a pup with a transmitter enters a birth lair where a signal detector is hidden, a signal will be transmitted to and stored in the central data recorder; we refer to this as a proximity-detection system. Microphones will also be placed in selected birth lairs to monitor seals' use of these lairs and to document the vocal behaviors of mothers and pups; despite several attempts to record Baikal seals in the wild, their vocalizations remain unknown.

The data resulting from these studies will be used to calibrate transect surveys made in early- to mid-April.



## FEASIBILITY PROPOSAL

### Baikal International Centre for Ecological Research

#### 1. Ecological studies on Lake Baikal

##### 1.1. Lake Baikal and Its Environment

Lake Baikal is situated in East Siberia. It is the deepest lake in the world (1637 m). It contains some 23 000 cubic kilometers of very pure sweet water, which equals to 1/5 of liquid fresh water of the world. The catchment basin of Lake Baikal (major tributaries: Selenga, Barguzin and Upper Angara rivers) has an area of 560 000 square kilometers (G. Galazy, "Baikal: Questions and Answers", Moscow, Mysl, 1988, 285 p.). This area is inhabited by only some 1.5 million people (cf. 40 million people in the catchment basin of American Great Lakes). For this reason, and due to the fact that industries and agriculture in the catchment basin are not strongly developed, the lake did not yet suffer from anthropogenic pollution to the same extent as other lakes of the world situated in heavily populated countries. This does not mean, however, that the problem of pollution does not exist: quite the contrary, technologies used in the catchment basin are still far from perfect, and the amounts of pollutants delivered to the lake by tributaries are great; the ecological system of Lake Baikal is unique, and ecologists believe that it is very fragile. Therefore, pollution must be brought to a minimum, as demanded by the decree of Soviet Government of April 13, 1987. There is a chance to conserve Baikal as a unique, naturally developing ecological system, and all the necessary efforts must be applied.

Baikal is considered as one of the wonders of the world. Of special value are landscapes adjacent to its water body. Soviet Union has recently joined the Convention concerning the protection of the world cultural and natural heritage of UNESCO, and Baikal Lake is now considered as a candidate to the World Heritage List.

Protection of Lake Baikal must be based upon reliable and diverse scientific information and knowledge which only may be obtained by attracting attention of most talented scientists equipped with the best available instruments from all over the world. This is the first reason for international scientific cooperation around Baikal within the frameworks of Baikal

- 2 -

## 1.2. National and Supra-National Research Aspects. Findings of Past Research Programs

Baikal is one of the best studied lakes in the world. An outline of the earlier work is given in the book "Lake Baikal and Its Life" (1963) by Prof. M. Kozhov. Subsequent years gave new important information, especially in the fields of biological systematics, and geology. These studies have clearly shown that Lake Baikal is a unique laboratory built by Nature, a "synchrotron" for ecologists. The following lines are written by Prof. Ya. I. Starobogatov, a Soviet aquatic biologist.

"Of the numerous lakes of the world, only twelve lakes and lacustrine countries contain unique complexes of organisms found only in these lakes and lacustrine countries (Ya. I. Starobogatov, "Molluscs Fauna and Zoogeographic Mapping of Continental Water Bodies", Leningrad, Nauka, 1970, 371 pp.). This is due to the fact that the environmental conditions within these lakes remained constant over long periods of time (in the geological scale). The greater is the size of these lakes, and the more constant have been these conditions (large size helps to maintain constant conditions), the greater is the biological diversity. Therefore, half of these lakes contains only a few endemic species. Of the remaining six lakes which contain large endemic complexes, only three are situated in the moderate climate zone. These are Baikal, Caspian, and Ochrid (Yugoslavia). The three remaining "endemic fauna" lakes are situated in the tropical zone; these are the Great African Lakes Victoria (Ukereve), Tanganyika, and Malawi (J. L. Brooks, "Speciation in Ancient Lakes; Quat. Rev. Biol., 1950 a, b; v. 25, No. 1, p. 30-60; No. 2, p. 131-176; Brown D. S., Mandahl-Barth G., "Living Molluscs of Lake Tanganyika; a revised and annotated list; Journ. conch., 1987, v. 32, p. 305-307).

The two lakes situated in USSR - Baikal and Caspian - contain extremely diverse endemic faunistic and floristic complexes... Baikal is characterized by greater densities of population, and more animals and plants are endemic, so that their phylogenetic relations may be studied, and their evolution reconstructed by a wider variety of morphological, cytological, and biochemical methods...

...The giant sizes of the lakes and the constance of environmental conditions facilitated speciation - organisms occupied different biotopes, parts, and vertical zones. Therefore, these lakes may be regarded as unique laboratories well suited for studies of speciation, and ecosystems evolution (the latter processes take greater times because speciations are only elementary acts of them; Ya. I. Starobogatov, "Problems



of speciation. Results of Science and Technology; General Geology, Moscow, VINITI, 1985, v.20, 96 pp.)".

Lake Baikal is inhabited by some 1500-2000 endemic species. Of them mentioned will be an endemic seal; some 30 endemic fishes; some 240 gammarid crustaceans (about 2/3 of all fresh-water species); some 100 molluscs; at least 70 flat worms, etc. Of special interest is comparison of the dates of major geological events which happened in Baikal depression during the 35 million years of its development with the dates of species splitting which will be elucidated by investigation of the primary structures of proteins and nucleic acids of these species.

The problems of speciation, the evolution of macromolecules of Baikal endemics in connection with the geological history are agreed topics of scientific cooperation of scientists of USSR (Irkutsk, Moscow, Leningrad, Novosibirsk), USA (Centre for Great Lakes Studies, South Carolina University), Belgium, Sweden, Finland. These studies are in progress.

Bottom sediments of Baikal which are up to 6 km thick have been accumulated during some 25 million years and therefore contain a unique long-term record of climatic changes on the Asian continent. Similar records can be obtained in oceans and serve to construct models of global climatic changes (e.g., Nature, 1989, v.338, p.553), but such models to be really global need data for continents, not only for oceans. Only one example: 11000 years ago there took place a "Younger Dryas" event, which was followed by a 7 increase of average temperature in Europe during only 50 years (Nature, 1989, v.339, p.532). The reason of the event is believed to be a change in the oceanic currents in North Atlantic. No convincing evidence of Younger Dryas has been found in Northern America - this is probably due to the fact that the global winds blow from Europe via Asia to America. Modelling of the global paleoclimate before and after Younger Dryas is of outstanding practical importance, because a similar increase of temperature may occur soon due to the "greenhouse effect". Data for the Asian continent which may be obtained on Baikal are of fundamental importance for such modelling. Studies of Baikal sediments performed by Soviet and foreign scientists (like the group of Prof. Wong from Hamburg University, or Prof. Williams from South Carolina proposing "Baikal Drilling Project") have paleoclimatic reconstructions as one of the most important aims.

Baikal still remains one of the cleanest lakes of the world due to the relatively small population in the catchment basin and extremely large volume (23 000 cubic kilometers), as mentioned above. Therefore, it may be regarded as a

"background" water body compared with polluted lakes of other regions.

Long-term monitoring of the content of sulfate anion as indicator of general airborne pollution in snow covering Baikal (performed in March) shows that the majority of its area is only polluted due to global transfer. Annual outfall of sulfate here is 0.2-0.4 t/sq.km (cf. background territories of West Europe, 3.5; of Canada, 2.5 t/sq.km.

Measurements of the content of specific man-made pollutants (pesticides, organic chlorine compounds, etc.) in its water, sediments and biota may be very useful for studies of the global processes of the transfer and turnover. For example, the content of DDT and its metabolites in Baikal seals fat appeared to be the same as that in Arctic seals fat, according to studies of scientists of the Limnological Institute. Prof. Schecter from USA collected human milk samples in Irkutsk, Baikalsk (the site of a pulp and paper plant), Kachug (a town with no industrial pollution sources at the western shore of Baikal), Moscow, and gave them for analysis for polychlorodibenzodioxines and related super-toxic compounds to the Federal State Control Laboratory of North Rhine-Westfalia. It appeared that levels of dioxins in human milk in the Baikal region were lower than those in USA and Federal Republic of Germany, but higher than in less industrialized countries.

Baikal may be regarded as a small-scale model of an ocean. Its multi-disciplinary studies by methods of physics, chemistry, remote sensing, hydrobiology, mathematics may lead to a new level of understanding of the function of large aquatic ecological systems which still remains very insufficient. This problem is of great interest to many oceanologists.

Many other arguments may be presented, but even the above ones clearly indicate that studies on Baikal may unite many scientists from all over the world for long-term interdisciplinary international cooperation.

### 1.3. The danger of External Influences, Especially Man-Made Pollution, to the System

The rate of turnover of Baikal waters is very small. If no water was delivered to it by tributaries, the basin would be emptied in some 300 years. For this and other reasons, unfavourable actions upon its ecosystem may lead to measurable consequences only after a long time. The following dangerous external influences will be mentioned:

#### 1.3.1 Input of nutrients (first of all, nitrogen and phosphorus) by rivers in excess over "natural demand".

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- 1.3.2. Input of salts (like sodium sulphate or sodium chloride) which will finally change the salinity.
- 1.3.3. Input of long-acting ecotoxicants like organic chlorine compounds which exist in water bodies for long times and tend to accumulate along food webs.
- 1.3.4. Overcatch of fish (omul and other); hunting for Baikal seals.
- 1.3.5. Biological pollution - introduction of new species, transfer of new viruses and parasites, etc.
- 1.3.6. Changes of the level due to work of hydro-electric power stations.

According to "Norms of Permissible Action upon the Ecological System of Lake Baikal for the Period of 1987 to 1995" accepted officially in 1987, all kinds of unfavourable influences upon Baikal must be brought to a minimum by proper choice of technologies.

The Norms demand that mathematical models are constructed for the populations of seals and omul; that balance of nutrients is obtained by continuous monitoring in Selenga and Barguzin rivers (about 70% of water input) and in Angara river (100% of water output). Obviously, it will be very important also to measure the balances of most important specific pollutants (see 1.3.2 and 1.3.3) which are delivered to Baikal by rivers and by global airborne transfer.

In order to create a comprehensive monitoring system, it will be necessary to rely upon high technologies. For example (see 1.3.4), determination of the abundance of omul, of the size and age structure of its populations, of its food resources and growth potential depending on inherited biochemistry, needs application of computerized sonars, of most sophisticated methods of biochemistry, etc. The balance of ecotoxicants (1.3.3) may be determined only by means of sophisticated procedures of organic ultramicroanalysis with modern chromato-mass-spectrometers. Identification of viruses (1.3.5) may depend upon the use of the latest achievements of molecular biology like polymerase chain reaction and immunoanalysis with monoclonal antibodies. Information which is very valuable for monitoring of Baikal as a whole may be obtained by remote sensing methods using satellites.

Efforts in all of these directions have been started by LI. Many studies in progress are done in cooperation with scientists of other countries. A good example of an

investigation which has already given interesting and important results is identification of the reasons of epizootics which occurred in 1987-1988 among Baikal seals and seals of Western Europe: in both cases, the agents happened to be strains of canine distemper virus. These studies have been done by a group headed by Dr.A.Osterhaus (The Netherlands) and by a group of Soviet scientists (see Nature, 1988, v.338, p.209-210).

A task very important for monitoring is creation of a comprehensive computer data bank containing all the available information on physical, chemical, biological, geological characteristics of Lake Baikal accumulated during the many years of its scientific investigation which started on a regular basis in the 19-th century. These data are certainly of great interest for all scientists involved in problems of aquatic ecology.

## 2. Objectives of BICER

### 2.1. Research - Multidisciplinary and Ecosystems Research

Objectives of BICER follow from the considerations above outlined. They are presented in the "Draft Agreement..." distributed among the participants of the Preliminary Founding Conference in October, 1989 (see Clause 3).

In a way, BICER has already started its function. In 1988 and 1989, Baikal has been studied by many international expeditions; special mention will be made here of the expeditions of scientists of the Centre for Great Lakes Studies (USA), and of the group of Prof. Wong from Hamburg, Federal Republic of Germany. National Geographic Magazine of USA is proposing 11 Soviet-American expeditions to Lake Baikal for 1990. Many scientists from other countries are going to come.

Hence, there is a need to coordinate efforts so that reliable and valuable results could be obtained in minimum time. The Board of Directors of BICER is proposed to perform coordination.

### 2.2. Formulation of Protective Measures

As mentioned in Clause 2 of the "Draft Agreement...", the first ten years of operation of BICER will be designated as the Baikal International Research Decade (BIRD). There is no doubt that intensive international research during this decade will every year bring most valuable information

necessary for formulation of protective measures which will have to be undertaken according to the decree of April, 1987, and in connection with the expected inclusion of Baikal into the World Heritage List of UNESCO. A special organ of BICER ("research department") will put these formulations into a system in form of scientific reports and reviews, and deliver them to governments of the countries participating in BICER. Moreover, international teams of scientists which will arise in BICER may be called to cope with urgent problems of fresh-water ecology, and even oceanology in other countries.

### 3. Existing Scientific Competence and Infrastructure

#### 3.1. The Limnological Institute (LI)

LI is part of the Irkutsk Scientific Centre of the Siberian Division of the Academy of Sciences of USSR. It occupies a new laboratory building in the Academic Town of Irkutsk; the building has an area of some 7400 sq.meters. LI also has access to a few laboratory rooms in the house belonging to the Baikal Ecological Museum in Listvyanka, 70 km from Irkutsk, on the shore of Lake Baikal. The Institute owns ten research ships and boats of different size of which the greatest is RV "Vereshchagin", ca. 500 t d.w., and a park of expedition cars and trucks. Some 450 people work in LI, of them some 150 directly involved in basic scientific research. The Institute consists of the following laboratories:

1. Laboratory of Mathematical Modelling.
2. Laboratory of Climatology and Meteorology.
3. Laboratory of Physical Limnology.
4. Laboratory of Hydrology and Hydrophysics.
5. Laboratory of Hydrobiology and Systematics.
6. Laboratory of Ichthyology.
7. Laboratory of Aquatic Mammals Biology.
8. Laboratory of Microbiology.
9. Laboratory of Biocenology.
10. Laboratory of Deep-Water Research.
11. Laboratory of Nucleic Acids Chemistry and Biochemistry.
12. Laboratory of Genosystematics.
13. Laboratory of Molecular Enzymology.
14. Laboratory of Hydrochemistry and Analytical Chemistry.
15. Group of Radioactive Izotopes Application.

The Institute has also two departments involved in applied research and development, the Department of Ecologically-Cycled Technologies, and the Department of Ecological Instrumentation. It also hosts a "coop" (private enterprize) where some specialists of LI and of the Irkutsk State University on a commercial basis educate engineers from industries and consult them in the field of high-performance

liquid chromatography, and use this method to analyze drugs, chemicals, food, water, etc.

LI is now increasing its instrumentation. During the two years, 1988 and 1989, it bought a few modern personal computers; more than 10 high-performance liquid chromatographs; a scintillation counter; equipment for electrophoresis and processing of biochemical samples; equipment for inorganic trace analysis; automatic oligonucleotide synthesizers; spectrophotometers, ultracentrifuges, etc. Planned for the middle of 1990 is purchase of equipment for automatic sequencing of nucleic acids and proteins from Applied Biosystems (USA) and of a scanning electron microscope from Phillips (The Netherlands).

Facilities of LI also involve a mechanical shop in Listvyanka and a field laboratory in Bolshie Koty, nearby the Baikal Biological Station of the Irkutsk State University.

### 3.2. Other Infrastructure

Other institutes of the Irkutsk Scientific Centre along with LI are going to participate in the activities of BICER. These are Institute of Geochemistry (isotope dating and inorganic analysis), Institute of Earth Crust (geology), Baikal Ecological Museum. BICER will be supported also by facilities of the Baikalsk Institute of Ecological Toxicology and of the Irkutsk State University. Buryat Branch of the Siberian Division of the Academy of Sciences in Ulan-Ude (capital of Buryat Autonomous Republic) is eager to develop international cooperation within BICER (for example, there is a strong laboratory in its Biological Institute studying endemic parasites of Baikal animals) and on other topics like social aspects of ecology and improvement of technologies used by industries and agriculture in the catchment basin of Baikal.

Many institutes of the Siberian Division of the Academy of Sciences in Novosibirsk are going to take part in research on Lake Baikal: Novosibirsk Computer Centre (simulation modelling, computer treatment of geophysical data); Institute of Geology and Geophysics (geophysical studies of Baikal depression), Institute of Chemical Kinetics and Combustion (studies of atmospheric aerosoles), etc.

The Institute of Oceanology of the Academy of Sciences of USSR (Moscow) is going to study Lake Baikal by efforts of a few of its laboratories; in 1990 it is going to bring to Baikal "Pisces" deep-water submarines and to use them in many international expeditions.

Guests coming to take part in international expeditions

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to Lake Baikal may live in a few hotels of Irkutsk (Intourist, Angara, hotel of the Academy of Sciences) and Listvyanka (Intourist), although these hotels are overcrowded in summer.

There is a highway connecting Irkutsk with Listvyanka where new facilities of BICER are going to be built. International communications are not perfect, but it is possible to communicate with other countries by mail, telgraph, telex and telephone. There is a custom office in Irkutsk. It is possible to come to Irkutsk not only via Moscow, but also via Nakhodka (Eastern coast of USSR) by plane and via China by railroad.

### 3.3. Service Contracts and Fees between LI and BICER

The principles of the provision of services by BICER to international expeditions are outlined in the "Draft Agreement..." Such services are diverse and may include provision of airplane tickets within USSR, accommodation, food, medical aid, expedition cars and ships, laboratory rooms, auxiliary man-power including scuba divers, etc. It is expected also that BICER will help to distribute orders for geochemical, paleontological, biochemical and chromatographic analysis among best equipped laboratories of Irkutsk and other cities of USSR, and, probably, of other countries. Many of these services will be provided to BICER by LI.

BICER, according to Clause 3 of the "Draft Agreement...", will help to organize joint investigations between scientists of USSR and other nations. It is therefore expected that part of the expenses for every project will be covered by Soviet participants of these investigations. Many institutes of other countries having close contacts with LI are ready to cover part of the expenses in connection with Baikal expeditions in hard currency. Therefore it is believed that, after appropriate capital investments, BICER could become self-paying, and could even gradually increase its facilities. However, it is possible also that governments will provide direct financial support. The principles of financing and contracts must be discussed very thoroughly at the Founding Conference with potential members of the Board of Directors.

*M. Grahev*

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August 9, 1990

Professor Mikhail Grachev  
Limnological Institute  
Ulan Batorska 3  
664033 Irkutsk  
USSR

Dear Professor Grachev:

The purpose of this letter is to bring you up to date on several matters of mutual interest, and also to encourage a more practical dialogue concerning plans for future measurements on Lake Baikal. As you will, no doubt, have learned first-hand, Yura Kusner and I spent a very short but very productive time together during his recent visit to California. After many hours of discussion, I believe we finally have a more rational understanding of each other's views concerning the deep mixing rate of Lake Baikal. I am still confident that the longer mixing time is the right one, but I now think I understand the observational data which support Yura's interpretation of a shorter mixing time, and I would like to propose a measurement program to find the source of the disagreement

Yura will surely describe the nature of our discussions to you in greater detail, but for me the most convincing evidence in support of his argument for rapid mixing came from the dissolved oxygen and carbon dioxide data in 1957 and 1958 as presented in a 1965 paper of K. K. Votintsev. These data, especially the deep oxygen time series plot in figure 9, cannot be explained without either rapid mixing or bad standardization of the oxygen measurements.

Arguing against the rapid mixing hypothesis are several very strong arguments. First, there are the freon profiles. To explain these profiles with a rapid mixing would require a mechanism for rapid freon removal at depth because the surface water boundary conditions at the time when the temperature profiles will permit vertical mixing (*i.e.* when the surface is between 3.2 and 3.8°C) will always be higher than the observed deep water values. While such removal cannot be absolutely excluded, there is no evidence of it elsewhere where freons have been studied in natural waters.



Professor Mikhail Grachev

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Second, there are the helium-3/tritium data. These give "ages" very close to the freon ages, for a mean deep water residence time of about a decade. To explain the observed accumulation of excess helium-3 in the water as being produced more rapidly than required by the radioactive decay of the tritium in the water (this is required if the rapid mixing hypothesis is correct, because helium-3 is lost to the atmosphere in surface waters) would require a rapid injection of helium-3 into deep waters *without* a corresponding helium-4 injection (there is no major helium-4 enrichment). No mechanisms for such helium-3 injection is known.

Third, and perhaps most persuasive, is that Yura's rapid mixing one-dimensional model won't give a mass balance for temperature. In his model there must always be a flux of heat downward — that is, the water at the bottom is always a few tenths of a degree colder than at 200-250 meters, so there must be a heat sink at the bottom. There is, however, no reasonable mechanism for sustaining such a heat flux. Indeed, the geothermal heat flux is surely in the other direction!

As an experimental scientist, my own view is that the historical oxygen data suffer from poor calibration, so that the relative *precision* on any particular day is reasonably good, but there are day-to-day changes in the *accuracy* of the calibration standards. Such an outcome would not be surprising, if the history of oxygen titrations in oceanography is any guide. For example, the Woods Hole Oceanographic Institution, one of the world's leading laboratories for ocean measurements, was unable to produce reliable oxygen numbers until about a decade ago! Thirty years ago, when the data cited by Votintsev were taken, very few of the world's oxygen measurements were reliable.

My suggestion is that we undertake a joint effort to study the seasonal deep water oxygen and temperature distributions in the south basin by carrying out accurate measurements twice a month through a complete annual cycle. In my view, this would be a far easier and more instructive program than trying to do only one set of winter freon measurements.

The idea would be for the instrumentation to be provided by my laboratory for oxygen and by Eddy Carmack's laboratory for temperature. A key element would be to have a Soviet graduate student or senior technician who would be responsible for the routine year-round operation of this program. In the event that the work would be done by a student (I personally think this would be a good thesis problem) I would be very willing to serve on that student's thesis committee. In addition to providing the equipment, we would also provide careful training for the Soviet operators of that equipment. We would ask that your institute provide logistic support for the field work, chemical supplies for the oxygen titrations, and also the plastic water sampling bottles similar to the design plans we sent you last year. Experience has already shown that metal sampling bottles give bad oxygen data, presumably due to redox reactions with the metal surfaces.

Professor Mikhail Grachev  
August 9, 1990  
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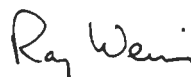
I hope we can establish a useful dialogue based on these interesting scientific problems. The rate of deep mixing is obviously of key importance to many of the ongoing studies of Lake Baikal, and such a program would make a major contribution.

On the subject of our planned summer geochemical expedition funded by National Geographic, I believe you already are aware of our request to postpone the work from 1990 to 1991. This came about principally because of poor coordination among the many US groups working in 1990. We had planned all along to work in July 1990, but as the summer approached we learned that Doug Williams had already been given the use of the R/V *Vereshchagin* during that period. Since we were no longer flexible to set a new schedule, and since there seemed to be too many conflicting groups working in 1990, we decided to postpone our work one year. This would also make it possible to take advantage of any new discoveries found by those working in 1990.

As I have discussed with Yura Kusner, we would prefer to work in July of 1991, covering the full length of the lake and also including sampling of rivers and terrestrial hot springs, as well as Pisces sampling of any lake-bottom hot springs which might be found in 1990. I hope that we can schedule the R/V *Vereshchagin* for this purpose, for a three week period in July 1991.

Please let me know your reactions to these proposals by return mail or by Telex. My telex number is 7401422 RWTX UC. I trust that you share my enthusiasm for these plans and that any prior misunderstandings no longer stand in the way of a fruitful collaboration.

Sincerely,



R. F. Weiss

Xc: E. C. Carmack  
Y. Kusner ✓

SUMMARY OF PROJECTS FROM THE ROYAL BELGIAN INSTITUTE OF NATURAL SCIENCES WITHIN THE FRAMEWORK OF B.I.C.E.R. (partim: Molecular Systematics and Population Genetics)

The projects below were adapted following the results of the discussions held during the "Meeting of the Founding Members Council of B.I.C.E.R." (15-16 March 1991).

All projects involve the following scientists:

Russia: Dr. D.Y. SHERBAKOV (Molecular systematics)  
Dr. T. SITNIKOVA (Malacology)

Belgium: Dr. T. BACKELJAU (Malacology, Molecular systematics)  
Dr. E. VERHEYEN (Molecular systematics)

PROJECT 1. Molecular systematics of the family Baicaliidae (Gastropoda: Prosobranchia).

This project aims at constructing a species tree of the family Baicaliidae based on molecular data. Morphological, anatomical and karyological data concerning this family are currently being studied by Dr. T. SITNIKOVA. In 1991 we made preliminary collections of three problematic species complexes. This material is currently being analysed in the K.B.I.N. (Brussels) using allozyme electrophoresis. Preliminary, yet succesful, tests on mitochondrial DNA isolation and amplification were performed in the Hydrobiological Institute (Irkutsk). All data will be interpreted in population genetic and phylogenetic terms.

PROJECT 2. Genetic divergence between populations of Lymnaea peregra/ovata from the Lake Baikal Basin and western Europe.

By means of protein electrophoresis we will look at the population genetics of Lymnaea peregra/ovata in the Lake Baikal Basin. This information will be compared with similar data obtained for populations of (supposedly) the same species in western Europe. Such data will give information on the taxonomic status of different morphotypes, as well as on the degree of genetic divergence between populations from different regions (i.e. possible founder effects). In 1991 we made preliminary collections of two morphotypes in the Angara River near Irkutsk. Additional populations were sampled in Belgium and the Azores (almost certainly introduced in the latter).

Ch.C.2

PROJECT 3. Population genetics and phylogenetic relationships of Arion sibiricus.

Irkutsk is the type locality of this enigmatic terrestrial slug. We want to infer the systematic relationships of Arion sibiricus by means of allozyme electrophoresis, since one of us (TB) is already applying this technique in a systematic and population genetic study of the genus Arion. In this context, Arion sibiricus has been considered as either a good species, or subspecies of the European Arion subfuscus. The dry and hot weather in 1991 prevented adequate sampling of this slug.

PROJECT 4. Phylogenetic position of the families Benedictiidae and Baicaliidae as assessed by complete gene sequencing of small-subunit ribosomal RNA.

This project aims at sequencing the 18S rDNA genes in the Benedictiidae and Baicaliidae in order to infer the phylogenetic relationships of these two endemic Baikalian prosobranch families. This project was still in a conceptual phase in 1991, but since the beginning of 1992, it was possible to engage a Ph. D. student at the Department of Biochemistry in the University of Antwerp, who will, as a part of her research activities, determine the required 18S rDNA sequences.

Dr. V. ~~F.~~ Pastukhov  
Limnological Institute — book on Baikal seals

## **Research Plan on the Biology of Baikal Seals and the Environmental Study in the Lake Baikal**

**Nobuyuki Miyazaki**

**Department of Zoology, National Science Museum, Tokyo**

### **Research Items:**

1. Environmental study in the lake Baikal
  - (1). Pollutants (organochlorine compounds and heavy metals) in air and waters
  - (2). Pollutants in waters of the typical inflow river into the lake and those of the outflow river from the lake
  - (3). Comparison of pollutants in waters between a typical clean inflow river and a typical inflow river contaminated by the pulp factory
  - (4). Pollutants in the organisms living in the ecosystem of the lake, especially crustacean, fish, seal and so on
2. Biological study of the Baikal seal
  - (1). Catch data and density
  - (2). Life history: growth and reproduction, feeding habit, school composition
  - (3). Genetic relationship of Baikal seals to other species and social behavior of Baikal seals by biochemical methods, mtDNA and DNA fingerprinting
  - (4). Diving behavior of Baikal seal by the depth meter

### **Members of Research Team**

1. Dr. Miyazaki Nobuyuki of National Science Museum, Tokyo
2. Prof. Ryo Tatsukawa, Dr. Shinsuke Tanabe and colleagues, Ehime University, Matsuyama
3. Prof. Kenichi Numachi and colleagues of Ocean Research Institute of Tokyo University, Tokyo
4. Prof. Yasuhiko Naito of National Polar Institute, Tokyo

### **Main Work in 1991**

1. Collection on the scientific paper and the available information concerning with above research
2. Establishment of exchange system of scientific information between Japanese scientists (project leader: N. Miyazaki) and Russian scientists (counterpart)
3. Selection of good field spot and good season for above researches based on Russian scientist's recommendation
4. Establishment of research system between Japanese and Russian scientists for the forthcoming years

## **Technical Problems for Research**

1. We hope to get Russian scientist's recommendation when, where and how we obtain Baikal seals for our research?
2. We hope to get about 100 Baikal seals composed of various age specimens of both sexes and various reproductive condition of adult females and males?
3. We hope to dissect and examine these seals in the Baikal Research Center or other facility.
4. We hope to collect the followings samples from each seal; 1)skull for osteological study, 2)teeth for age determination, 3)sexual organs for reproductive study, 4)stomach content for feeding study, and 5)several tissues or organs (eg. blubber, muscle, liver, kidney, brain, blood and so on) for biochemical study.
5. We hope to collect the several kinds of organisms in the ecosystem of the lake Baikal in order to investigate bioaccumulation of pollutants through food chain from plankton to Baikal seal.
6. We hope to know the information of available facility of Bai kal Research Center for our research.

## ПРЕДЛОЖЕНИЯ

### о преобразовании Байкальского международного центра экологических исследований в Байкальскую открытую международную лабораторию

1. БМЦЭИ сыграл большую роль в развитии международного научного сотрудничества на Байкале. С момента его открытия в 1990 г. реализовано около 200 проектов. Установлены постоянные тесные связи между учеными многих стран. На базе БМЦЭИ выполнены исследования, результаты которых изложены в 257 публикациях в рецензируемых научных журналах с участием ученых России, Бельгии, Великобритании, Швейцарии, Японии, США и других стран. Таким образом, БМЦЭИ как новый инструмент научно-технической политики Сибирского отделения РАН, открытая международная лаборатория, не имеющая постоянного бюджетного финансирования и работающая благодаря объединению средств поддержанных национальными и международными фондами партнеров из России и других стран, доказал свою высокую эффективность. БМЦЭИ оказал решающую поддержку исследователям Байкала в самый трудный для российской науки период начала рыночных преобразований, за что Сибирское отделение РАН выражает иностранным учредителям БМЦЭИ свою глубокую благодарность.
2. Устав БМЦЭИ был принят до распада СССР, в принципиально отличающихся от современных политических и экономических условиях. Практика работы свидетельствует о том, что статус БМЦЭИ нуждается в изменении, чтобы его деятельностью можно было управлять более эффективно в условиях рыночной экономики. В связи с этим члены совета учредителей БМЦЭИ с бельгийской (Я.Клеркс) и российской (Н.Добрецов, М.Грачев) стороны предлагают совету учредителей рассмотреть возможность реорганизации БМЦЭИ и создания на его основе Байкальской открытой международной лаборатории глобальных изменений и видообразования (БОМЛ; Baikal Open International Laboratory for Global Change and Biological Speciation; BOIL).
3. БОМЛ предлагается учредить в качестве отдельного юридического лица, некоммерческой организации при Лимнологическом институте Сибирского отделения РАН. Сибирское отделение РАН как со-учредитель БОМЛ обяжет Лимнологический институт отдавать приоритет международным проектам БОМЛ при планировании своей деятельности, в частности, при планировании экспедиций на научно-исследовательских судах. Как и в БМЦЭИ, реализовываться будут те проекты, в которых иностранные ученые работают совместно с российскими учеными. При этом предполагается, что российские и иностранные партнеры по конкретным проектам будут самостоятельно формировать состав международных экспедиций, исходя из имеющихся у них средств и обеспечивая совместную компенсацию полной стоимости использования научно-исследовательских судов. Со своей стороны, Президиум Сибирского отделения РАН будет принимать меры для обеспечения готовности судов в навигационный период.
4. Совет учредителей БОМЛ будет осуществлять поиск потенциальных российских и иностранных партнеров, координировать подготовку заявок на гранты в национальные и международные финансирующие агентства, руководить обменом информации о деятельности БОМЛ, контролировать обоснованность расчетов стоимости использования научно-исследовательских судов и других связанных с

обеспечением международного сотрудничества услуг, планировать международные экспедиции. Как и совет учредителей БМЦЭИ, он будет собираться ежегодно. Для облегчения поиска российских партнеров Сибирское отделение РАН передает иностранным учредителям БМЦЭИ (БОМЛ) сведения о проектах российских исследователей Байкала, поддержанных российскими и международными грантами, и ожидает получить аналогичную информацию о проектах иностранных ученых от иностранных учредителей БМЦЭИ (БОМЛ). Сибирское отделение РАН считало бы желательным, чтобы при подготовке предложений в национальные и международные агентства участники сотрудничества в рамках БМЦЭИ (БОМЛ) своевременно информировали своих потенциальных партнеров о содержании заявок (на условиях конфиденциальности). Сибирское отделение РАН также считает необходимым детально разработать под руководством совета учредителей БМЦЭИ (БОМЛ) порядок публикации результатов совместных исследований и подготовки таких публикаций, принципы соавторства, порядок использования неопубликованных данных, санкции за нарушение согласованного порядка.

5. Для организации текущей деятельности БМЦЭИ будет создана исполнительная дирекция в составе директора, бухгалтера и секретаря. Исполнительная дирекция будет осуществлять содействие российским и иностранным партнерам в подготовке их соглашений между собой и с другими российскими организациями, обеспечивающими поддержку экспедиционных работ, в частности, с Лимнологическим институтом об использовании экспедиционных судов. Она будет (по согласованию с российскими партнерами) оформлять поддержку виз иностранным партнерам, встречать и провожать их в Иркутске, размещать в гостиницах, способствовать приобретению билетов на самолеты и поезда, оформлять транспортировку грузов, обеспечивать их погрузку и разгрузку, осуществлять таможенное оформление. Работа исполнительной дирекции БОМЛ будет финансироваться либо за счет выделенного учредителями бюджета, либо путем компенсации расходов (включая заработную плату, налоги и подтвержденные документами прямые расходы) российскими и иностранными партнерами, пользующимися ее услугами. Исполнительная дирекция БОМЛ подотчетна совету учредителей БОМЛ.
6. Сибирское отделение РАН намерено выступить учредителем БОМЛ и приглашает учредителей БМЦЭИ стать равноправными со-учредителями БОМЛ без вступительного финансового вноса.
7. Если совет учредителей БМЦЭИ принципиально одобрит настоящее предложение, Сибирское отделение РАН до конца первого квартала 1998 г. подготовит проект устава БОМЛ и проект учредительного договора и ожидает, что указанные документы будут согласованы учредителями БМЦЭИ в своих странах до конца третьего квартала 1998 года с тем, чтобы учредительный договор был готов к подписанию к моменту следующего заседания совета учредителей БМЦЭИ.
8. Сибирское отделение РАН готово рассмотреть другие предложения учредителей БМЦЭИ о его реорганизации. Однако, учитывая изложенное выше, при отсутствии согласия всех членов-учредителей БМЦЭИ, в соответствии с его уставом оно объявит о ликвидации БМЦЭИ не позднее конца 1998 г. и об учреждении БОМЛ самостоятельно, либо совместно с теми иностранными учредителями БМЦЭИ, с которыми будет достигнуто согласие.
8. До официального преобразования участники совместных экспедиций БМЦЭИ работают на прежних основаниях, однако, при этом:



- решение о выплате иностранными участниками 50 долларов США в сутки во время пребывания в Иркутске и работы в экспедициях на Байкале отменяется;
- российские и иностранные партнеры - участники совместных экспедиций БМЦЭИ - самостоятельно решают вопросы долевого финансирования и совместно оплачивают полную стоимость использования научно-исследовательских судов, другого экспедиционного транспорта, питания; не позднее 1.05.97 они направляют свои заявки на экспедиции с гарантией оплаты в Лимнологический институт СО РАН, что обеспечит приоритет при формировании плана экспедиций; заявки, поступившие позднее, могут быть отклонены, если они вступят в конфликт с принятым расписанием, которое будет окончательно согласовано с руководителями проектов до 1.06.97, либо если недостаточный спрос на суда не позволит ввести их в эксплуатацию.

**EAWAG**



**From:** Rolf Kipfer **Fax #:** (41) 1 823 52 10  
(41) 1 823 50 28

Environmental Physics  
EAWAG/ETH, Dübendorf, CH  
em: kipfer@eawag.ch  
(41) 1 823 55 30

**To:** Dr. M. Grachev **Fax #:** (7) 095 4202106  
Dr. N. Granin

Linnological Institute  
Siberian Division of the Russian Academy of Sciences  
Irkutsk, Russia  
(7) 3952 466 942

**Date:** 15.10.93

**# of pages:** 3

**Subject:** IAEA, Swiss grant for BICER, spring expediton

*ознакомить Гранина, Мингарева,  
Вружю мне.*

*Ознакомлен все.  
Кипфер*



Dear Dr. Grachev, dear Nick,

concerning your phone from the 13.10.93 there are three points that should be mentioned.

#### **IAEA money**

One should not care about the title 'principal investigator'. The goals of the IAEA project are as open as possible. It will be easy to meet all the requirements of the project objectives. The needed analysis will be done anyway as part of Roland's and Manuel's PhD works. The most important point is, that the IAEA money is available for the Limnological Institute to run projects (whatever that means).

#### **Swiss grant for BICER, 1994**

At the moment we are able to transfer any of the money for 1994, since the next part of the grant will be free to spend only in the beginning of the coming year.

Did you receive the outstanding 15000 US-\$ of Swiss contribution to BICER for this year?

Sincerely yours

Rolf Kipfer



**To Dr. Granin and Dr. Shimaraev: Spring expedition**

First I tried to send this information by electronic mail. As you can see the modern times convince in end also people from the computer stone age which means people like me. Obviously I got a bad e-mail number. So please answer me about your electronic mail address. I hope next time I will manage to communicate by computer.

Indeed it is good idea to study convective mixing processes in the spring, especially when the surface water cools down to 4°C. One should really think about a expedition in November/December.

But let us first analyse together the result of the summer expedition 1993 in order to see on which process one should concentrate, e.g. border related transport of cold water in the northern basin. Roland and Manuel are full in charge processing the July data. On the basis of this data we think about joint spring expedition in the next year. Further I have to tell, that unfortunately the university semester will start soon. Everybody has to do teaching beside the research work, so only little time left for other spontaneous activities. Again, we will try to spare some time in the spring season of next year.

I hope everybody feels OK. All my best regards you, your family and Dr. Shimarev.

RoKi

By the way: Can you inform Ruslan and Andrej that I got a textbook concerning the biding in Bridge.

BAIKAL INTERNATIONAL PROJECTS

LIN = Limnological Institute of the Siberian Division of the USSR  
Academy of Sciences, Irkutsk

Foreign participants (leaders of groups)	Address	Topic	Participants from USSR	F - fulfilled P - planned for nearest future R - research in progress
Prof. J. Janssen Dr. S. Coombs	Loyola University of Chicago, Department of Biology, USA	Behavior and anatomy of Cottoid fishes; sensory systems of Baikal endemics	Dr. V. Sideleva (LIN) Dr. T. Dmitrieva (Irkutsk University)	R
Dr. J. Smith	University of Michigan, USA	Comparative restriction analysis of genomic DNAs of Baikal and Great Lakes Cottoid fishes	Dr. S. Slobodyanuk (LIN) Dr. N. Kholodilov	R
Prof. H. K. Wong	Geological and Palaeontological Institute, Hamburg University, FRG	Geophysical and Geochemical studies of Baikal sediments	Dr. V. Fialkov (LIN) Dr. V. Mats (Irk. Polytechn. Institute) Dr. V. Nikolaev (Geological Institute, Ac. Sci., Moscow)	R
Prof. A. Oikari	Joensuu University, Finland	Accumulation of chlorophenolics of pulp and paper industry waste water in fish bile	Dr. G. Baram (LIN)	F
Prof. K. Nealson Dr. V. Klump	University of Wisconsin, Center for Great Lakes Studies, USA	Studies of the biogeochemical cycle of manganese in Lake Baikal	Dr. Yu. Kusner Dr. V. Verkhosina Dr. N. Sudakova Dr. I. Granina (LIN)	R

Dr. J. Chamberlin M. Jordan Prof. J. Janssen	Osborne Laboratories of Marine Sciences Atlantic Foundation, Loyola University of Chicago, USA	Life retrieval of deep-water animals	Dr. V. Sideleva (LIN)	P
Mr. E. Kristoff	National Geographic Magazine	Use of remote-operated equipment and PISCES deep-water submarine for multi-disciplinary studies of Lake Baikal	Dr. A. Sagalevich (Inst. Oceanol., Moscow) Dr. M. Kuzmin (Inst. Geochem., Irk.) Dr. V. Fialkov (LIN)	P
Dr. S. Pomponi	Harbor Branch Institution of Oceanography	Biologically active compounds of Baikal organisms	Prof. Yu. Elyakov (Pacific Inst. Bioorg. Chem., Vladivostok) Dr. G. Baram (LIN)	P
Dr. H. Salemaa	Helsinki University, Department of Botany, Finland	Chromosomes of Lake Baikal gammarides	Dr. R. Kamaltynov Dr. O. Timoshkin (LIN)	F; R; P
Prof. T. Karling Prof. A. Franzen Prof. J. Afzelius	Natural History Museum, Stockholm, Sweden	Phylogeny and systematics of Baikal turbellaria	Dr. O. Timoshkin (LIN)	P
Dr. A. Osterhaus	National Institute of Public Health and Environmental Hygiene, The Netherlands	Disease of seals in Lake Baikal and in West Europe: comparative studies of morbilliviruses	Prof. M. Grachev Dr. V. Kumarev (LIN)	F; R; P
Dr. C. Wimpee	University of Wisconsin, USA	Phylogeny of nucleic acids of Baikal endemics	Prof. M. Grachev Dr. V. Kumarev (LIN)	R; P

1	2	3	4	5
Prof. D. Edgington Dr. J. Kaster	University of Wisconsin, Center for Great Lakes Studies, USA	Studies of Baikal sediments: isotope dating, historic changes of diatom communities	Dr. V. Pampura (Geo- chemical Institute, Irkutsk) Dr. Yu. Kusner (LIN) Dr. G. Chernyaeva (Inst. of Earth Crust)	R
Prof. K. Nealson Dr. A. Brooks	University of Wisconsin, Center for Great Lakes Studies, USA	Studies of the patching of phyto- and bacterioplankton in Baikal and Lake Michigan	Dr. Yu. Kusner Dr. G. Popovskaya Dr. N. Sudakova Dr. V. Verkhosina (LIN)	R.
Prof. G. Hartmann Prof. E. Bautz	Institute of Biochemistry Ludwig-Maximilians Uni- versity, Munchen, FRG	Phylogeny of the active centers of RNA polymerases	Dr. M. Grachev Dr. E. Zaichikov Dr. A. Mustaev Dr. V. Kumarev (LIN)	F; R
Dr. M. Simon	Limnological Institute, University of Konstanz, FRG	Bacterial production in Lake Baikal by leucine in- corporation method	Dr. T. Zemskaya	P
Dr. M. Reuter	Åbo Akademi University, Finland	Ultrastructure of Baikal flatworms neurons system	Dr. O. Timoshkin	P
Dr. L. Rudstam	University of Stockholm, Sweden	Ecology of Baikal fishes (sonar studies)	Dr. V. Sideleva (LIN) Dr. S. Pushkin (Echo Research, Petroza- vodsk)	P
Dr. D. Williams	University of South Ca- rolina, USA University of Miami, USA	Baikal Drilling Project	Prof. N. Logachov (Inst. of Earth Crust, Irk.) Prof. M. Kuzmin (Geochem. Inst., Irk.) Prof. L. Zonenshain (Inst. Oceanol., Moscow) Dr. V. Fialkov (LIN)	P

РОССИЙСКАЯ АКАДЕМИЯ НАУК  
СИБИРСКОЕ ОТДЕЛЕНИЕ

ЛИМНОЛОГИЧЕСКИЙ  
ИНСТИТУТ

664033, г. Иркутск-33, а/я 4199  
Тел.: 46-05-04, телетайп: 231548 Фауна  
Факс: 46-69-33

От 14.10.93 № 15356-01

На № \_\_\_\_\_ от \_\_\_\_\_

To: World Bank Mission

From: Prof. M. Grachev

Director of Limnological  
Institute,  
Managing Director of  
BICER, Member of Baikal  
Commission

Re: Proposals to Baikal Project

Limnological Institute, and Baikal International Center for Ecological Research (BICER) may be interested to take part in many aspects of the World Bank Baikal Project. However, monitoring of the ecological system of Lake Baikal is part of the Project where they should be directly involved.

Siberian Division of the Russian Academy of Sciences has forwarded to Ministry of Environment Protection of Russia in the beginning of 1993 a project proposal as part of the program "Ecological Safety of Russia" named "Development and aprobaton of a system of multidisciplinary ecological monitoring of Lake Baikal and of its catchment basin". This proposal remains valid, but it is still under consideration in the Ministry because of the economic crisis (see Addendum 1). If approved by World Bank, Limnological Institute could organize a special workshop on this project.

Limnological Institute has a huge amount of information on results of many years of monitoring. However, they are not yet in a computerized form. If financing available, a computer data base could be compiled as demanded by World Bank and decision makers. This could be a topic of another workshop.

Another problem is evaluation of quality of data. I think that BICER members could help to organize peer review procedures in Russia and abroad, if financing available. If World Bank soundly expresses its interest, the problem may be discussed at annual BICER meeting in December 8 - December 18, 1993.

One more problem which could be proposed to BICER is preparation (and review) of quarterly, annual, or other regular condensed reports on the state of the ecological system of Lake Baikal on the basis of data which are



obtained due to diverse sources of financing, i.e., data of scientists of various countries working on Lake Baikal. This would need special financing for writing, typing, copying, postage, peer review, etc.; a special group for the purpose could be hired for the purpose by Limnological Institute.

Finally, there are very urgent needs in equipment. We must immediately start biannual evaluations of the stock of omul. Practically, it can be only done using R/v Vereshchagin, belonging to Limnological Institute. Of course, VostsibribNIIproject and Baikalribvod will be involved. The necessary equipment should be Simrod (Norway) computerized sonar equipment which costs some 120,000 dollars. Another piece of equipment is Perkin-Elmer (USA) instrumentation for analysis of water and air, of this a Liquid Chromatograph - Mass Spectrometer, the cost of which is some 400,000 dollars.

If these requests can be considered by World Bank, most detailed papers will be immediately delivered.

Sincerely,  
M. Grachev

## Research proposal for the Baikal International Center for Ecological Research (BICER) 1994.

1. Title: Ecology, taxonomy and life histories of the phytoplanktonic diatoms in Lake Baikal.

2. Contact person: Dr. David Jewson

Address: Freshwater Laboratory, University of Ulster, Traad Point,  
Ballyronan, Co. L'Derry BT45 6LR, Northern Ireland, UK.

Phone: 44 648418 264.  
44 648418 350

FAX: 44 648418 777

3. Belongs to the following major BICER activities:

Present state of Baikal Ecosystem: ✓

Speciation of Aquatic Organisms: ✓

4. New project: No. ? - continuation. 1993 Project number ?

In collaboration with:

Russia: Drs. Grachev, Likoshway, Sherbakova, Bondarenko,  
Guselnikova, Granin, Shimaraev, Prof. Kohova and others.  
Switzerland: Drs. Kipfer & Imboden (physical processes).  
Belgium: Dr. Goddeeris (benthic sampling)  
UK: Drs. Gibson & Heaney (Dept of Agriculture), Dr. Flower,  
Barnsley and Mackay (UCL).

**Research Goals:** Understanding the reasons for 'Melosira' years and determining the length of diatom life cycles in L. Baikal.

5. Logistic needs (ships, winches, etc.): Help with sampling under the ice from Feb to May 1994 and then lake sampling to trace population growth and decline, especially depth distribution of cells in summer and autumn.

6. Brief project description :

The aim of this project is to understand the factors controlling the population dynamics of the planktonic diatom *Aulacoseira (Melosira) baicalensis*. This species used to show enormous increases in cell numbers every three to four years. Over the last two decades, there has been a decline in the maximum cell concentration and the frequency in the occurrence of 'Melosira years' has become more erratic. From preliminary investigations, we know now that it will be important to quantify gains and losses to the whole population over the complete life cycle. So, it is proposed that there should be an interdisciplinary programme that is co-ordinated with other investigations of water chemistry, circulation patterns, sedimentation etc. Already, there has been some exchange of staff to plan out an appropriate sampling strategy for the lake and also to organise experimental and culture work in the laboratory. There are four main project areas being developed in collaboration with Russian and BICER scientists.

1. Sexual stages and the length of the life cycle - This involves a range of techniques, including light microscope and SEM studies of population size-structure, diameter decline and cell cycle experiments. It particularly requires looking at events under the ice. Dr. Jewson will visit Baikal during April 1994. He will be based at Listvyanka. The aim is to look at a number of sites, in both snow covered and snow-free areas and to investigate the possible link between life-cycle events and the availability of sufficient light.

2. Culture and Genetic studies - This is to establish whether *A. baicalensis* and *A. islandica* are separate species or just morphological 'varieties'. It is important that they should be isolated in culture. This will allow studies of changes in physiology, wall thickness and morphology under different growth conditions (Drs. Bondarenko & Guselnikova). At present, there is a possibility that one morphotype is more typical of inshore and the other offshore, but we need to be certain about their taxonomic position, before we can begin to relate their ecology to mixing processes and circulation patterns. One promising area is comparing the taxonomy based on morphological features (Dr. Likoshway) with results from DNA studies (Dr. Sherbakova). Preliminary studies have been started and further work is being planned to help decide whether there are one species or two.

3. Population dynamics and lake sampling - This is the most difficult to organise and will need considerable co-ordination between groups. It should include both deep and shallow water sites, with information on population dynamics, as well as water chemistry, light penetration, ice cover, circulation and mixing patterns (Prof Shimaraev & Dr. Granin), grazing and sedimentation. Several programmes already gather some of this information. So, part of the early planning should identify which parameters are not measured at present but which are necessary for a clear understanding of population dynamics. The study needs to last several years, to make sure it includes at least one 'Melosira' year. During the other years it will be important to adapt the sampling to collect sufficient cell numbers at low concentrations. Understanding events at these times is as important as looking at times of high concentrations. Remote sensing would help with spatial distribution of phytoplankton in summer (especially in relation to thermal bars etc.) and also the extent of snow and ice cover (both spatial and temporal). Dr. Gibson and Heaney will try a sedimentation and growth experiment in March 1994, to estimate the loss rate of cells. Later in the year, the proportion of cells returning from deeper water (most probably 100 to 400m) needs to be established.

4. Location of diatom resting stages: The aim is to collect surface bottom samples from 0 to 30m to try and locate the depth distribution of diatom resting cells. It should be possible to relate this to the depth of bed disturbance (mainly by wave action), which is the most likely mechanism for return of cells to the water column (most probably in late summer, autumn and/or early winter storms). It is possible that sampling by SCUBA diver could be co-ordinated with animal collections (see Goddeeris). The best time for initial samples would be in late summer, with a repeat sampling after a major storm.

Overall, there are obvious links with a number of other BICER projects and it would be beneficial to discuss co-operating both with sampling and exchanging information.



# Environmental Change Research Centre (ECRC)

University College London

26 Bedford Way  
London. WC1H 0AP  
U.K.

Director: Professor R. W. Battarbee

Tel: (44) 071 387 7050 Ext.....

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## 1994 SUGGESTED FIELD WORK PLANS FOR THE UNIVERSITY COLLEGE LONDON GROUP

**MARCH 1994.** Provisionally Drs Mackay and Flower and Mr Monteith hope to do more box coring through the ice in the early part of this month. Russian participants are to be advised by Dr Grachev.

**Plan:** to collect 6-8 cores in a transect from the middle of southern lake Baikal towards the east shore. With reliable equipment 8-10 days in the field is expected.

**Equipment:** vehicle, good portable winch and accessories with 1600m of fairly new 3 mm steel cable, portable echo-sounder capable of working in deep locations. The UCL box core ( this needs a new blade). Core sub-sampling to be performed on shore (Lisvianka?) each evening.

**JULY OR AUGUST 1994.** Probably only Dr Mackay will visit for about three weeks to collect a few more sediment cores to supplement those collected in 1993.

**Plan:** We are flexible about coring sites but would like to collect 2 cores from the Little Sea, several more cores from NW of the Selenga delta and, possibly, elsewhere in northern Baikal.

**Equipment:** Good reliable winch, 1700m cable, ship. UCL box corer and any other cores available.

Since probably only Dr Mackay will be participating on the summer sampling project it might be useful to try and incorporate his needs within an larger expedition (Swiss or Belgium groups, possibly?). Only about 2 hr/day on calm days is needed for this work.

Dr R J Flower 3.12.93

**Research proposal for the Baikal International Center  
for Ecological Research (BICER) 1994**

1. **Title** : Systematics and Ecology of Selected Animal Groups in Lake Baikal. Partim: Ecology of benthic organisms in Lake Baikal.

**Country** : Belgium

2. **Contact person** : Dr. Boudewijn GODDEERIS

**Address** : Royal Belgian Institute of Natural Sciences, rue Vautier 29, B-1040 Brussels, Belgium.

**Phone** : (32.2) 627.43.14

**Fax** : (32.2) 646.44.33

3. **Belongs to following major BICER research activities** :

Past global change : 0 Present state of Baikal Ecosystem : ●  
Speciation of Aquatic organism : ● Other : 0

4. **New project** : No To be continued, since : 1990

**Project number** : 30.35.2.1.

**In collaboration with** : Dr P. MARTIN, Dr K. MARTENS  
(R.B.I.N.Sc., Belgium); V. BELKOV, S. ALEXANDROV,  
Dr M. KAMALTIKOV, Dr L. SNIMSCHIKOVA, Dr. KARABANOV,  
Dr L. GRANINA (L.I.Irkutsk, Russia).

**Research goal** : To analyze the ecological segregation between Baikal benthic species as an evolutive mechanism, especially the habitat segregation of closely related species.

5. **Logistic needs (ships, winches, etc.)** :

*Subprogram 1* : a Reineck box-corer, the R/V 'Vereschagin' or a ship able to manipulate a Reineck box-corer and to give laboratory facilities, a winch with a cable 1.700 m long and strong enough to support the Reineck box-corer.

*Subprogram 2* : SCUBA-diver material, laboratory facilities.

6. **Brief project description (not more than 2 pages)** :

*Subprogram 1* : *Sampling of abyssal zones.*

For the research goal above mentioned, habitat characteristics (e. g. the oxygen distribution into the sediment, grain size, pH, organic matter,...) are analyzed parallel to benthic micro- and macrodistribution. Five animal groups are selected for this

study, namely oligochaetes, ostracods, chironomids, gammarids and mollusks.

As mentioned previously (see the research proposal for BICER 1993), given the high oxygen content of the waters of Lake Baikal, this parameter is assumed to be an important factor of ecological segregation. It allows organisms to penetrate deeper into the sediment and is likely to increase potential microhabitats. For this reason, the subprogram "Ecology of the benthos of Lake Baikal" was mainly directed thus far towards measurements of sediment oxygen penetration depths in relation with the vertical distribution of organisms.

1990 - 1993 program : Several transects have been sampled between 1990 and 1992 and were selected in order to survey the zoogeographical divisions of the lake (the three basins of the lake, the surroundings of the Selenga delta but not the Maloye more), and to be representative of its vertical zonations (from the littoral to the upper subzone of the abyssal zone mainly, 20-500 m; a few isolated stations have been sampled at more than 500 m). Sediment oxygen penetration depths (SOP) were measured, organisms collected and sediment samples were taken for grain-size, orgC and CO<sub>2</sub> analyses.

The sorting out of the 1991 material has been finished and the animals were available for study. The processing of the 1992 material is in progress.

1994 program : the program of this year is the logical continuation of what has been done during the previous years and is oriented to the sampling of the deepest zones of the lake (> 1000 to 1637 m). This work will enable us to finish our work on the distributions, according to the initial program. We intend to sample an abyssal transect, including the greatest depth of the lake near Olkhon Island (1637 m) and which logically continues through the Barguzinsky Bay. Processings and analyses similar to those of the previous years will be carried out, in collaboration with the Limnological Institute (SOPs, orgC, CO<sub>2</sub>, grain-size, pH, slicing of subcores for biological analysis). For this expedition, the R/V 'Vereschagin' is badly needed for a period of ten days in August in which the third week is included.

*Subprogram 2 : Patchiness in species diversity.*

A preliminary sampling of the experimental parcel of the Limnological Station is scheduled by means of a SCUBA-diver. This should allow to gather first informations on the micro-distribution of selected species and the patchiness in species diversity, as well as in specific densities. Measurements of similar physico-chemical parameters to those of the subprogram 1 are also necessary (in collaboration with the Limnological Institute). These results will orientate our future research on the lake.

**(preliminary) Research proposal for  
the Baikal International Center of  
Ecological Research (BICER)  
1994**

to be submitted before:

1. Title: Biogeochemical processes in L. Baikal Country: Switzerland

2. Contact person: Prof. Dr. Laura Sigg  
Address: EAWAG, CH-8600 Dübendorf, Switzerland  
Phone: (+41)-1-823 5494 Fax: (+41)-1-823-5028

3. Belongs to following major BICER research activities :  
Past global change:  Present state of Baikal Ecosystem:   
Speciation of Aquatic organism:  Other:

4. New project:  to be continued, since: Project number:  
In collaboration with: Prof. Dr. Bernhard Wehrli, Dr. Alfred Wüest and Dr.  
M. Sturm EAWAG; Dr. Liba Granina and Dr. Tamara Khodzher;  
Limnological Inst. Irkutsk

Research goals: 1. Determine the rates of organic carbon mineralization  
and SiO<sub>2</sub>-dissolution at the sediment-water interface; evaluate the effect of  
these processes on deep water mixing. 2. Trace analysis of Fe, Mn, Cu, Zn,  
Cd, ev. Pb in the water column; study the relation between trace metals  
and nutrients and the role of the Fe and Mn cycle in sediments.

5. Logistic needs : 1 ship, 2 weeks in summer (preferably July 15. - Aug. 31)

## 6. Brief project description (not more than 2 pages):

### 6.1 Exchange processes at the sediment-water interface

Biogeochemical processes at the sediment-water interface govern mineralization rates of organic carbon, dissolution of opal from diatoms and the redox cycles of S, Fe and Mn. The determination of benthic exchange fluxes is important for the construction of geochemical mass balances and the use of sedimentary records in paleolimnology. The mixing of deep waters may be influenced by chemical gradients of components like  $H_4SiO_4$ . A more detailed understanding of opal and calcite dissolution in L. Baikal sediments would therefore complement last year's deep-water mixing project. A systematic analysis of the redox conditions in recent sediments is very promising since a recent study (Callender & Granina, Water-Rock Interaction 7, p. 621, 1992) has shown that sulfate reduction is also observed outside the thermal fields of Frolikka Bay. In summer 1992 a pilot project based on gravity cores (M. Sturm, EAWAG, pers. comm.) has provided evidence for past anoxic events in the sedimentary record.

A detailed study of sediment pore-waters is proposed along a transect from the Selenga-Delta to the central basin in order to address the following questions:

1. How fast is the dissolution of opal from diatoms within the sediments? Can the flux across the sediment-water interface explain the large gradients of  $H_4SiO_4$  in the deep water?
2. Is there any detectable calcite dissolution within the sediments?
3. What are the typical mineralization rates of organic carbon in these sediments?
4. How deep is the penetration of oxygen, nitrate and sulfate?
5. Are reduced iron and manganese ions recycled within the sediments or is a release into the deep water possible?

Two methods will be used for the pore-water analysis: a) Micro-electrode measurements of  $O_2$ ,  $NO_3^-$ ,  $NH_4^+$ ,  $Ca^{2+}$ , and pH will be performed on fresh sediment cores using ion selective microelectrodes and a simple micro-manipulator. b) Pore-water samples will be stabilized and analyzed at EAWAG for metals, Si, P and  $SO_4^{2-}$ . Biogeochemical models of early diagenesis will be used to extract rates from porewater profiles.

We plan to sample 3-7 stations (1 station per day) and ask for 2 weeks of ship time.

(B. Wehrli)



## 6.2 Regulation of trace elements

Lake Baikal offers a unique situation with respect to trace elements. Trace metal inputs are likely to be close to the natural background in the riverine inputs, and to background values in atmospheric depositions, because of the remote location and of the low population density in the catchment area. Particle concentrations in the lake are very low.

It can be therefore expected that the concentrations of Zn, Cu, Cd, possibly also of Mn in the lake are mostly regulated by interactions with phytoplankton, as this has been shown to occur in the oceans. In other freshwater lakes, high inputs from riverine and atmospheric sources, as well as redox cycles, often render the situation more complicated.

It would be interesting to investigate concentrations of trace elements in comparison to nutrients (P, N, Si) in lake water profiles and to compare them with the findings in the oceans and with other freshwater lakes. Some measurements in the tributaries and in atmospheric depositions should also be included in order to estimate the inputs. Measurements in sediments would give insight into the removal by sedimentation.

Preliminary results obtained on samples from 3 depth profiles during June 1993 indicate the following concentration ranges in the lake water column: Mn 1-8 nmol/L; Cu 1-3 nmol/L, Zn 3-13 nmol/L; Cd < 0.01 - 0.06 nmol/L; Fe 5-50 nmol/L.

These concentration ranges are thus close to those in the oceans. In order to obtain reliable results at these low levels, very careful sampling techniques, and very sensitive analytical methods are needed. Using our present analytical techniques, these concentration ranges are close to the limit of detection. We intend to improve our methods by using ICP-MS within the next year. More extended work on trace metals in lake water profiles could then be performed with improved methods. It is uncertain whether this will already be the case in summer 1994.

We propose therefore the following studies:

- Measurements of trace elements in sediment samples from available cores (sediments sampled in June 1993); (winter-spring 1993-1994).
- Limited sampling of lake water in connection with other studies during summer 94.
- Sampling campaign for trace elements in lake water and tributaries during summer 1995.
- Sampling of atmospheric deposition for trace metals should be discussed with T. Khodzher.

(L. Sigg)

# (preliminary) Research proposal for the Baikal International Centre of Ecological Research (BICER) 1994

to be submitted before:

1. Title: BIPWEX Country: Switzerland  
Baikal International Program of Water EXchange

2. Contact person: D. Imboden Address: Environmental Physics  
R. Kipfer Swiss Federal Institute of Technology  
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8600 Dübendorf  
Phone: (41) 1 823 55 36 Fax: (41) 1 823 52 10  
(41) 1 832 55 30 (41) 1 823 50 28  
E-mail: name@eawag.ch

3. Belongs to following major BICER research activities :

Past global change:  Present state of Baikal Ecosystem:   
Speciation of Aquatic organism:  Other:

4. New project: no to be continued, since: 1993 Project number:

In collaboration with: Russia:  
Dr. M. Shimaraev, Dr. N. Granin,  
Limnological Institute Irkutsk  
Belgium:  
Dr. J. Klerkx  
Musee Royal de l' Afrique centrale, Trevuren

Research goal: Deep water renewal of Lake Baikal

5. Logistic needs (ships, winches, etc.): one full equipped ship for a late  
autumn expedition (end of November)

6. Brief project description (not more than 2 pages):

## **BIPWEX, 94: Baikal International Project of Water EXchange**

In 1992 Russia and Switzerland launched the joint research project BIPWEX to define and to quantify processes which replace the water of Lake Baikal below 500 m.

During the spring expedition in 1993 the physical properties of the water column had been studied using high resolution CTD measurements at more than 200 different locations all over Lake Baikal. More than half of the stations align along a E-W striking transect crossing the middle basin in order to analyse the deep water formation which is related to a thermal front called 'thermal bar'. In spring this front represents the boundary between the warm water (temp > 4°C) of high salinity close to the lake shore and the cold fresh water (temp < 4°C) of the open lake. There water reaches its maximum density at a temperature of 4°C and starts to sink by free convection.

Preliminary CTD results show that due to its high salinity and enlarged particle content patches of warm water move from the shore towards the deeper part of the basin. Since the temperature of the sinking water always exceeds the one of the deep water, deep water formation processes related to the thermal bar phenomena will in long terms increase the temperature of the deep water. However measurements suggest that the temperature of the deep water in Lake Baikal does not change and remains constant. This yields to a different process which compensates the increase of temperature by deep water cooling. Temperature measurements in the northern part of Lake Baikal indicate the presence of such a mechanism. At the deepest part of the northern basin the temperature of deep water dropped more than 0.1°C during the period between the end of May and the middle of June (see figures). However, the nature and the origin of this cooling process could not be defined and remains so far a physical 'mystery'.

In late autumn of 1994 our research group will focus on the analysis of deep water formation processes which control the cooling of the deep water. So far only a few high resolution CTD measurements exist for this season of the year. The analysis of the physical properties of water column will help to define the critical periods of deep water formation during the year. The CTD measurements will be combined with the analysis of T-<sup>3</sup>He water age (time since a water parcel had the last contact with atmosphere) to quantify the long term rate of the deep water renewal in the different basins of Lake Baikal.

**Planned projects and preliminary research activities on Lake Baikal during a late autumn expedition in 1994:**

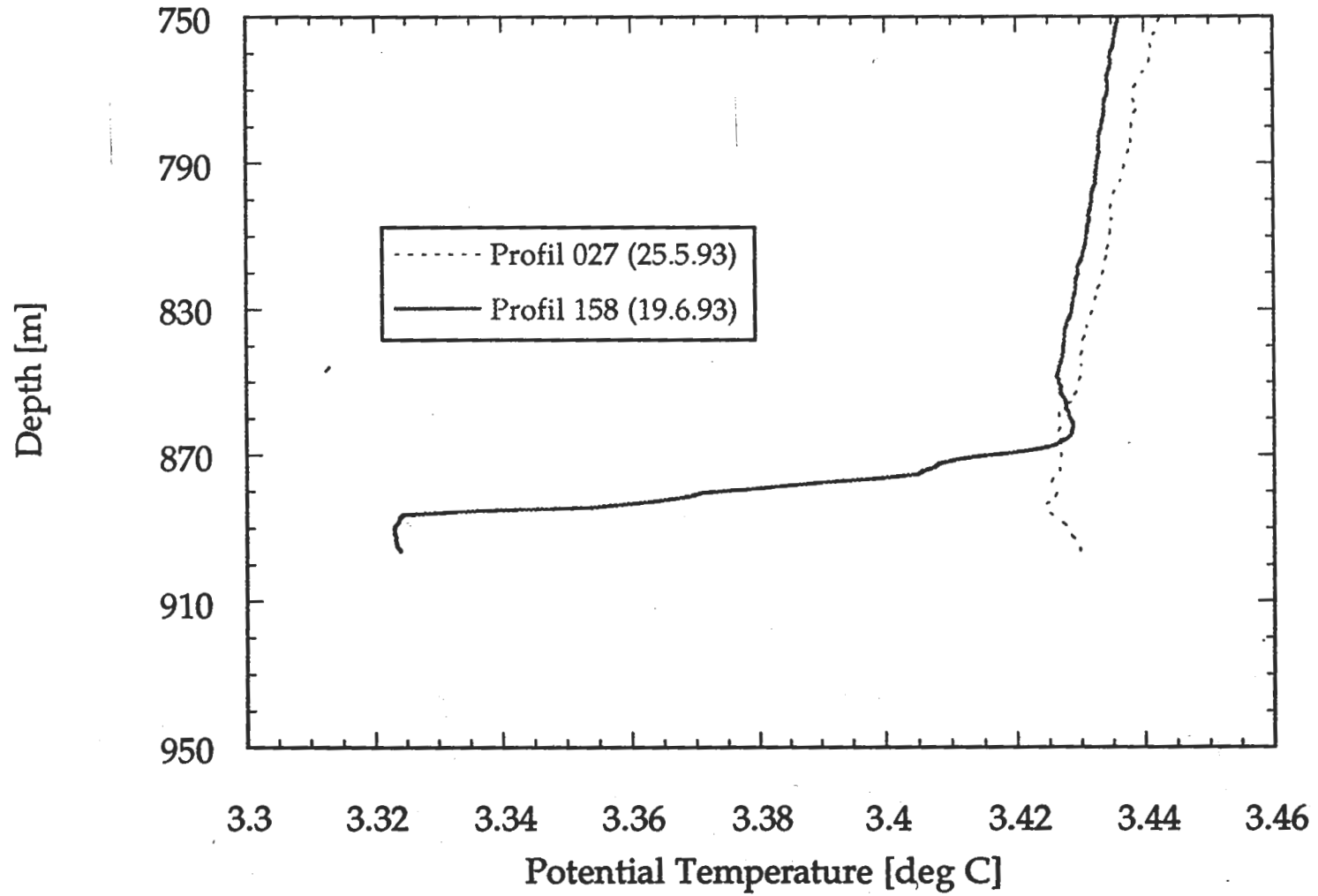
- i) Cruise along Lake Baikal from its southern to its northern end, taking:
  - high resolution CTD measurements
  - water samples for T-<sup>3</sup>He analysis (50 - 70 samples, repeating the 1993 stations)
  
- ii) Analysis of the transport of riverine water in late autumn, e. g. determination of mixing processes close to Selenga delta and Kukulii canyon using high resolution CTD measurements to trace the diving of riverine water of Selenga.

**Infrastructure needs:**

Fully equipped ship for a 2 - 3 week expedition from the end of November to the middle of December.

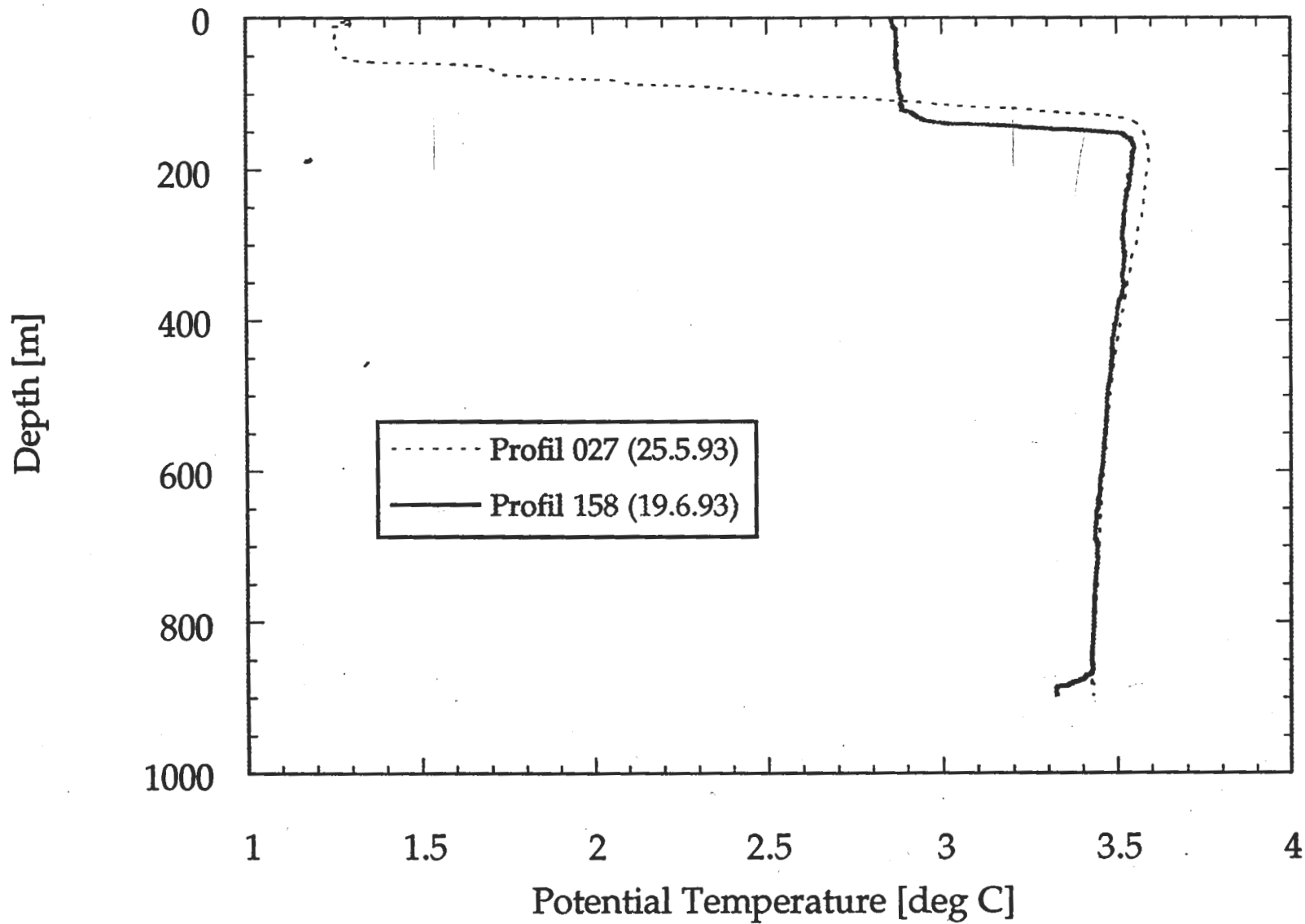
# Potential Temperature

(Station 027 & 158)



# Potential Temperature

(Station 027 & 158)



Dec.12,1994

1. Seismogeology and Neotectonics of Baikal Rift System  
Olifon Island, Towunka Basin-Baikal Sediment Interrelationships  
\*Akiara Takeuchi (1992- )  
Kirill Levi, Valerie V. Ruzhich, Victor Mats
2. Paleomagnetism and Rockmagnetism of drilled sedimentary cores from Lake Baikal  
\*Hideo Sakai, Masae Horii (BDP,1992- )
3. Geological survey on dynamics of the surrounding rift which affect mass transport in the bottom layers of the lake system  
\*Junryo Muramoto, Shoji Fujii, Akira Takeuchi (1992- )
4. Origin and evolution of Baikal Lake: geohistorical elucidation of continental-basin development  
\*Koji Minoura, Kuniki Ishizaki, Sadako Takeuchi,  
Masatoshi Shiba, Osamu Sasaki, Masao Iwai (new in BDP)
5. Glaciology, physical properties of ice and snow around Lake Baikal  
\*Katutosi Tusima, Kunio Kawada, Akio Toukairin, Hideo Sakai (new)
6. Paleontological research of Baikalian diatoms, mollusca and sponges  
\*Keiji Matsuoka, Takayoshi Kawai (new in BDP)
7. The Taxonomic and ecological research of Baikalian sponges  
\*Yoshiki Masuda (1993- )  
Valerii Chernykh
8. The paleontological research of Baikalian sponges  
\*Yoshiki Masuda, Takayoshi Kawai (new in BDP)
9. Phylogeny and speciation process of Baikalian sculpins (Pisces: Cottoidei)  
\*Akira Goto (1992- )  
V.G.Sideleva
10. Analysis of horizontal distribution of zooplankton and food chain in plankton community in Lake Baikal  
\*Takayuki Hanazato, Takahito Yoshioka (new)  
Oleg A. Timoshkin, Natasha Sheveleva, Nataly G. Melnik
11. Carotenoids in sediment of Lake Baikal as indicator of algal distribution  
\*Mitsuyuki Soma (new in BDP)
12. Spacial distribution of picocyanobacterial bloom patchness survey in L. Baikal *new writing: main food source June to Aug / winter diatoms*  
\*Yasunori Watanabe, Setsuo Okuda (1992- ) *July to Aug*  
Valentin Drucker
13. DNA comparison of microorganism between Lake Baikal and Lake Biwa  
\*Hiroto Maeda (1993- )

14. Study on turbidity current from the river Selenga and on the thermal bar effect with reference to the deep water renewal  
 \*Setsuo Okuda (1993- )  
 Shimaraev
15. Dynamics of Transport by Turbid Current of Selenga River  
 \*Ryohei Tsuda, Setsuo Okuda (1993- )  
 M.N. Shimaraev, N.G. Granin
16. A systematic review of Baikal amphipod genus Eulimnogammarus  
 \*Hiroshi Morino, Nobuyuki Miyazaki (1991- )  
 Ravil Kamaltynov
17. Analyses of population genetic structure for Eurinogammarus cyaneus in Lake Baikal  
 \*Kazuo Mashiko, Ken-ichi Numachi (1992- )
18. Taxonomical Study of North-East Asian Tubificidae (Oligochaeta)  
 \*Akifumi Ohtaka, Ken-ichi Numachi (1992- )
19. Baikal Drilling Project (100-300m) BDP3H94  
 \*Takayoshi Kawai, Yoshio Inouchi, Kimiyasu Kawamuro (1991- )  
 (1) drilling \*Hiroaki Tsukahara, Takayoshi Kawai  
 (2) dating \*Akira Takeuchi, Toshio Nakamura, Takayoshi Kawai, Masatoshi Morita  
 (3) chemistry \*Genki I. Matsumoto (organic), Takejiro Takamatsu (inorganic), Eitaro Wada (stable isotope)  
 (4) biological data \*Kimiyasu Kawamuro, Hiroto Maeda, etc  
 (5) physics \*Kenji Kashiwaya, Yoshio Inouchi  
 (6) data base \*Masayuki Kunugi
20. Stable isotopic structures of Lake Baikal from isotopic viewpoint  
 \*Eitaro Wada, Koichi Yoshii (1992- ) *Titov ko vakh ni*  
 Oleg A. Timoshkin, Nataly G. Melnik
21. Ecological and chemical monitoring in Selenga region  
 \*Susumu Hayashi (1992-1996)  
 Albert Beim
22. Ecological monitoring for forests damaged by air pollution  
 \*Susumu Hayashi (1993- )
23. Others  
 Some more roposal will be made later when new project on phylogeny and releted themes will be accepted by Ministry of Education, Science and Culture Japan.  
 \*N. Miyazaki et al.