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Initial Results of U.S.-Soviet Paleoclimate Study of Lake Baikal

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Lake Baikal Paleoclimate Project Members

Lake Baikal, a Miocene-age rift lake in southeastern Siberia, is an especially promising site for paleoclimate studies. Its high-latitude location (52°–56° N) makes it particularly sensitive to changes in solar insolation due to long-period variations in the Earth's orbital parameters. These variations are widely believed to be the main forcing functions of climate change in the Quaternary [*Hays et al.*, 1976; *Imbrie et al.*, 1984]. The extreme continentality of the climate in southeastern Siberia makes Baikal an ideal location to study temporal changes in seasonality. Baikal is also one of the few high-latitude lakes that has not been glaciated during the last 1–2 million years [*Grosswald*, 1980], although a record of glaciation in its drainage basin is preserved in the lake sediments. Finally, Lake Baikal is the largest (23,000 km^3), the deepest (1640 m), and one of the oldest extant lake systems in the world. The sedimentary section in the Baikal depression is more than 7 km thick and probably spans more than 15 million years [*Hutchinson et al.*, 1992]. Accordingly, Lake Baikal sediments represent one of the longest and most complete continental climate records available anywhere in the world.

Lake Baikal is also paleoclimatically important because the vast central Asian continent is a critical component of the global climate system, controlling, among other things, the atmospheric circulation patterns responsible for the Indian and southeast Asian monsoons [*Lamb*, 1972]. The central Asian deserts between Lake Baikal and the Himalayas are the source area for the extensive Chinese loess deposits, which contain a remarkable paleoclimate record [*Kukla*, 1987; *Maher and Thompson*, 1992]. Finally, it is probable that long paleoclimatic records from central Asia contain a history of the uplift of the Himalayas and the Tibetan Plateau, which certainly has profound regional climatic effects and which arguably has been a major influence on global Pleistocene glacial cycles and climate [*Ruddiman and Raymo*, 1988; *Molnar and England*, 1990]. At present, long-term paleoclimate information for central Asia is sparse.

The unique sedimentary record of Lake Baikal offers significant advantages in temporal scale and resolution. Due to the diversity of sedimentary environments in the lake [*Goldyrev*, 1982; *Mats*, 1992], sedimentation rates range from a few centimeters per thousand years to as much as one millimeter per year [*Edgington et al.*, 1991]. Reconstruction of the paleoenvironmental record from Lake Baikal thus will document climate events on a variety of time scales, including glacial/interglacial changes (10^5 year), the last Ice Age (10^4 year), events such as the Younger Dryas (10^3 year), and short-term events such as the Little Ice Age (10^2 year).

Baikal sediments contain a variety of climatically sensitive properties, despite the fact that biogenic carbonate is poorly preserved. These well-known properties include sediment grain size, biogenic silica, the amounts and isotopic composition of organic carbon, and the stratigraphic record of diatoms and pollen. In addition, a variety of experimental methods are being tried to extract information related to paleoclimatic reconstructions. These methods include measuring the isotopic composition of diatoms, the sediment magnetic properties (as indicators of eolian flux and other environmental variables), the chemical and isotopic

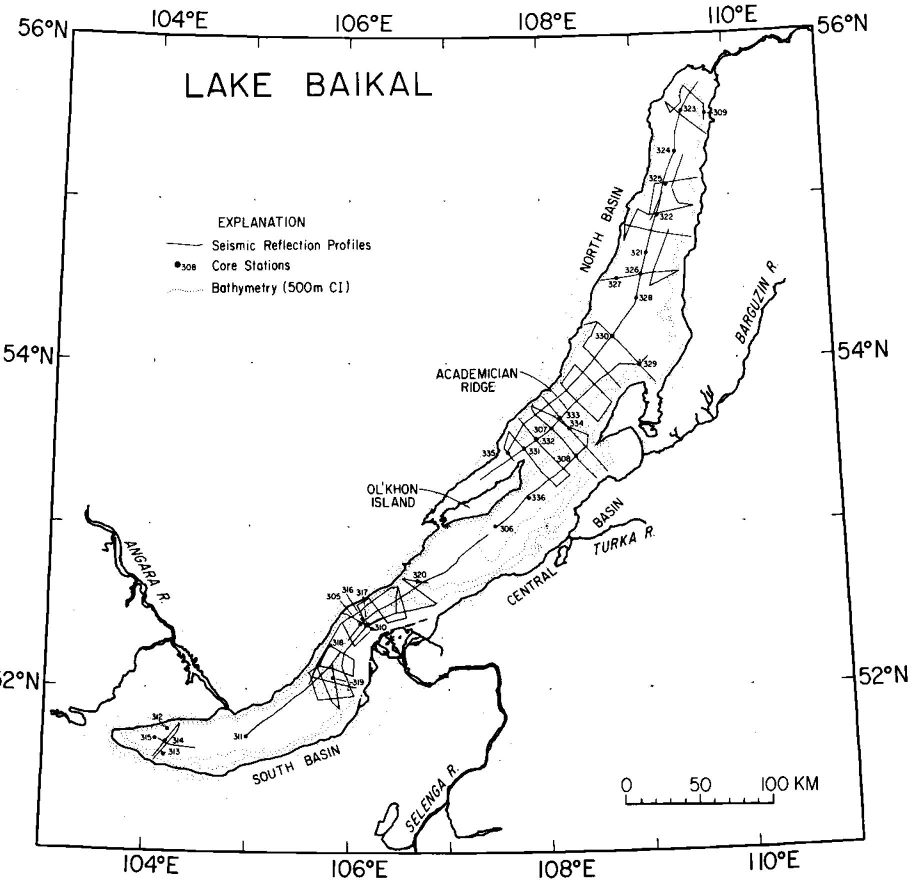

Fig. 1. Location map of Lake Baikal, showing the seismic-reflection track lines and core locations occupied in 1990 and 1991.

This article was compiled by S. M. Colman, U.S. Geological Survey, Woods Hole, MA 02543

signals preserved in pore water, the detailed organic chemostratigraphy, and the chemistry and isotopic composition of sulfur species. These methods of paleoclimatic reconstruction in a fresh-water, oligotrophic environment will be widely applicable elsewhere, especially in high-latitude areas where oligotrophic lakes are common.

Project Description

The objective of the Lake Baikal Paleoclimate Project is to reconstruct a high-resolution, quantitative paleoclimate record from this poorly understood, high-latitude, continental area. This objective addresses the highest priorities recommended by international paleoclimate research groups. These include the Past Global Changes (PAGES) initiative of the International Geosphere-Biosphere Program (IGCP), which is supported by the National Academy of Sciences Committee on Global Change; the first priority of the Earth System History element of the Committee on Earth and Environmental Sciences Global Change Research Program; and the objectives of the U.S. Geological Survey Global Change and Climate History Program.

We have engaged a large, multidisciplinary team for both field and laboratory work. Field operations are two-fold: to collect high-resolution seismic-reflection data to delineate the sedimentary environments and facies beneath the lake, to define how those environments have responded to climate change, and to locate and correlate the best sites for coring; and to acquire cores that provide the raw materials for detailed paleoenvironmental reconstructions. Analytical studies include micropaleontologic, isotopic, geochronologic, sedimentologic, and geochemical methods for reconstructing a detailed, quantitative Quaternary climate record.

The Lake Baikal Paleoclimate Project is an early phase of the Baikal Drilling Project [*Williams*, 1989], which grew out of a collaboration among groups of researchers from U.S. universities, the Siberian Branch of the Russian Academy of Sciences, and the USGS (Table 1). The U.S. efforts have been supported by the National Science Foundation and by the USGS Global Change and Climate History Program. The coordination and planning of this program, which involves many researchers, supported by multiple organizations and operating within two national bureaucracies, has been difficult and time consuming, especially because of the political changes within the former Soviet Union. Nevertheless, significant progress has been achieved in both international scientific exchange and research accomplishments.

During the first joint field effort on Lake Baikal in July 1990, we collected over 500 km of high-resolution seismic-reflection profiles and a set of gravity and box cores at seven sites (Figure 1). In the summer of 1991, a second field program acquired more than 2000 km of seismic-reflection profiles and a suite of box, gravity, and piston cores at 27 sites in a variety of environments throughout the lake. Finally, in summer 1992, we collected an additional 1100 km of seismic-reflection profiles and another suite of cores focused on the Selenga Delta and Academician Ridge. The field operations to date have achieved the first high-resolution seismic-reflection data, the first seismic profiles or core sites located with satellite navigation, and the first cores recovered using modern lined corers. These efforts have been concentrated on specific sedimentary environments suggested by previous Russian coring efforts, including the Selenga Delta (fast sedimentation), Academician Ridge (slow), and parts of the North Basin (moderate to fast) (Figure 1). Cores from these different depositional environments (with different sedimentation rates) provide the opportunity to study the paleoclimate record of Lake Baikal at different scales, time intervals, and resolutions.

Initial Results

Two seismic-reflection systems were used in our surveys of Lake Baikal (Figure 2): a very high-resolution 3.5-kHz system, which gave about 0.5-m resolution and commonly 30–50 m of penetration; and a broad-band water-gun system (100–1060 Hz) that gave 1–2 m of resolution and as much as 300 m of penetration. The high-resolution seismic data were used to delineate and differentiate the wide variety of depositional environments within the lake, including delta-fronts, pro-delta areas, isolated areas of limnic sedimentation, and turbidite fans. These different sedimentary environments served as large-scale targets for coring. Seismic profiles were essential for selecting core sites because of rapid lateral changes in sediment character and common disturbance of the sediments by faulting and erosion. The seismic data also showed important larger-scale features of the lake, such as where the lake floor and the youngest sediments in the lake are locally displaced by faults. Most of the faulting within 300 m of the lake floor appears to be relatively continuous, progressive, growth-type displacements. We also found that the Selenga Delta (Figure 1) appears to be built on top of a structurally high bedrock block, and is thus thinner than its morphologic appearance suggests.

Dip profiles along the axis of the Selenga Delta show remarkably few sedimentary

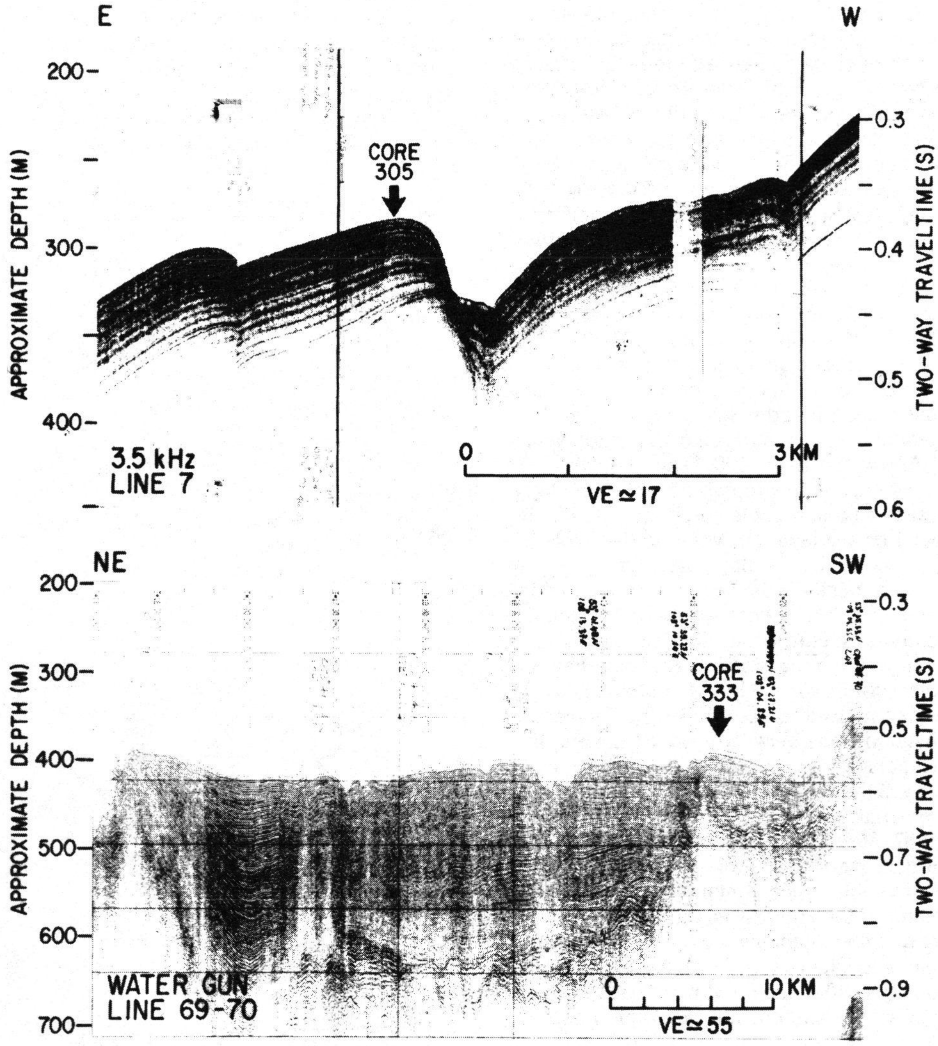

Fig. 2. Examples of high-resolution seismic-reflection profiles collected in Lake Baikal. (Top) 3.5-kHz profile, dip line on Selenga Delta and core site 305. (Bottom) water gun profile, strike line on Academician Ridge and core site 333.

structures, such as channels, levees, or slumps, that are typically associated with channelized flow in delta-front environments. Bedding reflections on the delta front are continuous and parallel to the lake floor, evidence of relatively even, fine-grained sedimentation. The sediments are cut by several young faults that displace the lake floor downward toward the head of the delta, thus creating scarp barriers to near-bottom turbidity flows moving down the delta front. Channel deposits at the base of some of these fault scarps, along with bathymetric channels that parallel the faults on the upper part of the delta, suggest that recent faulting perpendicular to the axis of the delta has diverted near-bottom flows to the north and south, parallel to the basin margins. Much of the coarse deltaic sediment is apparently being channeled into the deep Central and South basins. Some areas of the delta front therefore are receiving primarily fine-grained deltaic sediment, probably at a relatively rapid rate.

Unlike the Selenga Delta, the Academician Ridge is isolated from terrestrial sediment sources and receives only a slow rain of limnic sediments. The ridge is characterized by relatively high local relief and major faults that offset the lake floor. These faults can be correlated from the high-resolution seismic profiles to deep offset structures seen on multichannel seismic profiles [*Hutchinson et al.*, 1992]. Sediments beneath the ridge form several different sequences, ranging from a few meters to a few tens of meters thick, separated by unconformities and/or onlap surfaces. However, much of the ridge is underlain by several tens of meters of sediments in which continuous reflections parallel the lake bottom, indicating distinct, undisturbed bedding.

In the deep basins of Lake Baikal, the smooth, flat basin floors are generally underlain by continuous, horizontal reflections. However, on the margins of the deep basins, complicated sequences of sediment underlie cones and fans; channeling, lensing, and onlap of reflection sequences occur near the steep walls of the basins. In two places, large, erosional, axial channels, 30–35 m deep, cut the basin sediments. These seismic indications of a dominantly turbidity-current environment are confirmed by the presence of interbedded sand and mud in cores from the basin floors.

Based on our interpretation of the high-resolution seismic data and lithologies observed in cores, the Selenga Delta and the Academician Ridge appear to have the greatest potential as sites for paleoclimate study because of laterally continuous bedding, parallel to the lake floor, indicating relatively constant sedimentation and lack of disturbance by faulting or erosion; and the absence of seismic or sedimentologic evidence of significant turbidite sedimentation. The floors of the deep basins of Baikal are somewhat less desirable sites than Academician Ridge or the Selenga Delta for initial paleoclimate research because they are dominated by episodic, coarse-grained turbidite sedimentation. However, turbidites appear to be thicker and more common in sediments of Pleistocene age than in those of Holocene age, so that the basin floors ultimately merit attention for paleoclimatic research.

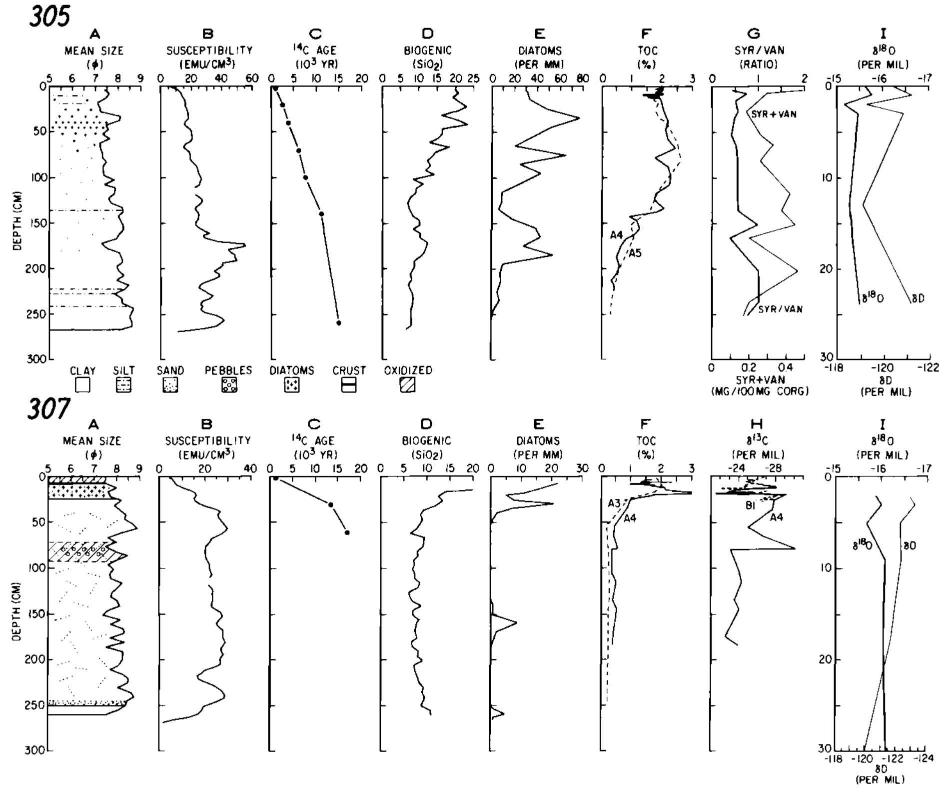

Fig. 3. Core descriptions and analytical data for core sites 305 (Selenga Delta) and 307 (Academician Ridge). All analyses are for cores 305-A5 and 307-A3, except as noted. A, lithology and mean grain size (S. Colman and S. Carter, unpublished data, 1992); B, low-field magnetic susceptibility (J. King and J. Peck, unpublished data, 1992); C, AMS radiocarbon ages on total organic carbon (S. Colman and G. Jones, unpublished data, 1992); D, biogenic silica (S. Carter and S. Colman, unpublished data, 1992); E, diatom concentration (number per millimeters of microscope traverse using standard preparation techniques) (J. Bradbury, unpublished data, 1992); F, total organic carbon (TOC) percentages (W. Orem (305-A5), unpublished data, 1992, and D. Williams (305-A4), unpublished data, 1992); G, lignin oxidation products—syringyl/vanillyl ratio and sum (W. Orem, unpublished data, 1992); H, $\delta^{13}C$ values (PDB) (D. Williams, unpublished data, 1992); I, pore-water isotope composition (SMOW); note change in depth scale (W. Shanks and R. Seal, unpublished data, 1992).

The remainder of this article is devoted to preliminary analytical results from two core sites occupied in 1990: site 305, on the front of the Selenga Delta, and site 307, on Academician Ridge. Both sites are underlain primarily by gray, clayey silt, which is locally diatomaceous (Figure 3). The sediments at site 305 are rather uniform gray muds with minor sandy and silty zones. The surface at site 307 is characterized by thin, brown, oxidized mud, which is underlain by an iron-manganese crust; the cores from this site also contain a buried oxidized zone (about 73–95 cm in core A3). The buried oxidized zone has mineralogical and chemical properties that suggest long exposure to well-oxygenated bottom waters and very slow sedimentation rates compared to those of the intercalated gray, reduced clays (E. Callendar, unpublished data, 1992).

Detailed grain-size analyses reveal both fine-scale and coarse-scale fluctuations, although interpretation of the textural data in diatom-rich zones is complicated by the different origins of similar-sized diatoms and silt grains. However, clastic texture and mineralogy, combined with other indicators, may reflect climatically induced changes in sediment sources, transport pathways, and/or depositional conditions in the lake. Holocene sediments in the two cores are generally coarser grained than late Pleistocene sediments, in part because they contain more silt-sized diatoms. Magnetic properties of the sediments, including low-field susceptibility (shown as an example in Figure 3), appear to correlate with the grain-size variations and may also reflect climatic change. A variety of other magnetic analyses are in progress to define a complete suite of magnetic properties, which have been shown to be sensitive indicators of depositional conditions and sediment sources. These magnetic properties also show a dramatic change at approximately the Pleistocene-Holocene boundary. Paleomagnetic directional measurements are also being made on the sediments, to be used as a correlation and dating tool in conjunction with radiocarbon ages. Preliminary results of paleomagnetic analyses (J. King, unpublished data, 1992) indicate good correlation of secular variation on a 10^4-year scale, and a short magnetic reversal in core 287 collected by the Russians in 1989 suggests an age of several hundred thousand years for some of the cored sediments.

Accelerator-mass spectrometer (AMS) radiocarbon ages on total organic carbon (TOC) show that sites 305 and 307 have distinctly different average sedimentation rates (Figure 3). Site 305 appears to have had a relatively uniform rate of sediment accumulation of about 0.18 mm/yr in the Holocene. Conventional radiocarbon analyses for a nearby core (303; V. Kuptsov, unpublished data, 1992) suggest a rate of about 0.27 mm/yr. In contrast, site 307 appears to have had a sediment accumulation rate of only about 0.035 mm/yr, which is consistent with its isolation from terrestrial sediment sources. The data for both cores suggest that sedimentation rates were higher in the Pleistocene than in the Holocene. Radiocarbon analyses on different types and size fractions of organic carbon are underway to determine the extent of error due to different sources of carbon in TOC.

Biogenic silica in the sediments shows major variations (Figure 3), but is greatest in the upper (Holocene) portions of the cores. Biogenic silica content serves as a measure of paleoproductivity in the lake because biogenic (primarily diatom) flux varies in relation to mineral sediment flux. The amount of biogenic silica approximately correlates with the abundance of diatoms in the cores (Figure 3) [*Bezrukova et al.*, 1991]. Detailed diatom counts and biostratigraphic analyses are underway to define the paleolimnologic and paleoproductivity conditions in the lake and to help correlate cores from widely separated sites. Changes in total organic carbon content correlate well with changes in biogenic silica in the cores; both organic carbon and biogenic silica increase significantly near the Pleistocene-Holocene boundary (Figure 3).

Low amounts of lignin oxidation products (LOP) and low carbon/nitrogen ratios suggest that the majority of the organic carbon is autochthonous, having been derived from algal sources in the lake. This observation is true even for site 305 off the Selenga Delta, and autochthonous carbon is particularly dominant at site 307 on Academician Ridge. The stable carbon isotope record exhibits variations that track the other geochemical parameters, consistent with changes in algal productivity (Figure 3). The LOP fraction of the organic carbon, coupled with the stable carbon isotope data, has great potential for recording past vegetation changes surrounding the lake (Figure 3). The LOP fraction of the organic carbon in the lake sediments is produced only by vascular plants; thus, it is a measure of terrestrial organic carbon contributed to the lake. Initial results indicate that the LOP fraction is low throughout the lake, but that it is highest near river mouths (Selenga Delta). Thus it appears that terrestrial organic carbon is much less abundant than algal carbon produced in the lake. Moreover, different types of LOP are indicative of different types of vegetation (for example, gymnosperms versus angiosperms) in the surrounding drainage basin. Therefore, the LOP changes at approximately the Pleistocene-Holocene boundary (Figure 3) suggest a change from vegetation high in angiosperms to vegetation high in gymnosperms (conifers). Pollen records [*Bezrukova et al.*, 1991] show high *Artemesia* (sagebrush) in the Pleistocene and high *Betula* (birch) and *Pinus* (pine) in the Holocene.

The isotopic composition of pore waters changes with depth (Figure 3). Plots of the isotopic compositions fall close to the δD–$\delta^{18}O$ meteoric water line, suggesting that the pore waters have been little affected by diagenesis, at least in the upper parts of the cores. These pore waters may thus preserve a signal of the past isotopic composition of the lake waters. Analyses of very small samples of diatoms by laser-fusion methods are underway to determine the isotopic compositions preserved in the diatoms.

Conclusions

These initial results of the Baikal Paleoclimate Project indicate that Lake Baikal sediments contain an interpretable paleolimnologic and paleoclimatic record that can be deciphered on a variety of time scales. Particularly notable in the initial data are major changes at the Pleistocene-Holocene boundary. These changes include those in grain size, magnetic susceptibility, sedimentation rates, biogenic silica, organic carbon, and lignin oxidation products. Dating and time resolution within specific time intervals depend on sedimentation rates, but AMS radiocarbon and paleomagnetic methods appear to offer century-scale resolution for the late Quaternary. We are presently analyzing 5- to 6-m cores collected from a variety of sedimentary environments in the lake in 1991, and we have recently (July 1992) collected 9-m piston cores from the Selenga Delta and Academician Ridge. A drilling program, aimed at obtaining 100-m cores at water depths of as much as 800 m from the winter ice-covered surface of the lake, is in the testing phase. In March 1992, the drilling system was assembled and tested in northern Lake Baikal by the Russian drilling enterprise *NEHDRA*. Also during 1992, the Baikal Drilling Project will be expanded to include Japanese scientists as part of the Baikal International Center for Ecological Research. In the winter of 1993, 100-m drill cores are planned for locations defined by high-resolution seis-

Table 1. Present Principle Investigators*, Lake Baikal Paleoclimate Project

PI	Affiliation
Coordination and Planning	
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M. Grachev	Limnological Institute, Irkutsk
M. Kuzmin	Institute of Geochemistry, Irkutsk
Seismic Stratigraphy	
S. Colman	USGS, Woods Hole
E. Karabanov	Limnological Institute, Irkutsk
A. Bardardinov	Limnological Institute, Irkutsk
Sedimentology	
E. Karabanov	Limnological Institute, Irkutsk
S. Colman	USGS, Woods Hole
C. Nelson	USGS, Menlo Park
AMS Radiocarbon Dating	
S. Colman	USGS, Woods Hole
G. Jones	Woods Hole Oceanographic Institution
V. Kuptsov	Institute of Oceanology, Moscow
W. Elders	University of California, Davis
Biostratigraphy and Ecology	
J. Bradbury	USGS, Denver
Y. Likhoshvay	Limnological Institute, Irkutsk
G. Chernyaeva	Institute of the Earth's Crust, Irkutsk
G. Khursevich	Institute of Geochemistry and Geophysics, Minsk
E. Stoermer	University of Michigan
Y. Bezrukova	Limnological Institute, Irkutsk
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P. Hearn	USGS, Reston
D. Williams	University of South Carolina
K. Kelts	Limnological Research Center, U. of Minnesota
Inorganic Geochemistry	
E. Callendar	USGS, Reston
M. Kuzmin	Institute of Geochemistry, Irkutsk
C. Pilskaln	MBARI, Monterey
Y. Bogdanov	Institute of Oceanology, Moscow
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* Only present active investigators are listed here. A large number of other researchers are either peripherally involved through other projects or are in the process of developing active research projects.

mic-reflection data collected in 1990–1992. This order of magnitude increase in core length should provide us with an order of magnitude increase in the length of paleoclimatic record from Lake Baikal.

Acknowledgments

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References

Bezrukova, E. V., Y. A. Bogdanov, D. F. Williams, L. Z. Granina, M. A. Grachev, N. V. Ignatova, E. B. Karabanov, V. M. Kuptsov, A. V. Kurylev, P. P. Letunova, E. V. Likoshvay, G. P. Chernyaeva, M. K. Shimaraeva, and A. O. Yakushin, A dramatic change of the ecological system of Lake Baikal in the Holocene, *Pap. Acad. Sci. USSR, 321*, 1032, Doklady Akademii Nauk USSR, 1991.

Edgington, D. N., J. Val Klump, J. A. Robbins, Y. A. Kusner, V. D. Pampura, and I. V. Sandimirov, Sedimentation rates, residence times and radionuclide inventories in Lake Baikal from ^{137}Cs and ^{210}Pb in sediment cores, *Nature, 350*, 601, 1991.

Goldyrev, G. S., Osadkoobrazovaniye i chetvertichnaya istoriya kotloviny Baikala (The sedimentation and Quaternary history of the Lake Baikal basin), 181 pp., Siberian Branch of the Soviet Academy of Sciences, Novosibirsk, 1982.

Grosswald, M. G., Late Weichselian ice sheet of Northern Eurasia, *Quat. Res., 13*, 1, 1980.

Hays, J. D., J. Imbrie, and N. J. Shackleton, Variations in the Earth's orbit—Pacemaker of the ice ages, *Science, 194*, 1121, 1976.

Hutchinson, D. R., A. J. Golmshtok, L. P. Zonenshain, T. C. Moore, C. A. Scholz, and K. D. Klitgord, Depositional and tectonic framework of the rift basins of Lake Baikal from multichannel seismic data, *Geology, 20*, 589, 1992.

Imbrie, J., J. D. Hays, D. G. Martinson, A. McIntyre, A. C. Mix, J. J. Morley, N. G. Pisias, W. L. Prell, and N. J. Shackleton, The orbital theory of Pleistocene climate—Support from a revised chronology of the marine ^{18}O record, in *Milankovitch and Climate, Part 1*, edited by A. L. Berger et al., pp. 269–305, D. Reidel Pubishing, Boston, Mass., 1984.

Kukla, G., Loess stratigraphy in central China and correlation with an extended oxygen isotope stage scale, *Quat. Sci. Rev., 6*, 191, 1987.

Lamb, H. H., *Climate: Past, Present, and Future*, vol. 1, *Fundamentals and Climate Now*, 613 pp., Methuen and Co., Ltd., London, 1972.

Maher, B. A., and R. Thompson, Paleoclimatic significance of the mineral magnetic record of the Chinese loess and paleosols, *Quat. Res., 37*, 155, 1992.

Mats, V. D., The structure and evolution of the Baikal rift depression, *Preprint 1*, 70 pp., Baikal Center for Ecological Research, 1992.

Molnar, P., and P. England, Late Cenozoic uplift of mountain ranges and global climate change: Chicken or egg?, *Nature, 346*, 29, July 5, 1990.

Ruddiman, W. F., and M. E. Raymo, Northern Hemisphere climatic regimes during the last 3 myr: Possible tectonic connections, in *The Past Three Million Years: Evolution of Climatic Variability in the North Atlantic Region*, edited by N. J. Shackleton et al., pp. 227–234, Cambridge University Press, England, 1988.

Williams, D. F., Long-term paleoclimatic records for central Asia: The Baikal Drilling Project (BDP), *Eos Trans. AGU, 70*, 1136, 1989.

NASA Reorganization Splits Earth and Planetary Sciences

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NASA Administrator Daniel S. Goldin announced a series of organizational changes at the agency on October 15. The surprise announcement, which according to Goldin was meant to bring focus to space programs and to improve management, has left the scientific community puzzled. "I was very surprised by it," said Jeff Dozier, University of California, Santa Barbara, and former EOS project scientist, adding that many of the NASA people affected by the shake up were also taken by surprise.

One of the main changes made was the splitting of the Office of Space Science and Applications into two divisions. Previously, Earth sciences, planetary science, and astrophysics fell under OSSA. The two new divisions are Mission to Planet Earth and Planetary Science and Astrophysics.

The split has received mixed reviews. One NASA observer noted that it is hard to see that it is a step forward. The two offices will now be competing directly for resources, he added, rather than being in the position of trading off. Dozier feels the split is a good idea because the division will allow each group to be more manageable, but he expressed concern that the beneficial cooperation experienced in the past might be lost.

Shelby Tilford, previously director of OSSA's Earth Sciences Division, will become Acting Associate Administrator of Mission to Planet Earth. Wes Huntress, previously director of the Solar System Exploration Division, will become Acting Associate Administrator of Planetary Science and Astrophysics.

In other changes, Lennard Fisk has been promoted to the new position of NASA chief scientist. He was previously Associate Administrator for Space Science and Applications. Marty Kress will become Space Station *Freedom*'s Deputy Program Manager for Policy and Management. Previously, he was Assistant Administrator for Legislative Affairs. Other management changes were made in NASA's Russian programs, and in the aeronautics and space technology office, which was split into two parts.

Goldin's restructuring is in part a response to the 1990 Augustine Commission report, "Report of the Advisory Committee on the Future of U.S. Space Programs." It recommended management changes and a separation of Mission to Planet Earth due to its large size and broad scope.

Several groups are planning to meet in the near future to analyze the changes. The National Research Council's Space Studies Board will meet in mid-November. Goldin has asked SSB chairman Louis J. Lanzerotti to provide insights into the changes. NASA's Space Science and Applications Advisory Committee will meet the first week in November to discuss the changes.—*Susan Bush*

Birch Remembered at Fall Union Session

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Francis Birch, geophysicist, 1960 Bowie medalist, AGU Fellow, and past-president of the Tectonophysics Section (1953–1956) passed away on January 30. AGU is honoring his contributions to geophysics with the session "Francis Birch and the Solid Earth: A Memorial Retrospective," at the AGU Fall Meeting in San Francisco.

The full-day Union session will feature both oral and poster presentations and will cover the many topics of Birch's studies of the Earth's mantle, crust, and core.

According to Henry Pollack, University of Michigan, Ann Arbor, and convener of the session, Birch had a tremendous influence on the direction of geophysics in the United States and internationally.

Starting out as a physicist at Harvard in the 1930s, Birch became interested in geology and was asked to set up the experimental geology laboratory. Most of his research was devoted to studying the ways materials respond to the high pressure found at the Earth's interior. At the laboratory, Birch studied the elastic properties of minerals, the speeds at which earthquake waves propagate, rock viscosity, and the thermal conductivity of rocks.

Birch was both an experimentalist and a theoretician, said Pollack, and is well-know for his 1952 paper, "Elasticity and Constitution of the Earth's Interior," in which he describes a transition zone from 200 to 900 km where silicates transform to denser materials. Several papers at the AGU session will address Birch's famous paper, including one by Don Anderson. This theory is still guiding research today, said Pollack.

Birch also made some pioneer discoveries about thermal properties of the Earth. Birch realized that the internal temperatures of the Earth were likely affected by climate and found a way to identify this signal and remove it. His discovery laid the groundwork for an area of research that is still being pursued today. Pollack will present a paper on Birch's thermal work.—*Susan Bush*

Comments Pour in to NSF Commission

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The National Science Board Commission on the Future of NSF held its second meeting on October 16. This meeting, and the meetings of NSF's Physics Advisory Commit-