

A qualitative assessment of the influence of bioturbation in Lake Baikal sediments

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Abstract

The impact of bioturbation in Lake Baikal sediments, particularly on rhythmic layering and mixing, was assessed by studying the actual vertical distribution of benthic animals in continuous accumulation zones selected by seismic survey (Vydrino Shoulder, Posolskoe Bank, Continent Ridge). To assess the influence of the bioturbation, animals were extracted from short cores and identified at the relevant taxonomic level. The faunal distribution is examined in parallel with the bioturbation tracks observed in thin section. Oligochaeta, Nematoda, Ostracoda, Copepoda, Gammaridae, Chironomidae and Hydrachnidia were found inhabiting the sediment. Among them, only oligochaete worms were assumed to have a significant impact on sediment mixing because of their "conveyor belt" feeding. The other two most abundantly sampled groups, nematods and copepods, belong to the interstitial fauna that has no significant impact on the vertical displacement of sediment particles and do not ingest the sediment. The presence of a benthic fauna as deep as 15 cm in the sediment indicates that the possibility of sediment disturbance by invertebrate activity cannot be dismissed in Lake Baikal. The effect of biological mixing is more limited in the deepest stations because the number of potential bioturbators is reduced, qualitatively as well as quantitatively. Located in the abyssal zone, Continent and Vydrino (but outside turbidites) deep stations appear to be most promising sediment records for tracking climate signal at high resolution.

Keywords: bioturbation ; benthos ; sediment ; Lake Baikal ; Siberia

1. Introduction

Lake Baikal (great Baikal rift of Eastern Siberia) is the oldest (25 to 30 My), deepest (1,642 km) and most voluminous (23,615 km³) of all extant lakes (Kozhov, 1963; Kozhova and Izmet'eva, 1998; De Batist et al., 2002). Its location in a still active graben trough has permitted its preservation over time despite continuous infilling by sediments. Today, the Lake Baikal depression contains a sediment record estimated to be as thick as 8 km (Logatchev, 1993). As a result, the lake provides an exceptional opportunity for studying long and continuous records of continental climate change over a variety of timescales (e.g., see Kuzmin et al., 1993, 2000; Colman et al., 1995; Grachev et al., 1998; Karabanov et al., 2000; Minoura, 2000).

Recently, the CONTINENT project (<http://continent.gfz-potsdam.de>) was launched to exploit this unique continental sedimentary archive. However, reconstructing palaeoclimate signals from biogenic proxies relies on the assumption that sediment stratigraphy is representative of primary depositional processes and has not been altered by postdepositional reworking or removal of sediments. This is particularly important for Lake Baikal whose bathymetric characteristics, sediment inflows and interflows and redeposition processes can fundamentally affect the nature of the sediment record (Hutchinson et al., 1992; Mackay et al., 1998; Nelson et al., 1999; Kuzmin et al., 2000). As a result, areas of Lake Baikal that are free of bottom water currents and turbidites (or slightly affected by) recently received particular attention as suitable locations of sampling sites (Bangs et al., 2000; Charlet et al., 2005-this issue).

Paleoclimatic studies in Lake Baikal have yet to take into account the observation that subrecent sediment is also a natural habitat for a living benthic fauna. The displacement and mixing of the sediment by activities of benthic animals or bioturbation can deeply affect the primary stratigraphical signals contained in the sediment (Gage and Tyler, 1991; Boudreau et al., 2001; Meysman et al., 2003). In addition, bioturbation has possibly altered the sedimentary record of Lake Baikal during its entire existence and cannot be ignored in sedimentary-based palaeoclimatic research. Molecular studies have shown that some of the most speciose species flocks in the lake are very ancient groups whose origins date back at least to the beginning of the lake's history (Sherbakov, 1999). Moreover, in contrast to other similar "ancient" lakes (sensu Gorthner, 1994), such as the lakes Malawi and Tanganyika in East Africa, a distinctive feature of Lake Baikal is its water circulation, which carries oxygen to the deepest point and makes the "abyssal" area (presently defined as the area below the dimictic layer, i.e., deeper than 250 m; Kozhova and Izmet'eva, 1998) of the lake habitable for metazoan organisms (Martin et al., 1998). Consequently, no bottom area is potentially free of living animals and of bioturbation which act

to break-up sediment signal like laminations, diatom frustules or pollen distribution.

In this study, we aim at a better understanding of the extent to which bioturbation in Lake Baikal alters the sedimentary record in subrecent sediments, using qualitative, biotic and sedimentological approaches. To the best of our knowledge, no such an attempt has been made so far. The ability of an organism to mix sediments depends on the type of organism involved and its size, its population density and its vertical distribution in the sediment. The first two parameters can be theoretically tackled according to a considerable volume of literature on the distribution of benthos in Lake Baikal (see Kozhov, 1963; Kozhova and Izmet'seva, 1998; Timoshkin et al., 2000) although the first description of the general benthos from depths exceeding 500 m date back to only 10 years ago (Takhteyev et al., 1993). In contrast, data on the vertical distribution of benthic animals in the sediments are scarce, and while Martin et al. (1999) gave a description of the bathymetric and vertical distribution of oligochaete worms in Lake Baikal, the study was not focussed on bioturbation.

This work, as described here, was initially conceived to help select the most appropriate study sites for the CONTINENT project in terms of minimal bioturbation. This information will help in future studies to decipher the palaeoclimatic signal recorded in the most continuous sedimentation zones (e.g., high plateaus under the mixed water layer).

2. Material and methods

Sampling was carried out during a July 2001 expedition on Lake Baikal (expedition reference: CON01-04) on board the research vessel Vereshchagin. The three sites selected in the CONTINENT project as the most suitable locations for paleoclimate studies are described in Charlet et al., 2005-this issue, and were chosen because they were not (or slightly) affected by turbidites, postdepositional reworking or removal of sediments. These were located on the elevated plateaus of Vydrino Shoulder (CON01-433, 51°34'N-104°51'E, 623 m) and Posolskoe Bank (CON01-427, 52°05'N-105°52'E, 128 m) in the Southern Basin of the lake and "Continent" (Bolschaia) Ridge (CON01-416, 53°57'N-108°55'E, 390 m) in the Northern Basin (Fig. 1). Two additional cores from Vydrino site were sampled during an exploratory expedition in March 2001 (CON01-105, 51°36'N-104°54'E, 600 m; CON01-106, 51°37'N-104°54'E, 700 m). With the exception of one station (CON01-427), all stations investigated are located in the abyssal zone of the lake.

Short cores (29.2 cm of surface area) were sampled using a 60-kg EAWAG-63 gravity corer. Nine parallel cores were taken at each of the three sites. The cores were distributed to the different working groups for further analyses. Three cores were used for the study of bioturbation. Each sample was immediately mounted on an extruder, subsequently divided into nine slices (0-1, 1-2, 2-3, 3-4, 4-5, 5-7, 7-10, 10-15, > 15 cm) and fixed in 7% buffered formalin on board the ship. Samples were washed in the laboratory through a sieve of 250- μ m mesh, preserved in 70% alcohol, and organisms were sorted out using a binocular microscope and identified to the relevant taxonomical level.

The lithology was determined on cores CON01-416-12, CON01-433-6 and CON01-427-8 using macroscopic descriptions, smear slides and the Standard Rock Colour Chart of the Japanese Geological Survey. For fine sediment texture analyses, cores were longitudinally cut in half, photographed, then treated by an improved polymerization technique; the cores were freeze dried and impregnated to obtain a continuous cover by large thin sections to extend the observation of lateral variations. Then the vertical mixing and the bioturbation tracks were estimated according to micromorphological structures. The physical properties of the sediment were characterized by the magnetic susceptibility (MS) measured on the other half of the same core using a Bartington MS2E surface sensor (2 cm in diameter). For the dating of the surface layers and mixed horizons, the short cores were correlated with the AMS C dated Kasten cores using magnetic susceptibility measurements (see Boës et al., 2005-this issue, for explanation).

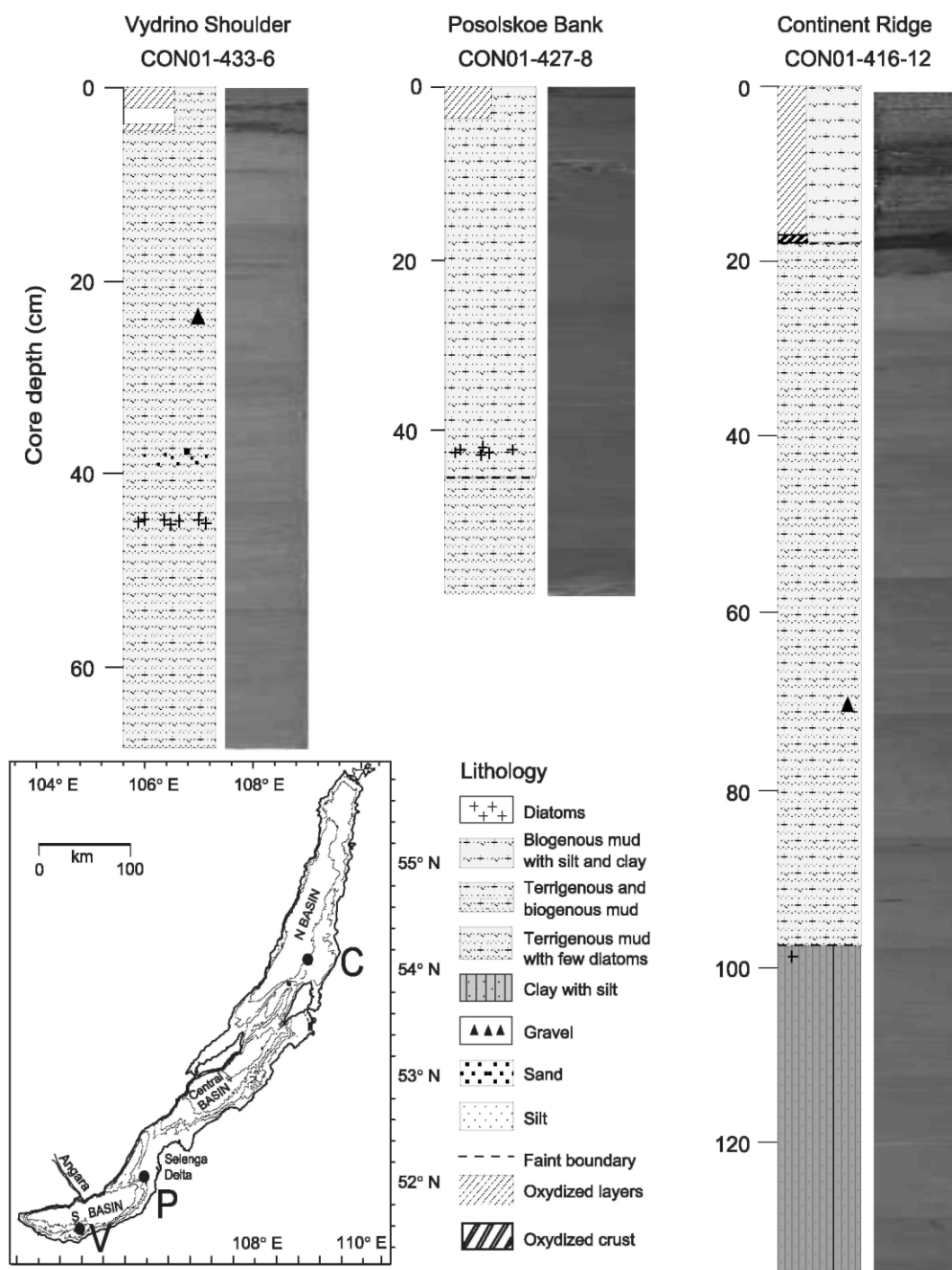
3. Results

3.1. Lithological description

Based on the sedimentation rates deduced from the upper part of the Kasten cores, the short cores from Vydrino Shoulder (COM) 1-433-6) and Posolskoe Bank both span ca. 4 kyr (62 cm at 0.10 mm year⁻¹; 57 cm at 0.13 mm year⁻¹, respectively) and the core from Continent Ridge ca. 16.5 kyr (124 cm at 0.04 mm year⁻¹; Boës et al., 2005-this issue). The uppermost sediments of the short cores from the three CONTINENT sites are characterized by an oxidized dark red to brown layer composed of dense diatom-bearing and terrigenous clayey sediments mixed with iron oxides (Fig. 1). The thickness of the oxidized layer ranges from ca. 20 cm in continent core to a few centimetres in Vydrino core. Macroscopically, the sediments are homogenous, with no distinct laminations. They are made by biogenous diatom-rich units with variable amount of detrital clay or silt particles. The detrital content is higher in the two more proximal Southern Vydrino and Posolskoe cores. No turbidites have been observed, only sparse sand grains related to ice-rafted sediment transport (e.g., see Vologina et al., 2003). The biogenous sediment is replaced by detrital silty clays in the lower part of continent core; this transition corresponding to late

Glacial/Holocene transition (Termination I).

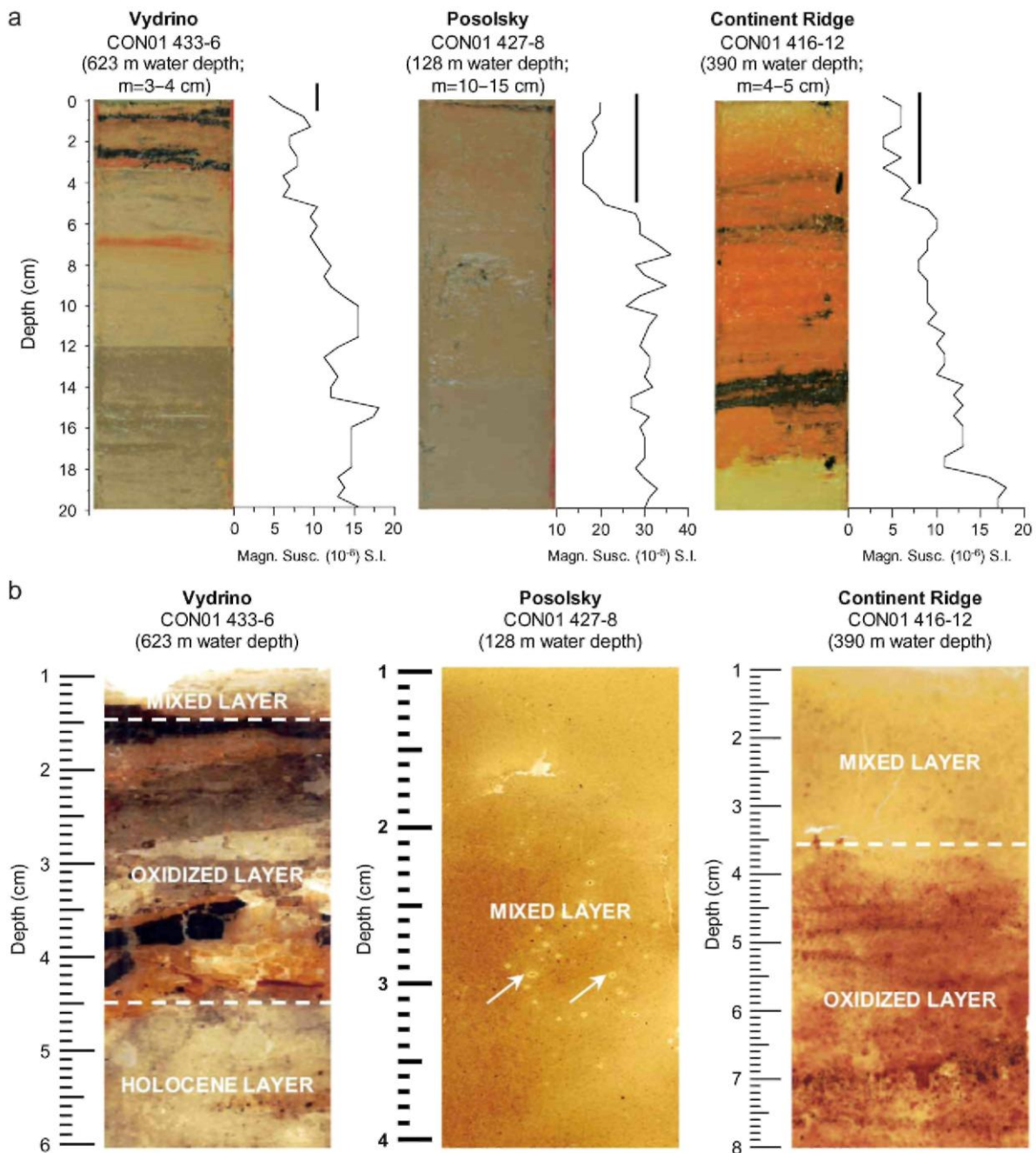
Fig. 1. Lithological description of short cores (CON-04 expedition) based on macroscopic and smear-slide observations (modified from Vologina et al., 2003; Vologina and Sturm, unpublished data). The photographs of the sediments are plotted on the right side.



In the first 20 cm of the three short cores, magnetic susceptibility (MS) values are low and tend to decrease at the top of the cores (Fig. 2a). In the Vyrino Core 433-6, MS varies from 15×10^{-6} S.I. at 20 cm (2100 cal year BP) to 5×10^{-6} S.I. in the oxidized layer (500 cal year BP to present). In the Posolskoe Core 427-8, MS is characterized by slightly higher values: 30×10^{-6} S.I. at 20 cm (1500 cal year BP) to 15×10^{-6} S.I. in the first 6 cm of sediments (500 cal year BP to present). Evolution of the MS in the Continent Core 416-12 is similar to Vyrino site with average values around 10×10^{-6} S.I. in the oxidized layer (2500 cal year BP to present) and 5×10^{-6} S.I. in the first

5 cm of the core (500 cal year BP to present). Based on thin-section qualitative observations, the low MS values are reached in the oxidized layers, and the lowest are concurrent with an upper homogenous pluricentimetric layer (Fig. 2b). We will emphasize later that this upper layer corresponds to the biological mixed layer.

Fig. 2. (a) Magnetic susceptibility measurements of the uppermost 20 cm of the short cores. The bars indicate the homogenous sediment horizon. The lowest MS at the top are concurrent to the thickness of the sediment layers mixed by the *Oligochaeta* worms (noted "m"). Only the cores 433-6 and 416-12 taken in the abyssal zone of the lake present an oxidized layer at the top. The Posolskoe core 427-8 is the only one taken in the dimictic zone. Note that the MS measurements do not take into account the semiliquid sediment water interface, (b) Enlarged images of the mixed/oxidized layers at the top of the short cores taken from thin sections. The arrows in the Posolskoe core 427-8 underline the presence of biological activity.



3.2. Biological description

The following animal groups were found inhabiting the sediments: Oligochaeta (Annelida), Nematoda, Ostracoda (Crustacea), Copepoda (Crustacea), Gammaridae (Amphipoda, Crustacea), Chironomidae (Insecta) and Hydrachnidia (water mites). Their respective effect on sediment mixing can be very different, according to their known biology (see Discussion below). As a rule, whatever the group, the abundance of organisms is low when present, and their size is very small as compared to populations known from shallow waters. In all abyssal stations, densities are never over an average of c. 3100 individuals m^{-2} (Fig. 3, Table 1). In contrast, the shallow station (CON01-427, Posolskoe Bank) harbours the highest observed densities (oligochaetes reach densities as high as 13573 individuals m^{-2} on average). Gammarids are present in this latter station at 128 m deep, while they are absent from all deep stations. The presence of some groups is anecdotal, such as Hydrachnidia (one specimen in a core at 388 m and two specimens in a core at 625 m) and chironomid larvae (two larvae in a core at 625 m). Interestingly, the two deepest Vydrino cores (CON01-105-7, 600 m, and CON01-106-3, 700 m) are virtually free from animals, suggesting that these stations are perhaps the best choice for the study of stratigraphy and climate proxies.

The vertical distribution of organisms in the sediment indicates that animals can be present as deep as 15 cm although at very low abundance at such depths (Figs. 4-6). Oligochaetes and nematods are the only groups able to deeply penetrate into the sediment at significant densities (Fig. 4) in contrast to all other groups, which stay closer to the sediment surface. Maximal densities however seem to shift to the sediment surface with increasing bathymetric depth, as suggested in Figs. 5 and 6, so that all animal groups are more concentrated near the surface in the deepest parts of Lake Baikal. In such case, the depth of sediment mixing due to bioturbation appears to decrease with increasing bathymetric depth (Fig. 2b).

As a point of relevance for deep-water renewal and sedimentation rates, which in turn have an impact on the extent of bioturbation, it is interesting to note the unusual presence of a few oligochaete Naididae in the upper slice of sediment of station CON01-433 at 623 m deep (as high as eight individuals per core), together with two chironomid larvae (see Discussion).

Fig. 3. Densities of benthic taxa with depth (CON 01-01 and CON 01-04 expeditions).

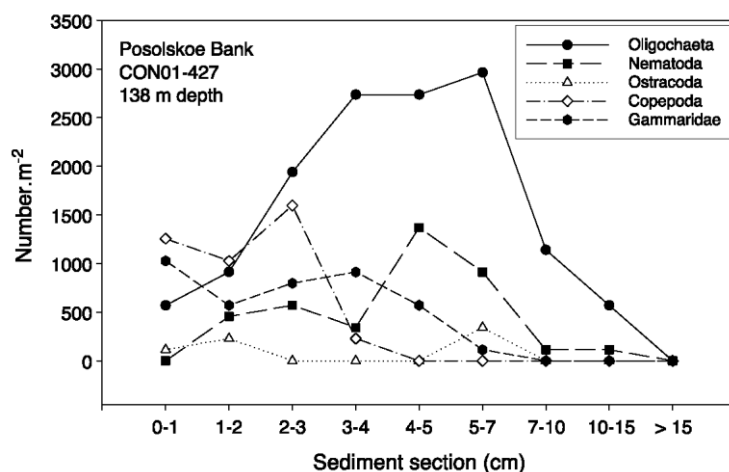


Table 1 Densities of the different animal groups sampled (number of individuals per m^{-2}), according to bathymetric depth

	CON01-427 Posolskoe (128 m)	CON01-416 Continent (390 m)	CON01-105 Vydrino (600 m)	CON01-433 Vydrino (623 m)	CON01-106 Vydrino (700 m)
Chironomidae	0	0	0	228	0
Copepoda	4106	1369	684	2509	342
Gammaridae	3992	0	0	0	0
Hydrachnidia	0	114	0	228	0
Nematoda	3878	2053	0	3308	0
Oligochaeta	13573	3080	1027	2509	0
Ostracoda	684	684	0	570	342

Fig. 4. Vertical distribution in the sediment of the different animal groups found in station CON01-427 (Posolskoe Bank) in the dimictic zone of Lake Baikal, expressed as the number of individuals per m^2 .

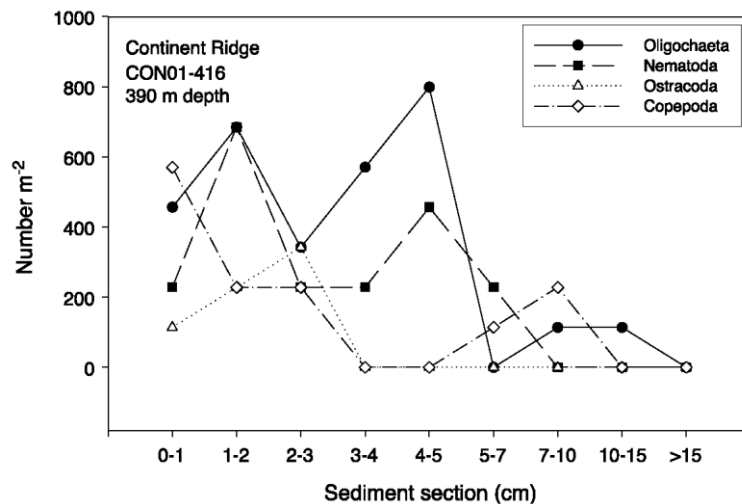


Fig. 5. Vertical distribution in the sediment of the different animal groups found in station CON01-416 (Continent Ridge) in the abyssal zone of Lake Baikal, expressed as the number of individuals per m^2 .

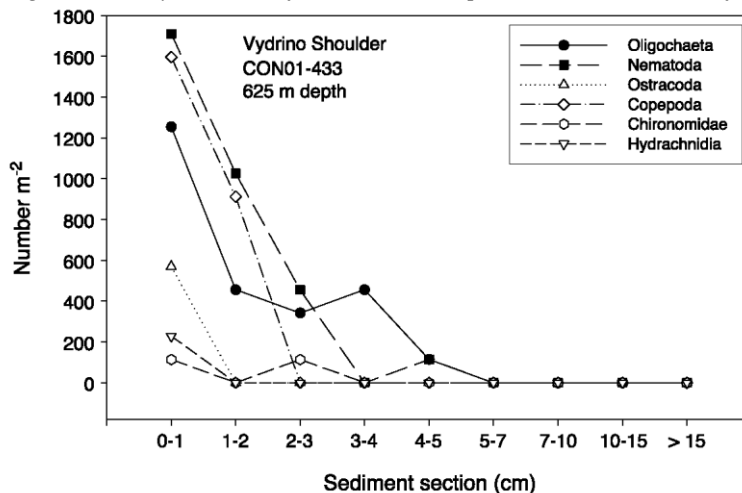
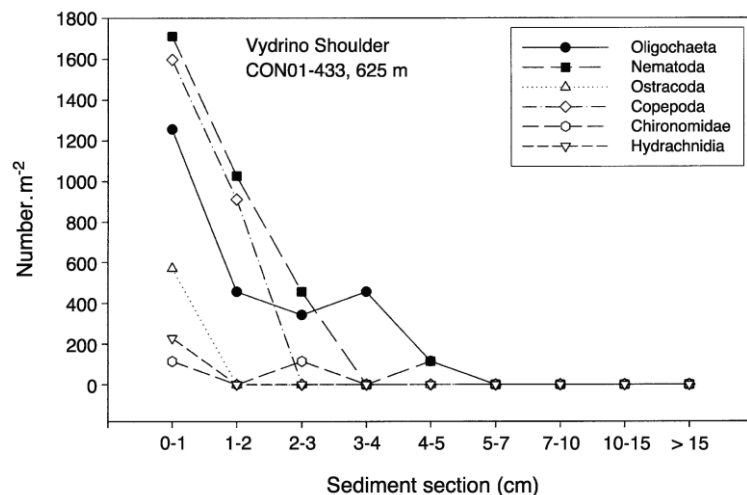


Fig. 6. Vertical distribution in the sediment of the different animal groups found in station CON01-433 (Vydrino Shoulder) in the abyssal zone of Lake Baikal, expressed as the number of individuals per m^2 .



4. Discussion

Bioturbation, namely, the sediment mixing by benthic animals, affects the sediment profile in different ways: production of trace fossils from biogenic structures, geochemical alteration of the sediment, filtering or smearing primary stratigraphic signals and influencing sediment stability (Gage and Tyler, 1991). Only the stratigraphic importance of bioturbation will be considered and discussed here. The ability of an organism to mix sediments depends on different parameters, including the type of organism involved and its size, population density and vertical distribution in the sediment (Soster et al., 1992).

4.1. Benthic animals and bioturbation

Among the different animal groups found in the sediments of Lake Baikal, only oligochaetes are assumed to have a significant impact on sediment mixing due to their feeding habit. With the exception of gammarids restricted to one shallow station and chironomids, the presence of which is anecdotal, all other groups can be considered as an interstitial fauna, namely, animals that occupy the interstices between the sediment particles without significant displacement of them.

Except for oligochaetes, nematods and copepods, the other two most abundantly sampled groups do not ingest the sediment (Hicks, 1983; Heip et al., 1985). Copepods can be burrowers, and morphological traits associated to specimens found in our samples suggest that they fall in this category. However, their very small sizes (less than 700 μm long without the furca and less than 140 μm wide), together with their feeding habit, suggest that their impact on sediment mixing is probably negligible.

Gammarids are mostly epibenthic animals (Barnard and Barnard, 1983), often of a great size, especially in Lake Baikal (Kozhov, 1963; Kozhova and Izmet'eva, 1998; the greatest individual in our samples being c. 1 cm long), and can occasionally burrow into the sediment. Such behaviour, while resulting in more permanent biogenic structure, is assumed to have a limited sediment mixing effect (Gage and Tyler, 1991). In the present study, benthic gammarids are restricted to only one shallow station. They can be present at all depths, however, but only at very low densities and biomasses in the abyssal (Takhteyev et al., 1993; Timoshkin et al., 2000; Martin et al., unpublished data). Amphipods are sensitive to oxygen shortage (Chapelle and Peck, 1999) and, as a rule, when found in the sediment, are mostly restricted to the oxidized layers (Takhteyev et al., 1993; Martin et al., unpublished data). This combination of biological features suggests that bioturbation by gammarids in "abyssal" sediment is probably limited.

In contrast to the benthic groups briefly reviewed above, oligochaetes are well known to have a significant influence on stratigraphy because of their "conveyor belt" feeding (Milbrink, 1973; Davis, 1974a,b; Soster et al., 1992; Pelegri and Blackburn, 1995). Many oligochaetes feed with their heads downward in the sediment and their posterior ends upward in the water. They ingest sediment particles, which pass vertically upward through the gut, and sediment is discharged above the water sediment interface as faecal pellets. Conveyor belt species thus cause a continuous vertical movement of particles in the surface layers of sediment. The presence of oligochaetes in all CONTINENT stations except one (station CON01-106-3) suggest that all sampled cores are potentially influenced by bioturbations, the extent of which depends on their vertical and bathymetric distribution.

4.2. Vertical and bathymetric distribution of oligochaetes and bioturbation

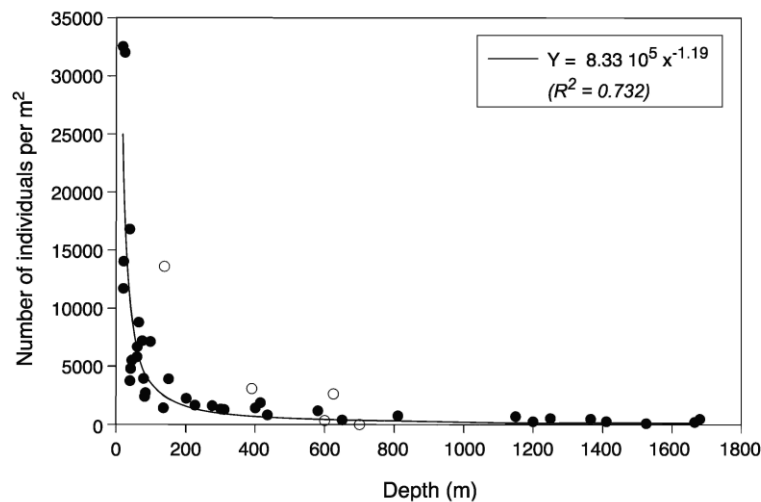
A recent study has shown that the bathymetric abundance of oligochaetes follows an exponential decline with depth, according to a power-decay equation (Martin et al., 1994, 1999). For each doubling of depth, densities roughly decrease by a factor of 2. Our data do not contradict such a relationship (Fig. 7). Similarly, the vertical distribution of oligochaetes follows the pattern suggested by Martin et al. (1999), namely, oligochaetes of the abyssal zone of Lake Baikal are concentrated near the sediment surface.

Assuming a relationship between oligochaete densities and the extent of bioturbation, this would suggest that the deepest stations of CONTINENT campaigns are better suited for the study of climate proxies. In such stations, animals are not only less numerous and, hence, have a reduced mixing impact, but they also do not affect the sediment deeply. An important objection to this assumption is that, as food abundance is a limiting factor of oligochaete distribution (Martin et al., 1999), animal densities could be adjusted to fit food availability, which in turn depends on falling of particles and, hence, on sedimentation rates. If historical layers display a more condensed pattern due to low sediment accumulation rates, bioturbation "concentrated" at the sediment surface can have a no less important impact than in stations characterized by high sedimentation rates and harbouring animals at higher densities, which penetrate deeper in the sediment.

The examination of sedimentation rates deduced for short cores taken in parallel at each of the three sites enables us to rule out or to strongly minimize this possibility. Although stations CON01-433 and CON01-427 are located as far apart as 623 and 128 m depth, respectively, they have very similar sedimentation rates (0.10 and 0.13 mm year^{-1}). Interestingly, in Posolskoe Bank, oligochaetes have densities not only 5.4 times higher than in Vydrino

Shoulder (Table 1, Fig. 3), they can also penetrate the sediment as deep as 15 cm (Fig. 4) in contrast to Vydrino where they are restricted to the first 4-5 cm (Fig. 6). In Continent Ridge, densities and the vertical distribution of oligochaetes in the sediment are intermediate as compared to the other two stations, while sedimentation rates are the lowest ($0.04 \text{ mm year}^{-1}$). The concentration of organisms near the sediment surface with increasing bathymetric depth can be explained by the fact that, during its slow descent from the surface waters to the benthos, organic matter is progressively used by mid-water organisms and degraded by autolysis and bacterial decay (Martin et al., 1999). As a result, there is no linear relationship between sedimentation rates and food availability.

Fig. 7. Bathymetric distribution of density of *Oligochaeta* (from Martin et al., 1999; solid line—power decay curve fit of 1999 data). Data from the CONTINENT project are illustrated as white circles. Sample stations from Martin et al. (1999) were located in the Southern and Central basins of Lake Baikal, including Academician Ridge.



4.3. Potential importance of bioturbation in subrecent sediments of Lake Baikal

It has been recognized that stratigraphy in lake sediments is well marked at all levels and allows remarkable fine scale interpretations to be made despite the numbers of animals moving up and down the substrate (Stockner and Benson, 1967; Stockner and Lund, 1970; Davis, 1974a). "Bioturbation does not destroy the stratigraphy, it merely blurs it" (Stockner and Lund, 1970). There is no reason to believe that this observation cannot be applied to sediments of Lake Baikal despite the objections raised above. This is especially true for the "abyssal" zone where the number of potential bioturbators is reduced qualitatively and quantitatively.

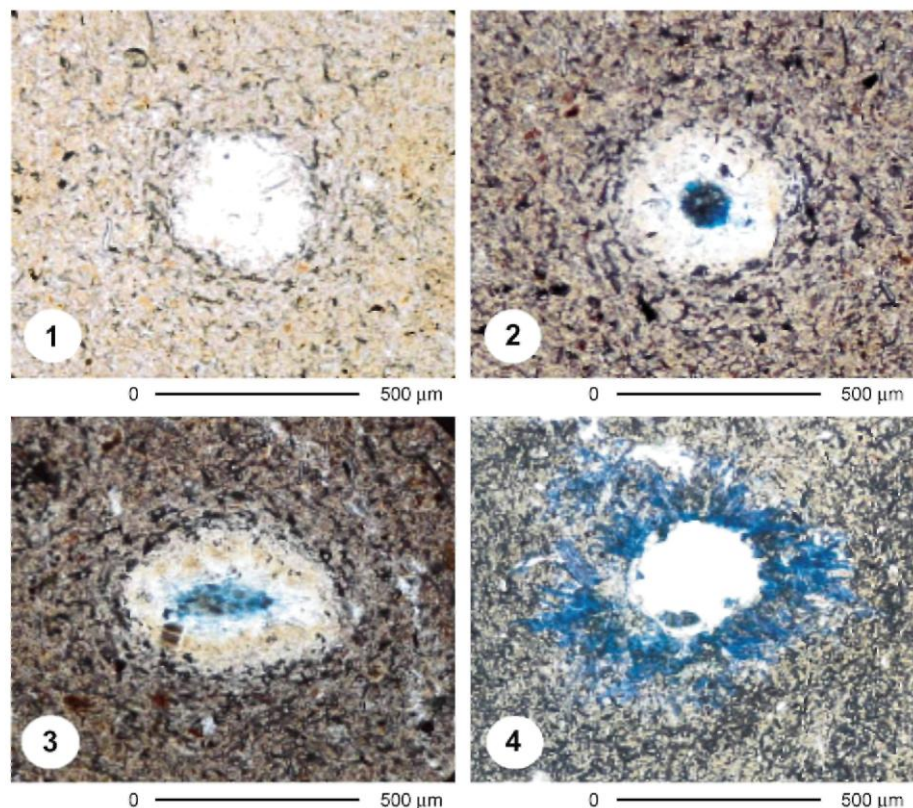
A comparison between biological data and sedimentological features gives interesting clues about the relevance of this observation in Lake Baikal. In the three stations considered, stratification features clearly appear below a homogeneous upper layer of a few centimetres (Fig. 2b). Taking into account that the first centimetres of semiliquid sediment are absent, it is noteworthy that the thickness of this homogeneous layer roughly fits the maximal penetration depth of oligochaetes, suggesting that the sediment is bioturbated everywhere these animals are present:

- (a) In Continent Ridge, oligochaetes penetrate as deep as 4-5 cm in the sediment (Fig. 5), in good accordance with the beginning of stratification features from the 3-4 cm layer onwards.
- (b) In Vydrino Shoulder, the oxidized part of the sediments is characterized by layering noticeable on the thin sections below 1 cm of homogenous sediment. Although present as deep as 3-4 cm in the sediment, oligochaetes are mostly concentrated in the first centimetre (Fig. 6).
- (c) Lastly, in Posolskoe Bank, oligochaetes are abundantly found as deep as 10-15 cm (Fig. 4), which fits the thickness of the homogeneous upper layer (6 cm; upper semiliquid sediment absent in Fig. 2b).

Based on sedimentation rates, the mixed sediment layers by bioturbation span approximately 300-500 years in each cores. On the thin sections, the mixed layers are characterized by light homogenous sediments without laminations (Fig. 2b). For instance, in Posolskoe core, the mixed layer is thick and shows numerous voids. Under the microscope, the voids are similar in size ($500 \mu\text{m}$ in diameter) but present different stages of evolution characterized by either external or internal coatings. All the coatings are made by hydrated iron phosphate crystals (vivianite; Fig. 8). Moreover, the more marked levels by vivianite neoformation represent the lowest MS values.

Those lowest MS could be related to infilling of chambers and channels by vivianite in the more bioturbated intervals. Note in the older part of the cores that other mineral phases linked to bioturbation (burrow) are rather concurrent with a sulfide oxidation activity.

Fig. 8. Thin-section micromorphological images of channels composed by crystalline material of biological origin in the Posolskoe core 427-8. The pictures indicate four stages of the vivianite phase (1 to 4), the form and fabric of the crystal resulting from biological activity: (1) channel without crystalline phase in diatom-rich sediments (1.5 cm depth), (2 and 3) channel with internal vivianite coating (5 cm depth), (4) channel with external vivianite coating (5 cm depth).



4.4. Disturbance by factors other than benthic invertebrates

Epibenthic animals, namely, animals living at the surface of the seabed or lake floor, can disturb the surface of the sediment by their activities linked to food search, locomotion or rest. In Lake Baikal, amphipods, giant turbellarian worms, (Timoshkin, 1994) and cottoid fishes are potential candidates capable of disturbing the sediment surface.

Recent underwater video recordings demonstrated the presence of superficial traces of amphipods and cottoid fishes in the abyssal (Timoshkin et al., 2000), but a quantitative estimate of the sediment surface disturbed by this activity is still missing. Seafloor photographs have shown that roughly 7% of the sediment surface on the continental slope is disturbed by traces and about half this value in the abyss (Gage and Tyler, 1991). In the absence of quantitative data in Lake Baikal, a first approximation suggests that the disturbing action of Baikalian epibenthic animals on the sediment surface is similar to maybe even or less than what is observed in the marine realm.

Lastly, the presence of a few oligochaetes of the family Naididae and some chironomid larvae in one deep station (CON01-433) is an indication of possible disturbance due to deep-water renewal. As a rule, Naididae mainly feed on algae and higher plants, the biomass of which is not significant below the first 100 m in Lake Baikal (Martin et al., 1999). Chironomids are particular in that only the immature stages are aquatic, while the adult reproductive stage is terrestrial (Proviz et al., 1994); therefore, young larval stages, resulting from egg laying at the water surface are not expected to occur at very high depths. On 19 stations sampled in the abyssal zone of Lake Baikal, Takh-teyev et al. (1993) reported only one unusual occurrence of chironomid larvae at 1670 m depth, in accordance with our own observations (Goddeeris et al., unpublished data). This suggests that these animals were transported by a sudden and rapid sinking of water masses. That these water masses could have "washed" the

sediment surface is a possibility that has to be taken into account in interpreting data from cores taken at this station.

5. Conclusion

The presence of benthic fauna as deep as 15 cm, as well as fossils tracks in deepest sediment, indicates that sediment disturbance due to activities of invertebrates cannot be dismissed in Lake Baikal. In the deepest investigated zones of the lake, low densities of benthic animals, as well as their concentration close to the sediment surface, suggest reduced sediment mixing. Abyssal plains would be the best place for the study of climatic proxies, but these regions are highly prone turbidites which limit the climate reconstruction at high resolution. In contrast, underwater highs seem to be the best compromise since they are virtually free of turbidites or bottom water currents, and bioturbation is still moderate below the dimictic zone of the lake. Among the CONTINENT cores selected by seismic survey on local continuous accumulation zones, Posolskoe station is more affected by bioturbation due to its location in the dimictic zone. The Continent and Vydrino stations appear to be the most promising for climate signal reconstruction as they are still in the abyssal zone, and the number of potential bioturbators is reduced, qualitatively as well as quantitatively.

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