Measurements of benthic gradients in deep lakes with ion-selective electrodes and video endoscopy

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Introduction

Several profiling benthic landers have been developed so far for oceanographic applications (Reimers, 1987). These instruments use oxygen and pH microelectrodes to analyze chemical gradients at the sediment-water interface with a resolution around 100 μm. Here we report the first results of our effort to construct a high-resolution profiler for studies of early diagenesis in lake sediments.

Concept and Methods

The profiling lander consists of a tripod with several pressure cases which are housing the power supply the electronics for electrochemical measurements and data acquisition, and the video-endoscope. Positioning of the sensors and the optics is done with a stepping motor which has a mechanical resolution of 50 μm. The instrument is designed for water depths down to 400 m which is sufficient for all deep lakes in central Europe. The profiler is linked to a ship via a RS-232 interface with two modems and a video cable. The position and the signals of the sensors can be monitored on-line. In addition to conventional oxygen and pH microelectrodes the instrument is equipped with different ion-selective electrodes. Selectivity and sensitivity of Ca^{2+}, NH_4^+, NO_3^-, NO_2^- and CO_3^{2-} electrodes allow measurements at the sediment-water interface of lakes. We have optimized the design of these liquid-membrane sensors. Disposable plastic pipette tips are used as electrode body. The diameter of the sensor tip is 0.4 mm. Ion selective ligands available from Fluka are used to produce the liquid membrane of the mini-electrodes. The detection limits are 0.1 μM for CO_3^{2-}, 1 μM for Ca^{2+}, and 10 μM for NO_3^-, NO_2^- and NH_4^+. The sensors show excellent nernstian response. The different electrochemical sensors produce pA and mV signals which are converted on a custom signal conditioning module, before they are sent to a datalogger (Campbell Scientific).

Previous studies (Gundersen and Jorgensen, 1990) have shown that it is important to determine the position of microelectrodes with respect to the sediment surface in order to perform reliable flux calculations. Our instrument is equipped with a pressure tight endoscope optics (Treier-Endoskopie) with a length of 25 cm and a diameter of 2 cm. It has an aperture of 65 and allows the monitoring of sensors at distances from 1 to 50 cm. A Sony CCD camera yields black and white images with 570 lines resolution. The video image is monitored and recorded on-line on shipboard. Optical fibre brings the light to the required position without disturbing the hydrodynamics in the vicinity of the electrochemical sensors. The system is able to detect the position of a sensor with respect to the sediment at a resolution of 0.1–0.2 mm.

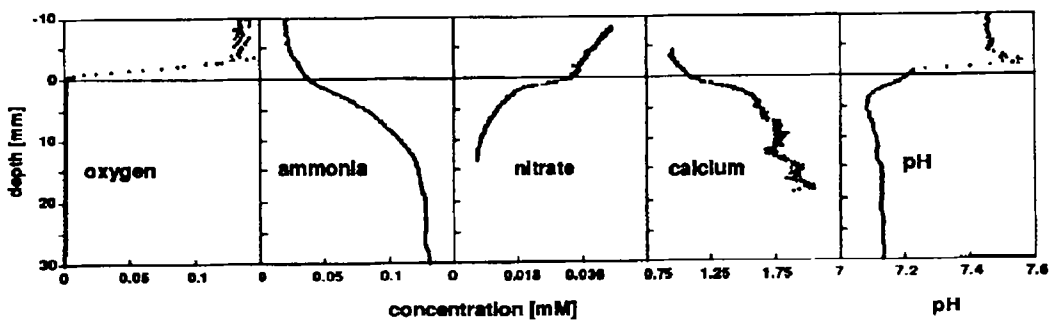

FIG. 1.

Results

The performance of the ion-selective sensors and the video endoscope has been tested extensively in the laboratory on sediment cores from Lake Lucerne. The figures show typical profiles of oxygen, pH, NO_3^-, NH_4^+ and Ca^{2+}. Measured concentrations within the sediment correspond well with data obtained by ion chromatography on filtered pore-waters. First *in-situ* measurements with the profiler in Lake Lucerne are scheduled for summer 1994.

References

C. Reimers (1987) *Deep-Sea Research*, **34**, 2019–35.
J.K. Gundersen, B.B. Jorgensen (1990) *Nature*, **345**, 605–7.