

Evaluation of the X-ray Microprobe for Analysis of Sediment Cores

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INTRODUCTION

Marine, lacustrine and estuarine cores can provide a wealth of information about natural and human-driven processes. Furthermore, because these cores usually contain a long and continuous record of these processes, they often prove more useful than discontinuous terrestrial deposits. However, in most cases geochemical analyses of the cores have been limited to discrete samples which are removed from the core at a specified sampling interval. The disadvantage of this approach is that it is often difficult to use the discrete analyses to reconstruct the time evolution of changes in geochemical properties. Also, the analyses are usually limited to a relatively small number of elements. We are developing a method for obtaining elemental geochemical analyses directly from continuous sections of core. This approach allows us to achieve high spatial resolution, which can be translated into high temporal resolution. Furthermore, by using monochromatic polarized x-rays, we can extend the analyses to a much wider range of elements. Finally, by developing the appropriate software, we should be able to obtain the analysis in real time which would allow us to go back and examine any important features at higher resolution and at greater compositional sensitivity.

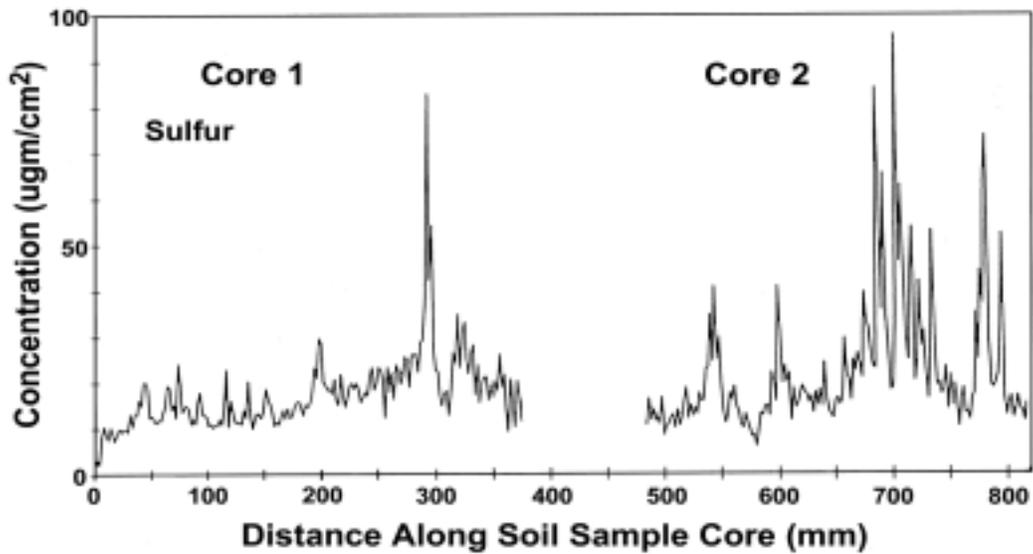
EXPERIMENT

Last summer, we analyzed a composite sample made up of segments from cores collected from two saltwater ponds associated with San Francisco Bay, near Mare Island. The Mare Island site is heavily contaminated with transition and heavy metals from decades of shipbuilding and maintenance. The sediment was contained in a "u-channel" which is a three-sided, plastic channel with a square cross-section, 2.5 cm on a side, and a length of 1 meter. The fourth, open-side of the u-channel was covered with a thin (1/8 mil) Mylar covering in order to keep the moisture content high enough to avoid the formation of a powdery surface and the loss of depth resolution.

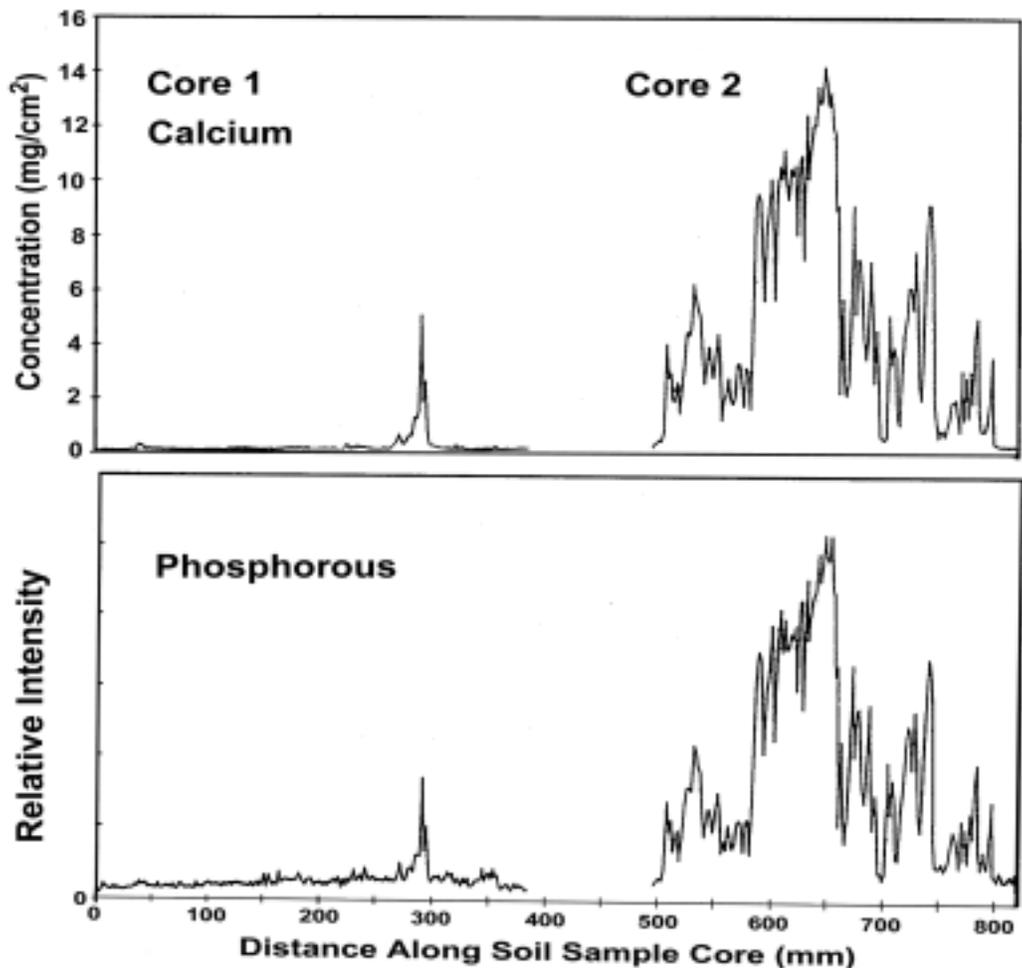
The u-channel was placed in a traveling stage that allowed us to move the u-channel in steps as small as 0.1 mm across the 5 micron x-ray beam spot. The analyses were calibrated using thin film standards, but additional work needs to be done to make corrections for thicker samples. The x-ray data were reduced using a Sun workstation.

RESULTS

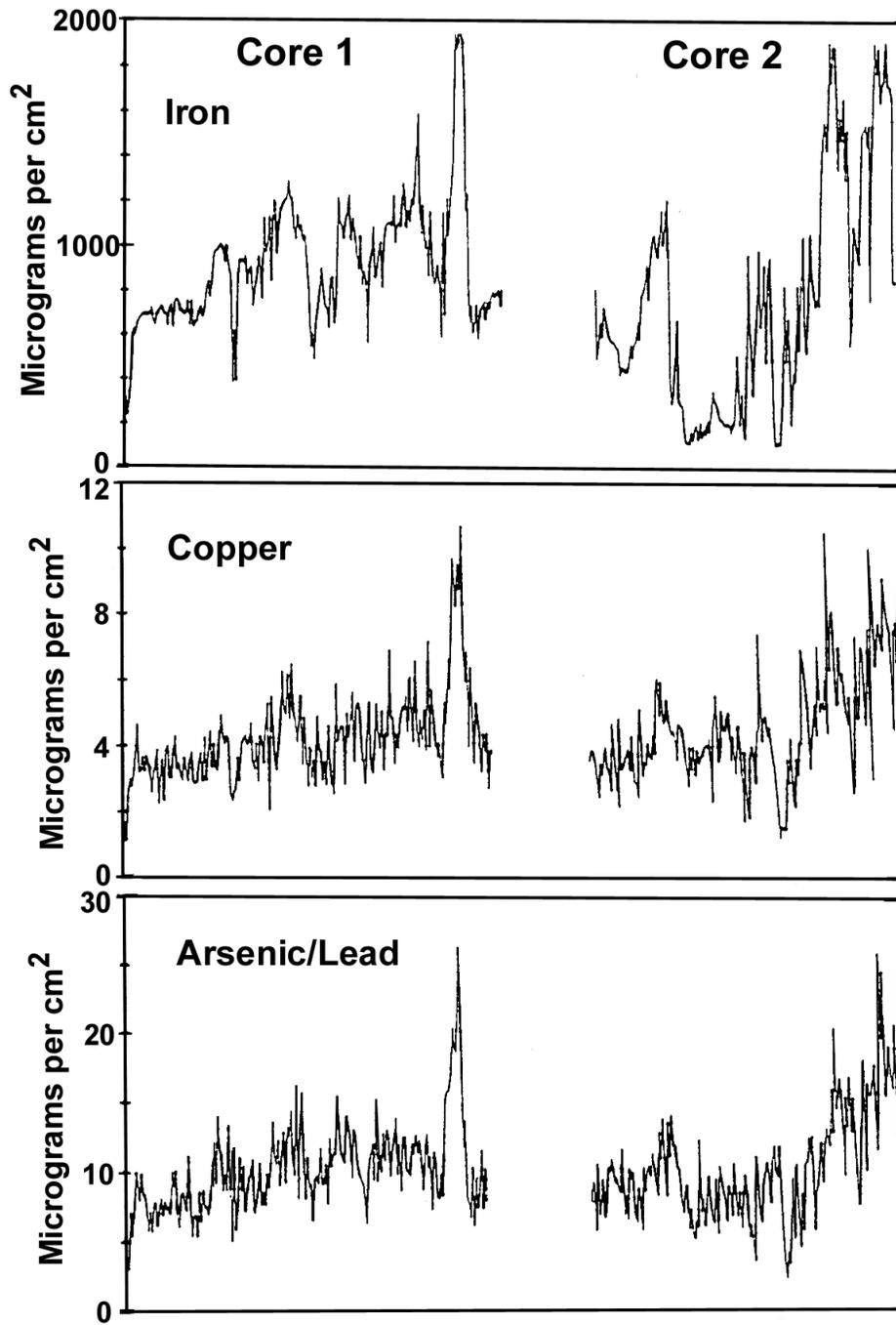
The first example is a scan of sulfur from the two ponds. The surface of each core is on the left in both cases. Both cores show considerable variation in sulfur concentration. Of particular interest are the peak at 290 mm in Core 1 and the peaks between 680 mm and 710 mm and between 760 mm and 800 mm in Core 2. In each case the changes in concentration appear to occur over very short depth intervals making these peaks prime candidates for higher resolution studies using the ALS x-ray microprobe.



A second example is the analysis of calcium and phosphorous. Again, we see large changes in concentration over short depth intervals, especially in Core 2, but what is of particular interest is that the variations of these two elements are very closely correlated. This correlation implies co-precipitation of these two elements in this pond and suggests that the conditions in the pond were often favorable to formation of the calcium phosphate mineral known as apatite.



Our third example is the analysis of iron, copper and arsenic/lead. Since iron is a major element and copper and arsenic/lead are trace elements, we would not necessarily expect these elements to be closely correlated which is what we see for the most part. However, the consistent peak in all three elements at the bottom of Core 1 suggests that this level represents a thin layer of heavy metal contamination that would need to be remediated as part of any clean-up effort.



CONCLUSIONS

These results clearly demonstrate that it is possible to use a u-channel of sediment mounted on a traveling stage to obtain non-destructive elemental geochemical analyses from continuous core segments with high spatial resolution to sub-PPM concentrations. In the near future we intend to extend this approach to cores representing a variety of depositional environments and sediment types from both lakes and oceans.

We also plan to develop an on-line data reduction capability so that we can obtain our analyses while the measurements are in progress. This will enable us to obtain results from standards and samples during the run so that we can identify interesting regions and study them at higher resolution.

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