THE ROLE OF BIOTURBATION AND RAPID SEDIMENTATION IN SHEAR STRENGTH DEVELOPMENT: COMPARISON BETWEEN THE EEL RIVER MARGIN (CALIFORNIA) AND SAGUENAY FJORD (QUEBEC) SEDIMENTS

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ABSTRACT

This presentation focuses on comparing two sedimentary environments where rapid sedimentation has taken place. For the Saguenay Fjord, we present the results of investigations carried out on the 1996 catastrophic flood layer (10 to 50 cm thick). It illustrates the differences in the signature in sediments insisting mostly on the shear strength development and the role of bioturbation. Comparison of field and laboratory data are shown from the point of view of geotechnical properties and microstructure. The main observation of this work underlines the significant impact that bioturbation plays on the shear strength, and also that some of the effects can be felt down to a critical depth of about 2 to 3 metres. In support of these observations we propose a conceptual Bioturbation Model illustrating both the resulting densification and increased strength. Also of interest is the potential use of the contrast between bioturbated and non-bioturbated sequences to identify turbidite layers in a given sedimentary environment.

EEL RIVER MARGIN, California, USA

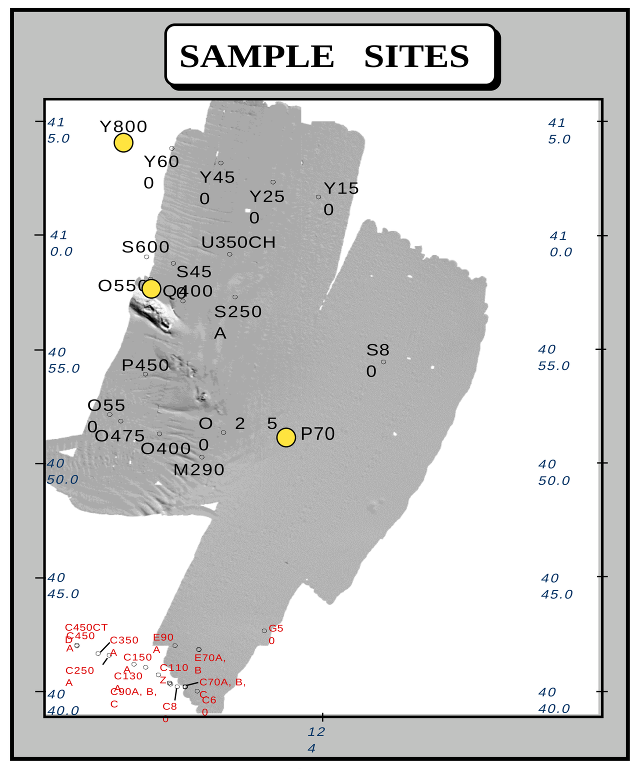
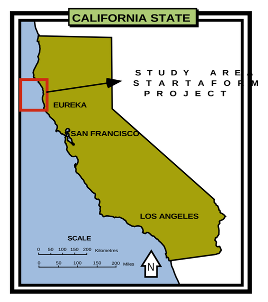


Figure 1



Eureka

The Eel River Basin (Figure 1) is located in Northern California and is part of an active collision margin with a coastal mountain range, narrow continental shelf (~20 km), and significant input of muddy fluvial sediment. Sediment is delivered to the Eel River Basin by a number of rivers (primarily the Eel and Klamath), with a combined input on the order of 10^7-10^8 tons/yr. Between storms, the deposits are mixed by benthic organisms. The resulting shelf strata are interlayered sands and mud modified by bioturbation that have formed a high-stand system tract 10 m thick.

Geotechnical profiles from cores taken at various depth are shown in Figure 2a, 2b and 2c. Figure 2a is a composite profile including data results from Box, Lehigh and Piston corers. Figure 2c is from a box core taken at a depth of only 70 mbsl. In order to evaluate the effect of bioturbation, a series of SEDimentation CONsolidation tests (SEDCON tests) were carried out on sediments from Eel River Margin (see Figure 3, 4 and 10). The SEDCON results are assumed to represent a normaly consolidated sediment which has experienced no bioturbation nor cementation.

In Figure 2, an arbitrary depth of bioturbation has been given (about 20 cm). Although the bioturbation is active only at a limited depth, its effect appears to be felt down to a depth of about 2-5 metres in the sediment column. The effect of this process results in a higher consolidation gradient in the upper surface of the sediment (Figure 3,4). Bioturbation acts by changing both the aggregation of the sediment (thus the grain size) and the water content (see Figure 5). The main role is to increase the resistance of the sediment to an increase in effective stress related to deeper burrial. However, at some point, this added resistance will be overcome. The equivalent depth at which this should occur appears to be at about at a depth providing an effective stress between 30 and 50 kPa. Deeper borehole in these sediments are required to provide a better control on this transition depth. The detailed effect of bioturbation on a strength profile will be illustrated by using Saguenay Fjord data (Figure 6).

SAGUENAY FJORD, Québec, Canada

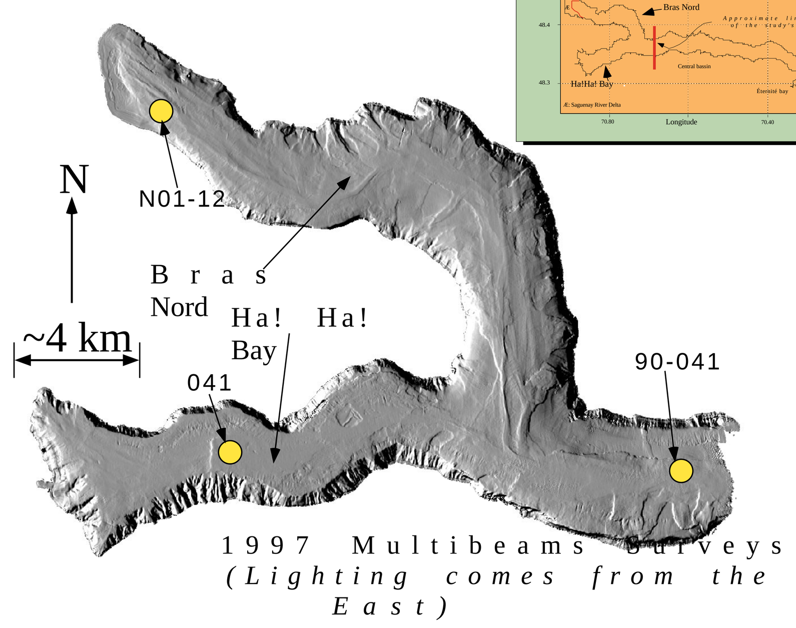
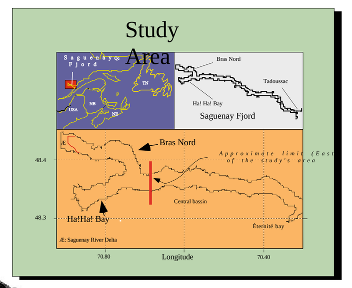


Figure 6



Saguenay Fjord

The Saguenay Fjord area (Figure 6) is located in the glacialy eroded Canadian Shield. We are looking here at the upper part which comprises two sectors: the Bras Nord and the Baie des Ha! Ha!. The water depth range from 0 to 180 metres with most of the area seen in Figure 6, at a depth of about 130 metres. A major flood occured in this area in July of 1996. This resulted in the deposition of a 20 to 50 cm thick layer of clayey silt for a total sediment input (in the Baie des Ha! Ha! alone) of about 6 millions cubic metres of sediments.

This flood layer provides a unique opportunity to observe the development of bioturbation. In Figure 7 we can see a striking example of a rapidly deposited layer showing a very high liquidity index which defines well the flood layer. In Figure 8, we can see that the flood layer, in that part of the fjord, after 2 years, has already been bioturbated with a resulting appearent inverse gradient profile: the water content increases with depth. In fact, this reveals that the bioturbation has modified the upper part, and is working its way down towards the remaining part which is at a fairly high liquidity index. The liquidity index is a good way or recognizing the presence of a rapidly deposited layer (along with the shear strength). As an example, we show the geotechnical profile observed in a deeper portion of the basin (Figure 9). At this site we mapped a 5 metre thick turbidite deposit (largely non-bioturbated) which has been bioturbated only on its upper surface and which lies directly on a bioturbated section (visible by a higher variability in the intact shear strength). When all data are compiled together (Figure 10) we can see that the turbidite layer tends to get much closer to the SEDCON curves while bioturbated ones are at a much lower liquidity index for the same vertical effective stress. A simple Bioturbation Model is shown in figure 11 to make this point clearer: bioturbation increases the density with a resulting increase in strength.

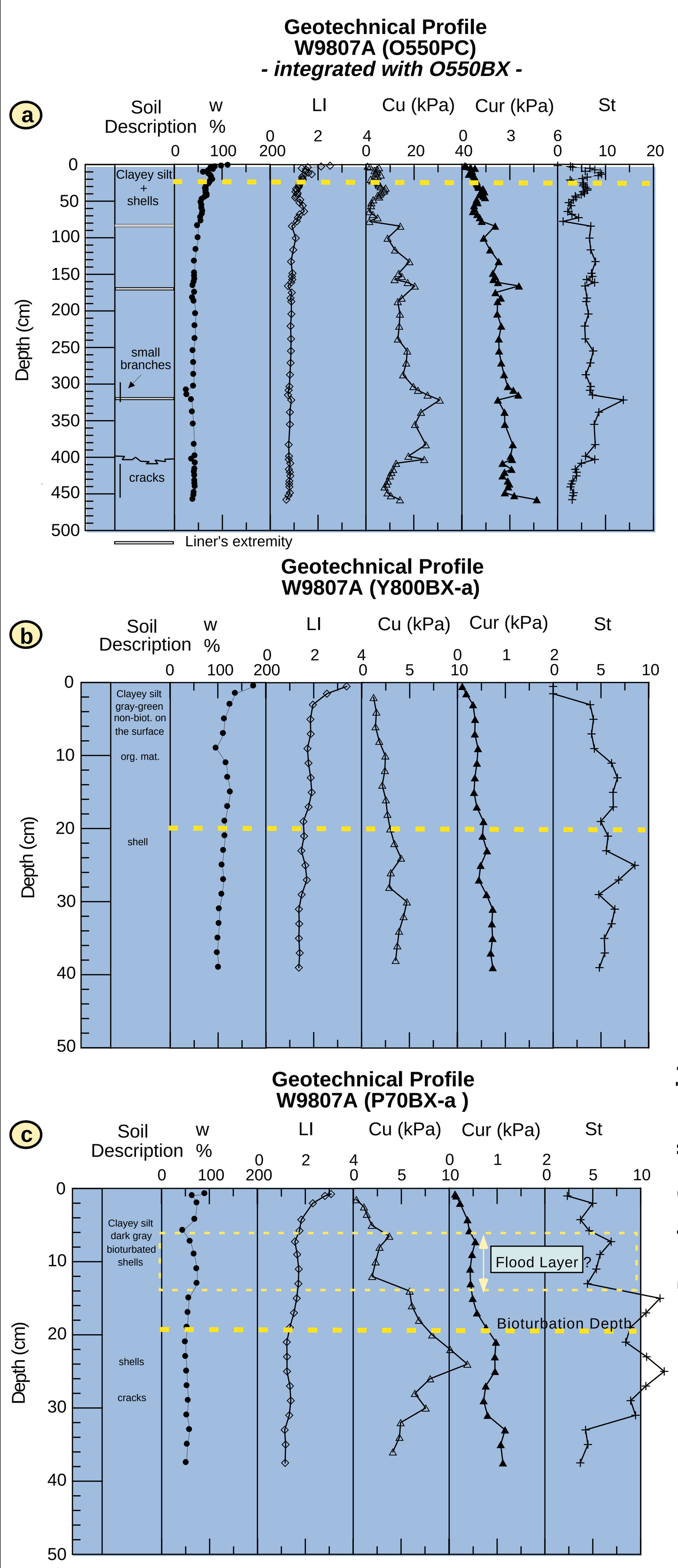


Figure 2

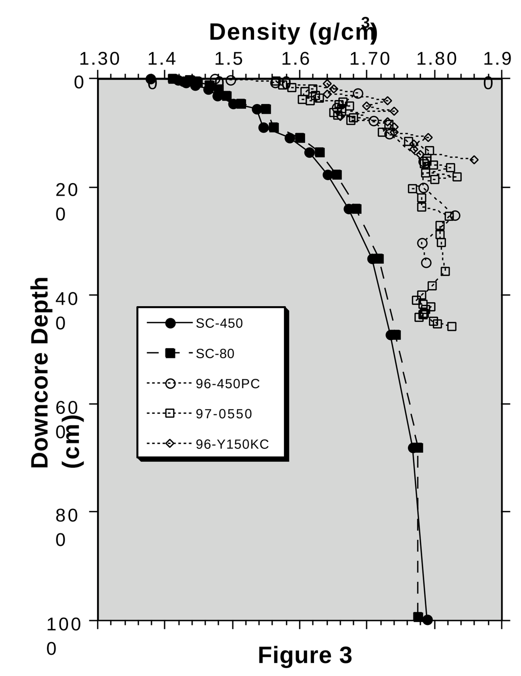


Figure 3

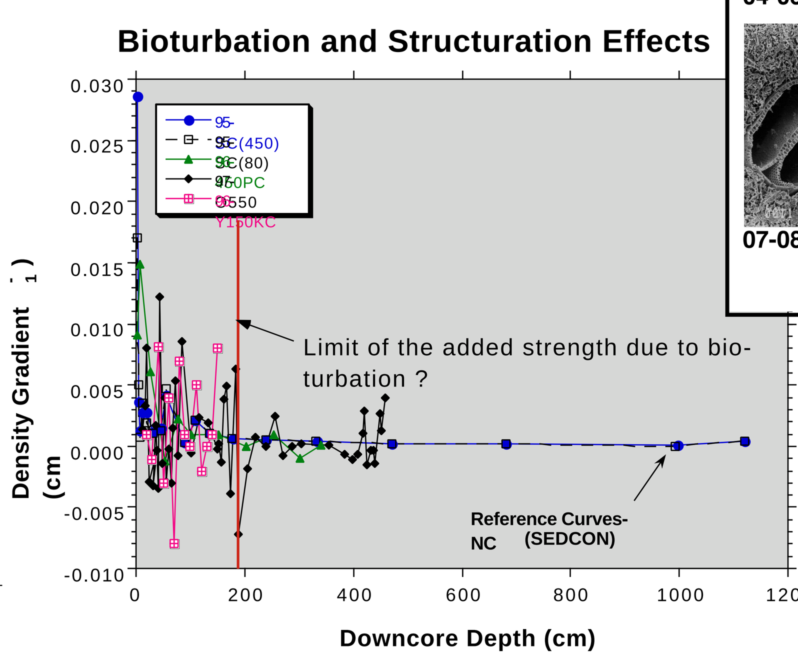


Figure 4

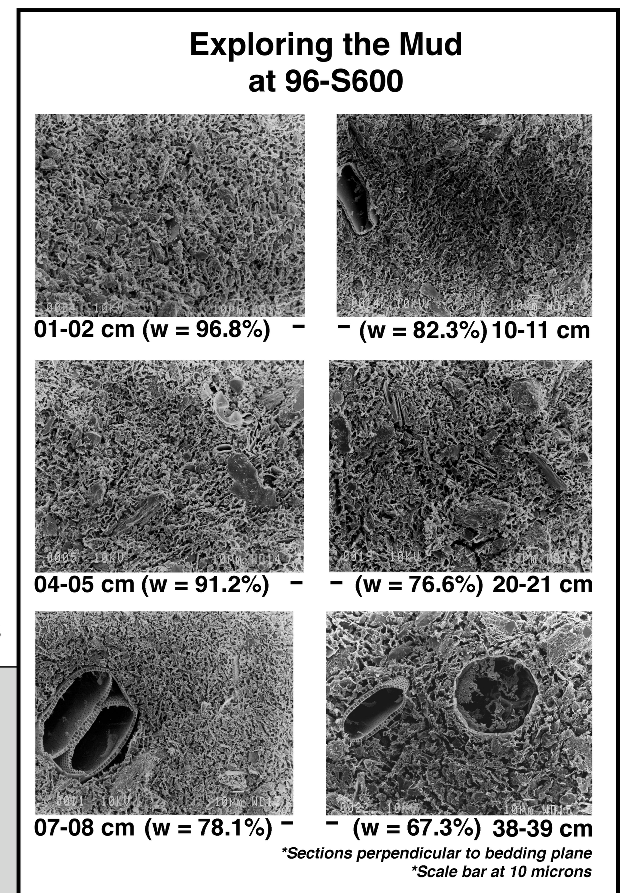


Figure 5

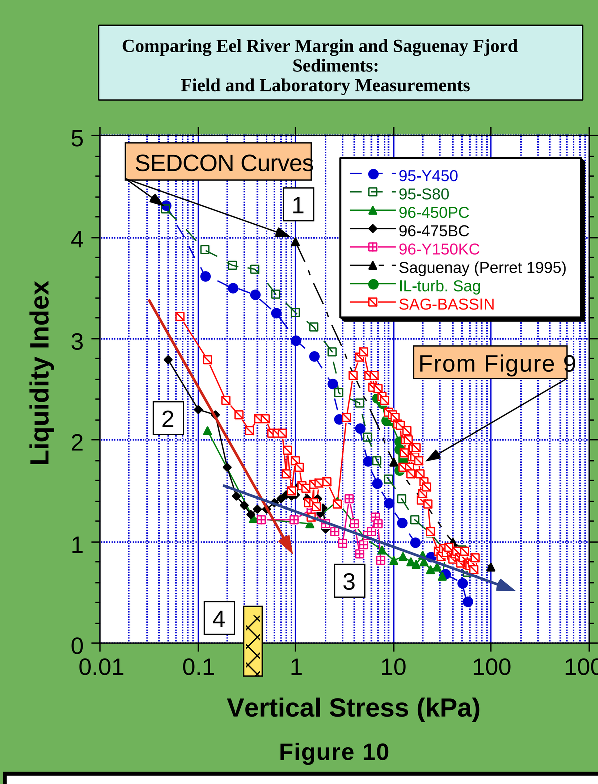


Figure 10

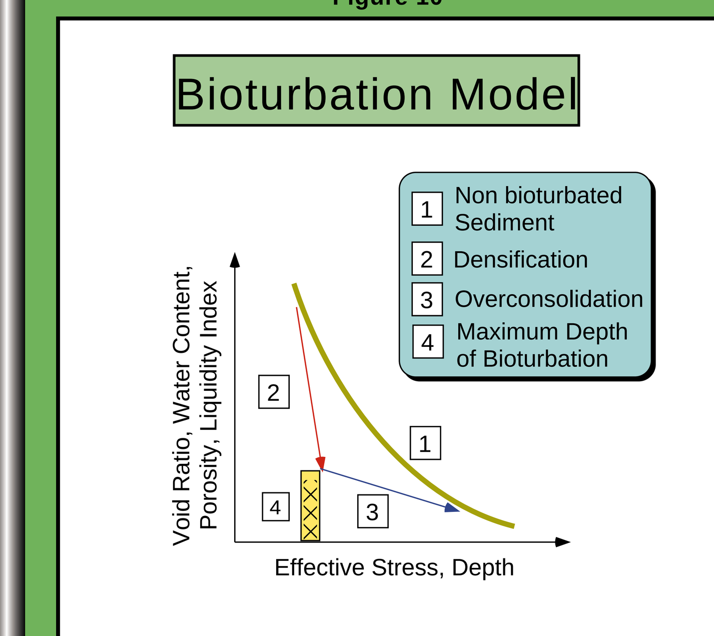


Figure 11

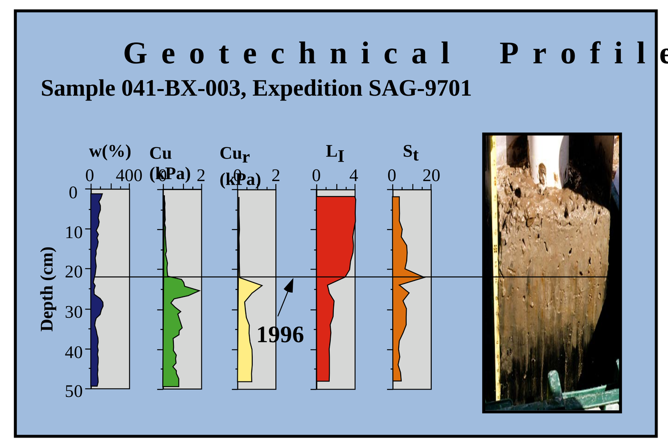


Figure 7

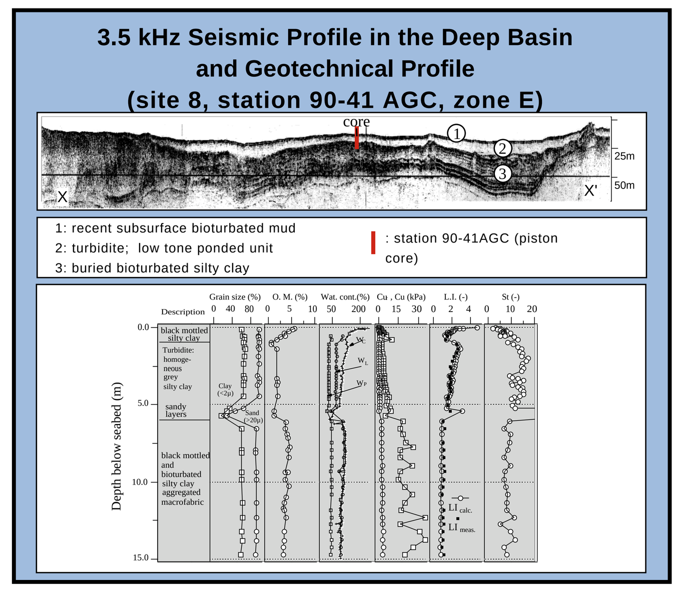


Figure 9

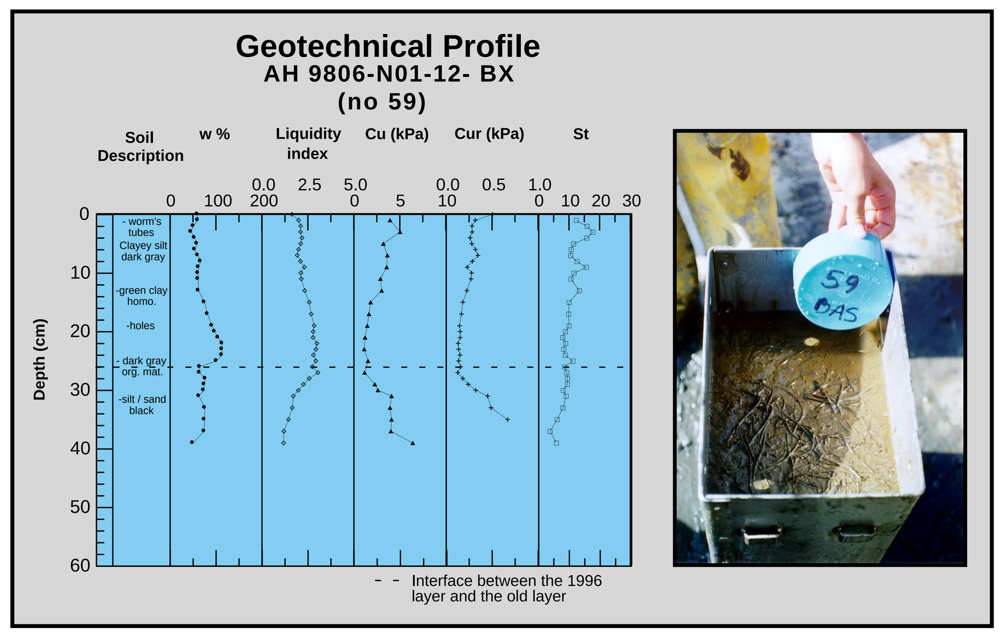


Figure 8

ACKNOWLEDGMENTS

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