Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

The Quest for a Novel Paleosalinity Indicator:

Did Tsunami Events Generated by an Extraterrestrial Bolide Cause a Change in Salinity in the Hudson River Circa 2300 BP?

Lisa Weber[1,2] and Dallas Abbott[2]
[1]Columbia College, Columbia University in the City of New York
[2]Lamont-Doherty Earth Observatory of Columbia University

ABSTRACT

The project aims to determine if tsunami events triggered by an extraterrestrial impact caused a change in salinity levels in the Hudson River circa 2300 BP. In the process of ascertaining such changes, scolecodonts (jawbones of polychaete annelids) exhibiting various amounts of iodine have been found to positively correlate with Hudson River salinity levels, making these microfossils useful proxies for future paleosalinity studies. Salinity is vital to estuarine ecosystems and can be intricately connected to climate, since increased precipitation leads to decreased salinity levels. Furthermore, air-water interactions can be influenced by salinity, since regions high in salinity will have low dissolved oxygen concentrations due to a decrease in vertical mixing. If one were to learn that tsunamis influence salinity levels, then scolecodonts could serve as a useful salinity indicator in the future to study this phenomenon.

INTRODUCTION

Evidence has been found for a megatsunami event that occurred circa 2300 BP in the New York-New Jersey region and may have reached elevations of approximately 60 meters above sea level near the coast. If such a catastrophe were to take place today, it would affect millions of lives in the NY-NJ area.

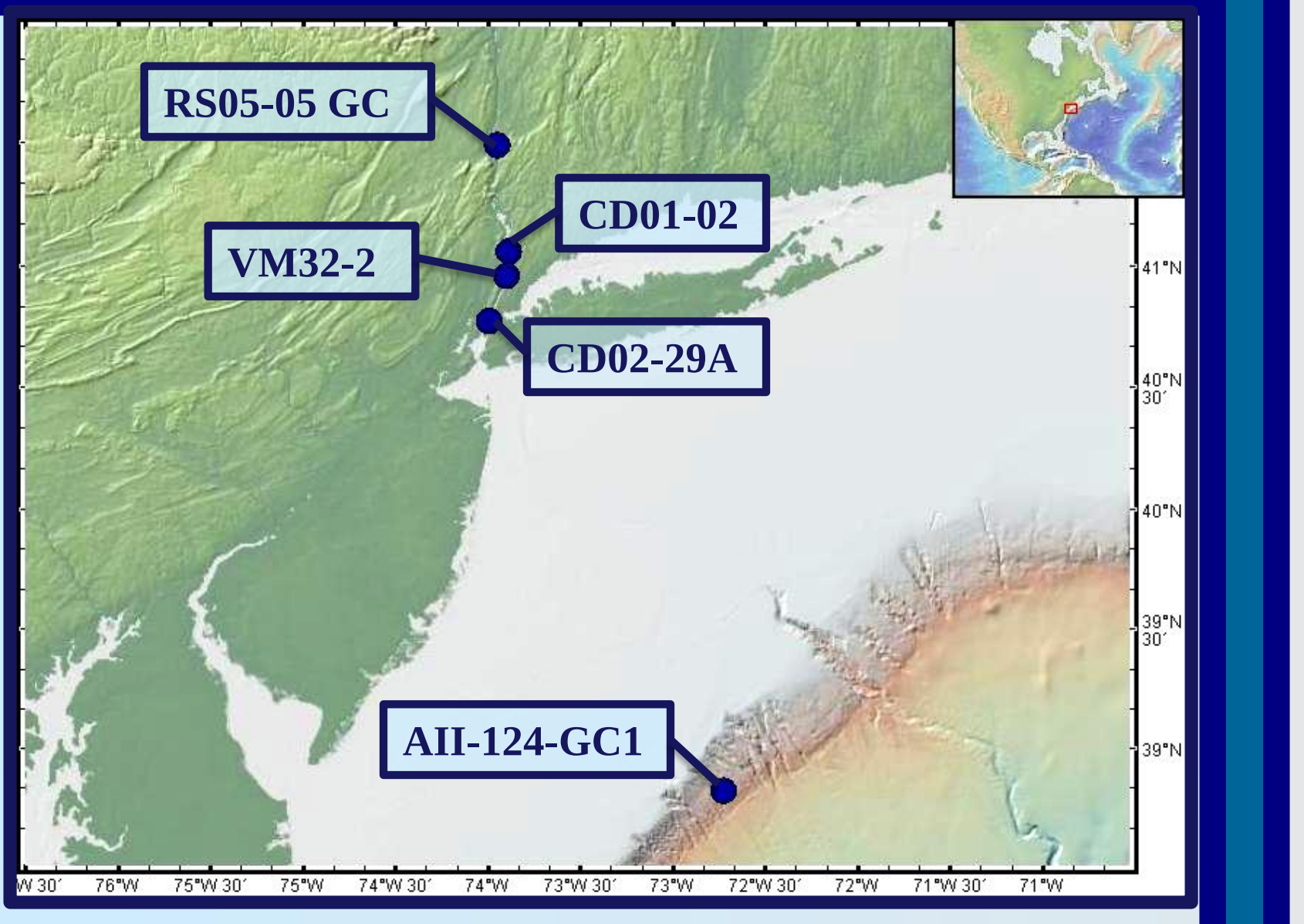


Fig. 1: GeoMapApp image detailing the locations of the Hudson River cores (CD01-02, VM32-2, CD02-29A, RS05-05) and marine core (AII-124-GC1)

Fig. 2: Example of scolecodont identified in the Hudson River (Core CD02-29A: Depth 68-70 cm)

The project entails analyzing the effects of tsunami events on changes in salinity through the use of scolecodonts, or the jaws of polychaete annelids, all of which have been identified in the selected sediment cores. These microfossils uptake large quantities of iodine, which have been found to positively correlate with salinity levels.

METHODS

Fig. 3: Sieving Station

Fig. 4: Balance Station

Fig. 5: Optical Microscope

Fig. 6: Petrographic Microscope

RESULTS

Iodine Analysis of Scolecodonts as a Proxy for Salinity

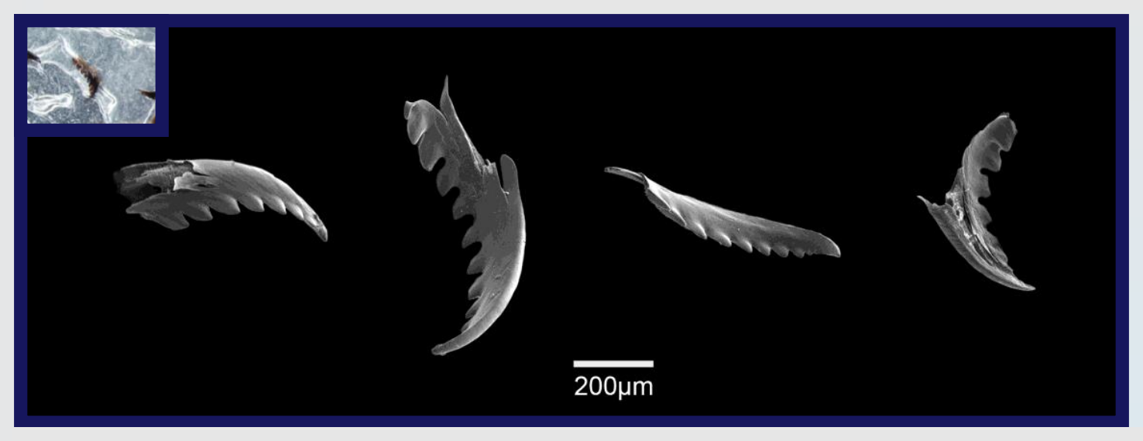


Fig. 7: Scanning Electron Microscope (SEM) image of scolecodonts from Hudson River cores CD01-02 and CD02-29A

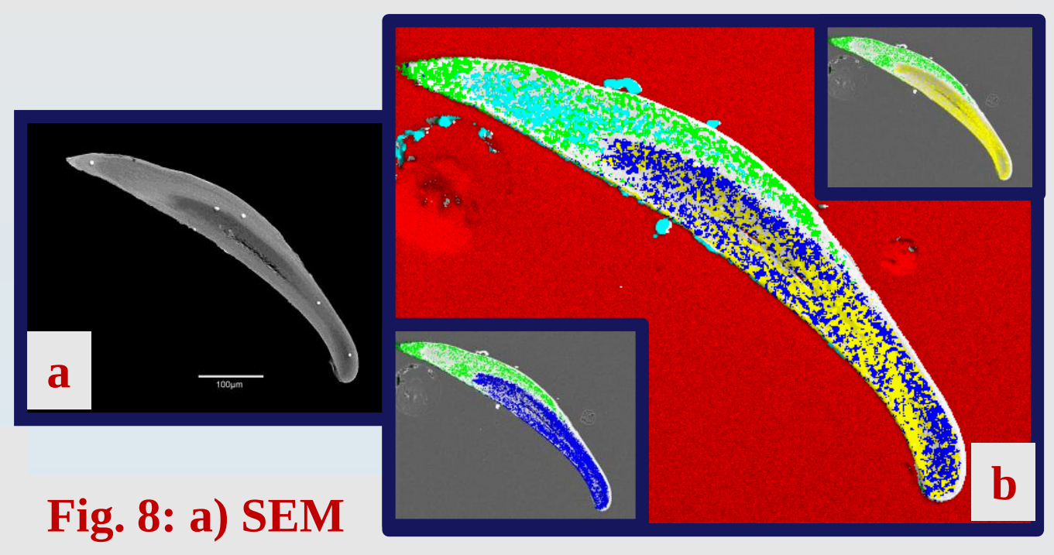


Fig. 8: a) SEM image of scolecodont thin section from Hudson River (Core VM32-2: Depth 152 cm); b) Element maps, indicating compositional variation in iodine (green), sodium (yellow), sulfur (blue), carbon (red), and aluminum (aqua)

Fig. 9: Comparison of Scolecodont Iodine Composition in Hudson River and Atlantic Ocean Sediment Cores

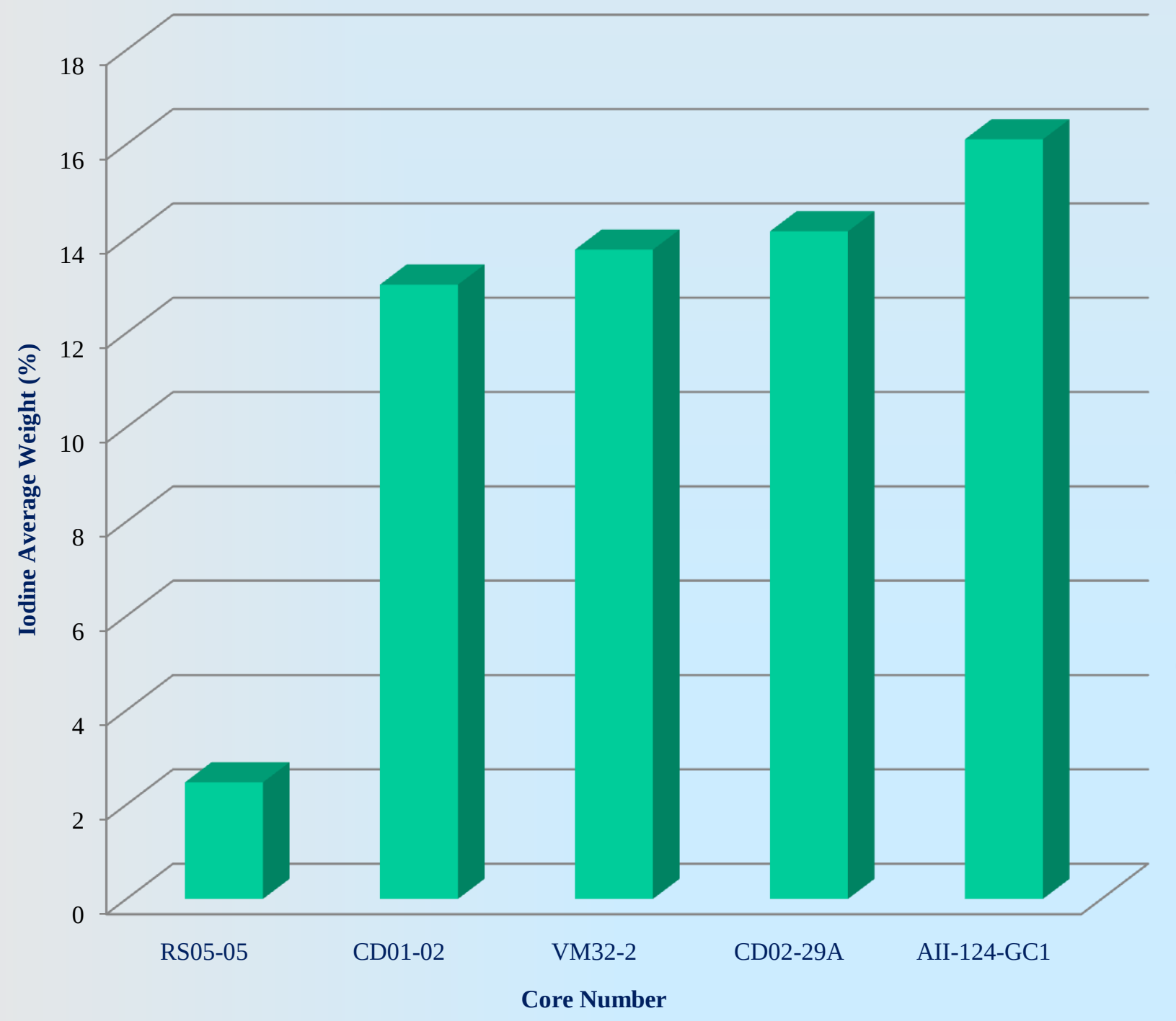
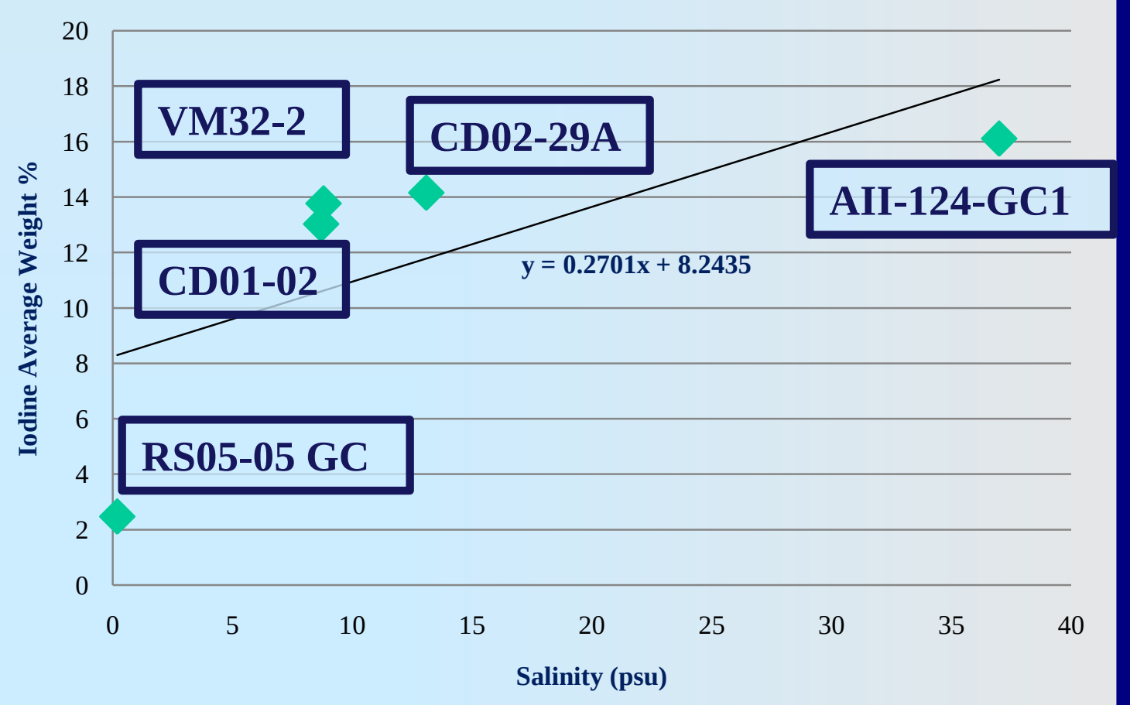


Fig. 10: Scolecodont Iodine Composition vs. Salinity in the River vs. Marine Sediment Cores



Iodine concentrations have been found to be higher in marine samples with 16.1% of the scolecodont consisting of iodine from AII-124-GC1, as compared to 13.2% of the scolecodont consisting of iodine in the estuarine sample of CD01-02 and to 2% in the modern-day upriver sample (RS05-05).

Multiple Tsunami Events Described by Three Types of Impact Ejecta

Impact indicators, consisting of vesicular aluminosilicate glass, carbon fibers, and various shocked minerals, have been identified in three cores (CD01-02, VM32-2, and CD02-29A) in the Hudson River and one marine sediment core AII-124-GC1 close to the crater candidate in Carteret Canyon, situated off the mid-coast of New Jersey.

Fig. 11

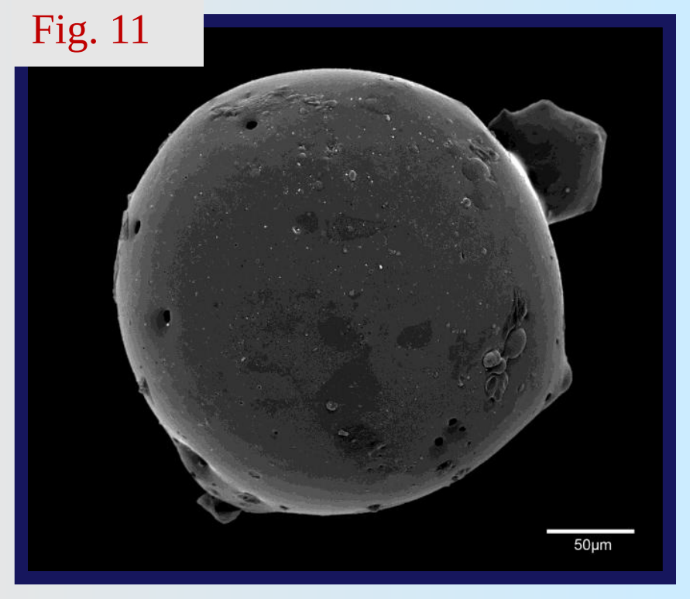
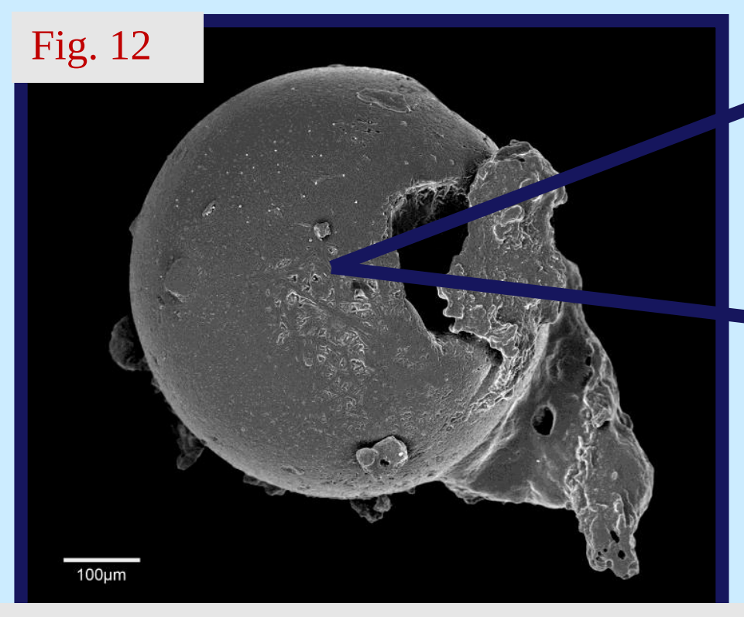


Fig. 12



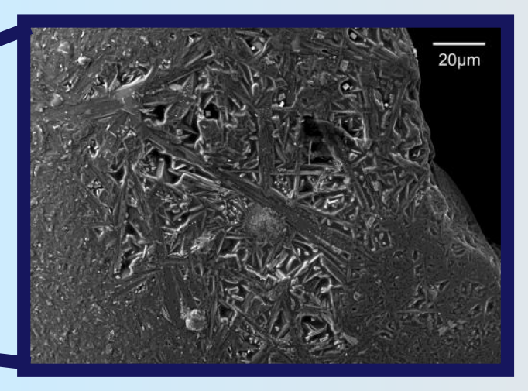
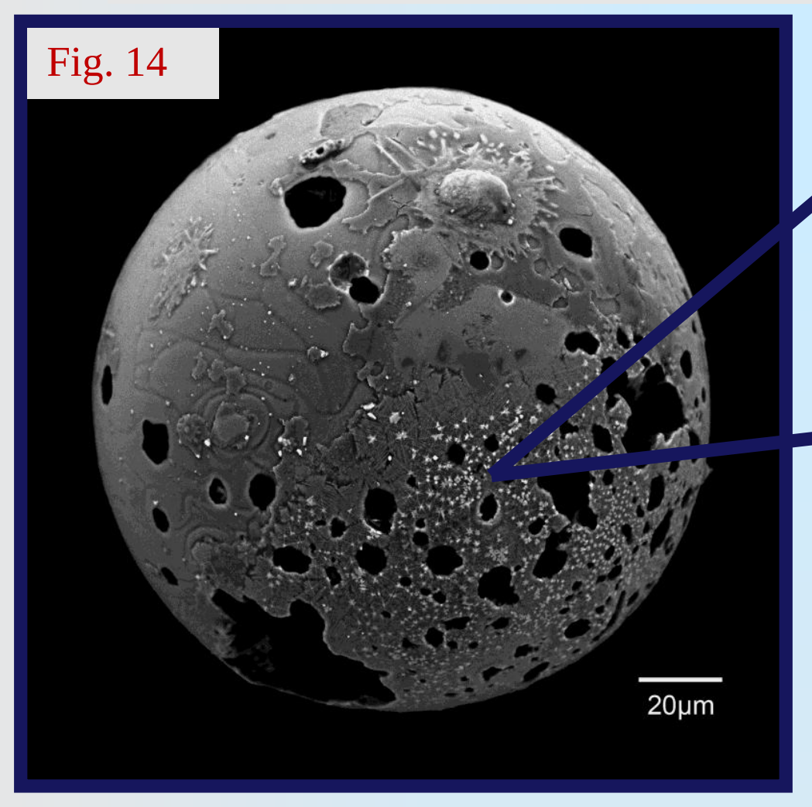


Fig. 13: Close-up of spherule with quench texture

Figs. 11-15: SEM photographs of CD02-29A glassy aluminosilicate spherules (Type 1 Ejecta from 2300 BP Tsunami Layer)

Fig. 14



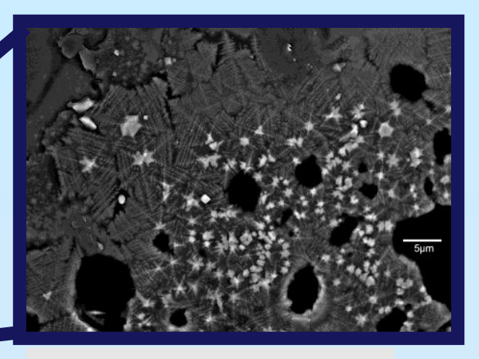


Fig. 15: Close-up of spherule with quench texture

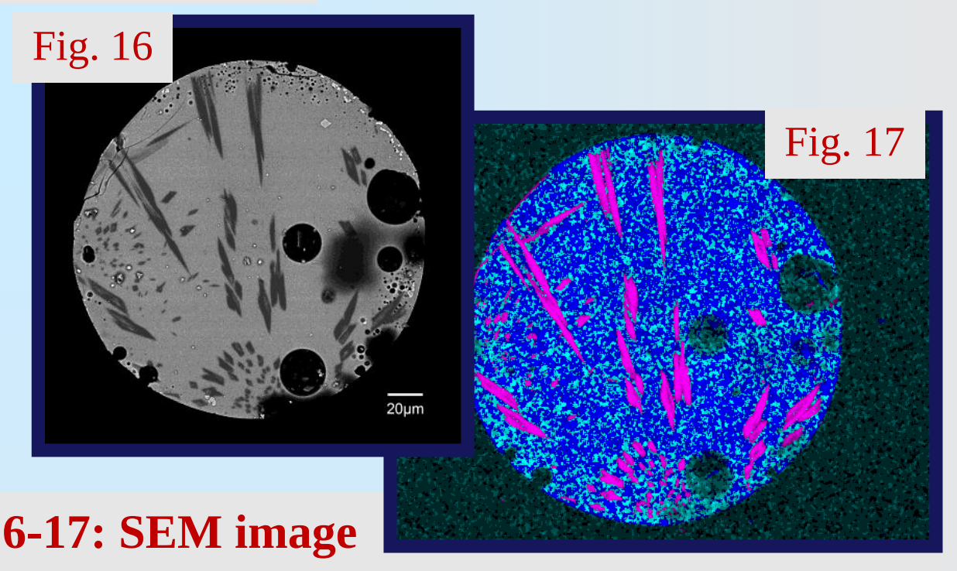
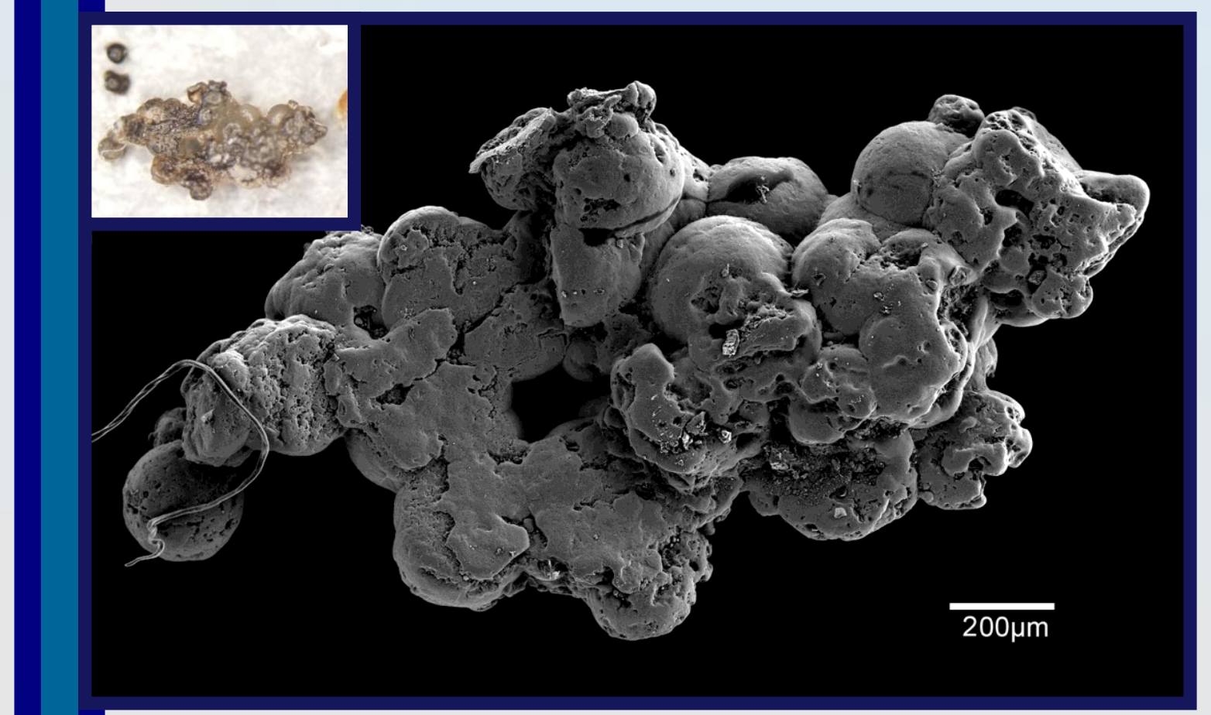


Fig. 16-17: SEM image and element map of VM32-2 aluminosilicate spherule, showing aluminum (pink), titanium (aqua), and iron (dark blue)

Fig. 18: SEM photograph of VM32-2 manganese, magnesium, and calcium spherule factory (Type 2 Ejecta)



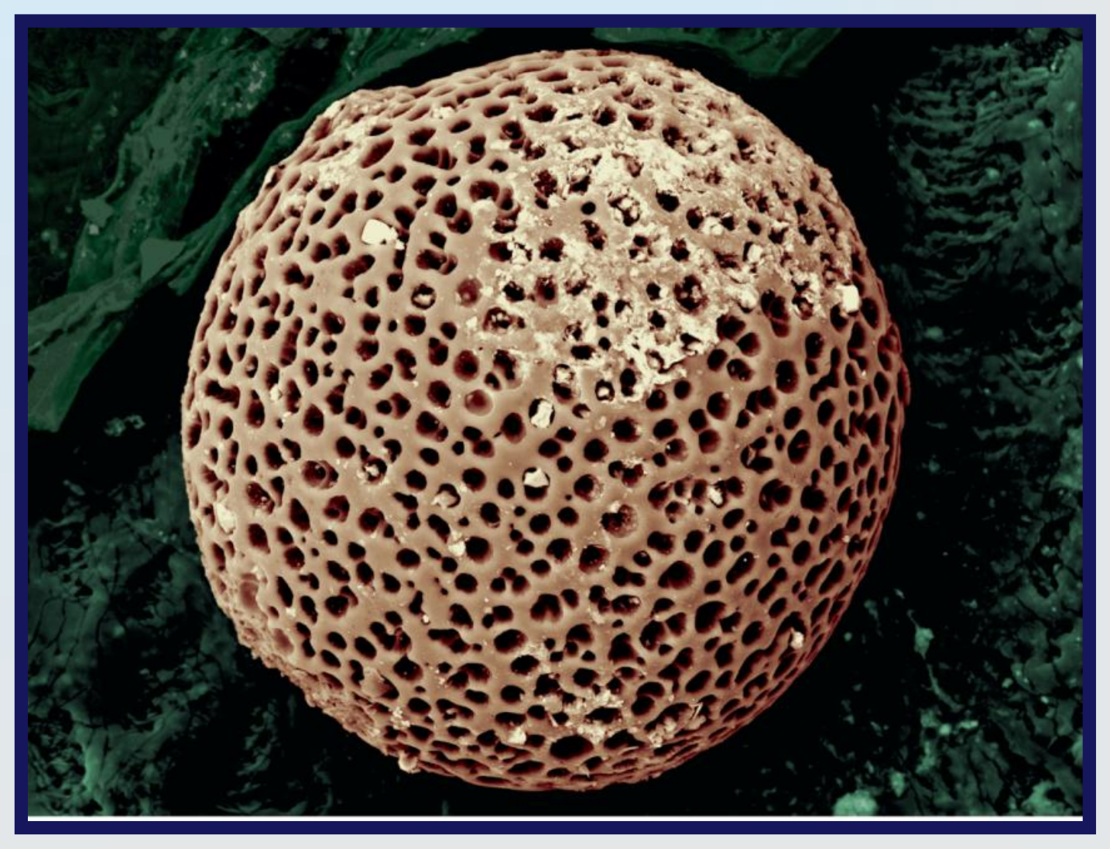


Fig. 19: Carbon spherule (Type 3 Ejecta)

CONCLUSION

Fig. 20: Scolecodont identified in marine core

Fig. 21: Scolecodont found in downriver core

Increased erosion and run-off from the surrounding regions can cause increased salinity, whereas more rainfall decreases the salinity levels. Salinity is vitally important for the well-being of an estuarine ecosystem. It has been proven that salinity is inversely correlated with dissolved oxygen levels, so that regions high in salinity will have low dissolved oxygen concentrations due to a decrease in vertical mixing (Stewart 2005). Such a characteristic can influence the type of species that can survive in specific regions, as well as indicate where the freshwater combines with the saltwater in the estuary. This project has shown that scolecodonts offer another record of paleosalinity. Coupling this work with future research on tsunami influences could lead to a better understanding of the implications of natural hazards on ecosystem health. By finding a sharp contrast between the marine and estuarine cores, this study has revealed another possible paleosalinity indicator with scolecodonts for future water quality testing that could prove invaluable to scientists in the coming years.

CONTINUED RESEARCH

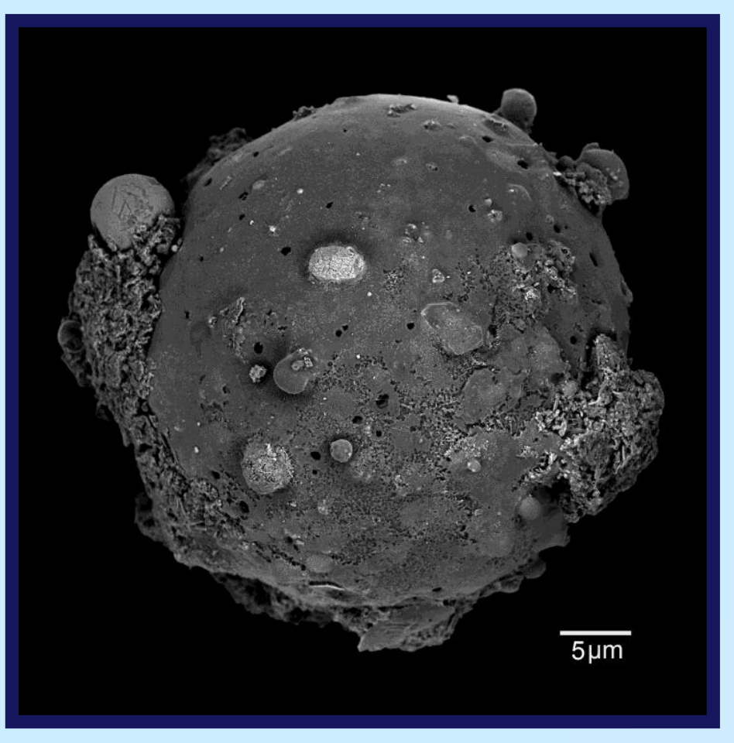


Fig. 22: SEM image of aluminosilicate spherule with budding passenger spherules

Future work should include finding the top of the tsunami layer, so that iodine concentrations can be compared in order to see if there is a difference before and after the tsunami hit.

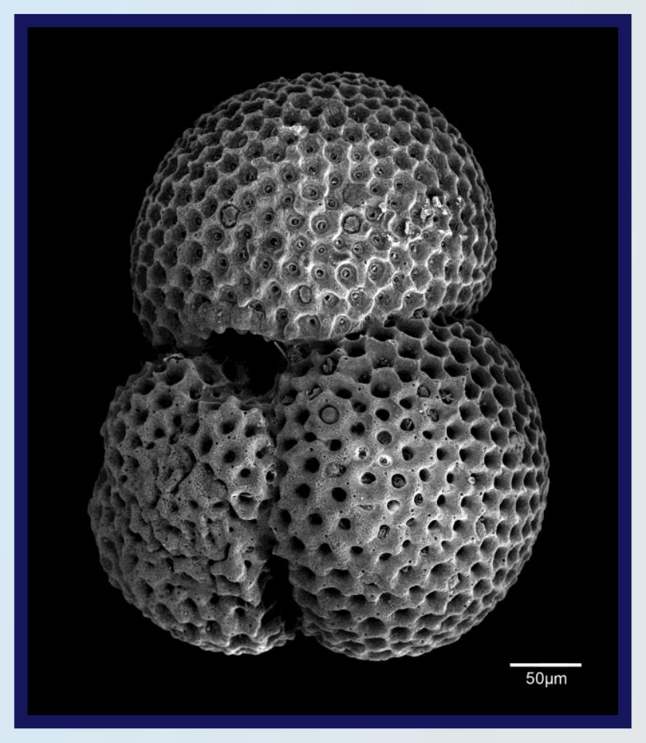


Fig. 23: SEM image of pelagic foraminifera, which is normally found at the top of the tsunami layer

REFERENCES

Al-Ameri, T.K. 1983. Acid-resistant microfossils used in the determination of Paleozoic palaeoenvironments in Libya. Palaeogeography, Palaeoclimatology, Palaeoecology. 44: 103-116.
Bergman, C.F. 1998. Reversal in some fossil Polychaete jaws. Journal of Paleotology. 72: 632- 638.
Croneis, C., and H.W. Scott. 1933. Scolecodonts. Geological Society of America Bulletin. 44: 207.
Eriksson, M.E., Bergman, C.F., and L. Jeppsson. 2004. Silurian scolecodonts. Review of Paleobotany and Palynology. 131: 269-300.
Goodarzi, F., and A.C. Higgins. 1987. Optical properties of scolecodonts and their use as indicators of thermal maturity. Marine and Petroleum Geology. 4: 353-359.
Hudson River Environmental Conditions Observing System. http://www.hrecos.org/joomla/
Pekar, S.F., McHugh, C.M.G., Christie-Blick, N., Jones, M., Carbotte, S.M., Bell, R.E., and J. Lynch-Stieglitz. 2004. Estuarine processes and their stratigraphic record: paleosalinity and sedimentation changes in the Hudson Estuary (North America). Marine Geology. 209: 113-129.
Purcell, J.E., White, J.R., Nemaziel, D.A., and D.A. Wright. 1999. Temperature, salinity and food effects on asexual reproduction and abundance of the scyphozoan *Chrysaora quinquecirrha*. Marine Ecology Progress Series. 180: 187-196.
Stewart, R. H. Introduction to Physical Oceanography. College Station: Texas A&M University, 2005.

ACKNOWLEDGEMENTS

I would like to thank Dr. Dallas Abbott for her expert mentorship, advice, time, effort, and support on this project. I am also grateful to Ms. Dee Breger for the Scanning Election Microscope images that were taken at the City College of New York Scanning Election Microscope Lab. Special thanks to Dr. Kim Kastens for research focusing meetings, as well as to Dr. Frank Nitsche and Dr. Suzanne Carbotte for use of their sediment cores and for their support. Many thanks to Ms. Nichole Anest and Mr. George Lozefski for their help in the Core Lab. Also, I am thankful to Dr. Sidney Hemming, Dr. Mark Anders, and Dr. Dave Walker for use of their microscopes, as well as to Cristina Subt, Nick Gogan, Katherine Cagan, Grace Cao, and Andre Scheinwald for their help with the team.