Linking Amorphous Silica to the Late Pleistocene Deglaciation of North America

Curtis A. Kimball, Advisor: Joel E. Johnson

Department of Earth Sciences, University of New Hampshire, Durham, NH 03824

Project Background

- In 2023 the UT-GOM2-2 expedition recovered 150 meters of sediment cores from the Terrebonne Basin in the Gulf of Mexico [4]
- Since 2023, Researchers have been studying these sediments, gathering various datasets [4] including amorphous silica
- Data sets are used to establish absolute time, and as proxies to make conclusions about the basin's characteristics over geologic time

Research Questions

- Can the source of measured amorphous silica in the UT GOM2-2 cores [9] be determined?
- How can a correlation between radiolarian microfossils and amorphous silica be interpreted as a paleoclimate indicator

Oceanographic Setting

- Marine sediments reflect a record of the depositional processes in a region
- In coastal, high-energy waters lithogenic sediments carried by rivers, wind, or ice dominate sedimentation
- In low-energy waters far from the coast, sedimentation is dominated by the remains of marine micro-organisms
- Sea level changes can shift the types of depositional processes occurring in a location over time
- Sediment cores obtained by scientific drilling allow researchers to see variation in sediments over large time scales

Radiolarian Microfossils

Overview

- Radiolaria is a family of marine micro-organisms identifiable by their radial symmetry and siliceous skeletons called 'tests' [1]
- Radiolarian skeletons are amorphous (biogenic) silica, meaning they lack a crystal structure [1]
- Radiolaria are uncommon in the modern Gulf of Mexico [7]

Why Radiolaria?

- Measurements of amorphous silica from the core track closely with reworked calcareous nano fossils, suggesting a reworked origin [9]
- Reworked cretaceous aged Radiolaria (Fig. 4) have been found in the gulf [7] and could be driving the amorphous silica signature

Significance

Paleoclimate

- Correlating proxies to meltwater pulses and low stands of sea level informs paleoclimate reconstructions
- Amorphous silica could serve as a proxy for river flux [9]
- Meltwater pulses can be tracked via river flux
- These pieces of information contribute to the reconstruction of late Pleistocene deglaciation, and modern deglaciation models

Energy

- Mississippi river flux and sea level influence coarse sediment deposition locations in the Gulf of Mexico
- Coarse sediment beds serve as accumulation sites for gas hydrate
- Gas hydrate has potential as a valuable source of natural gas [4]
- Gas hydrate reservoirs have potential to be used as a climate geoengineering solution [4]

Visualizing Marine Sedimentation

Figure 1: Diagram of the rock cycle

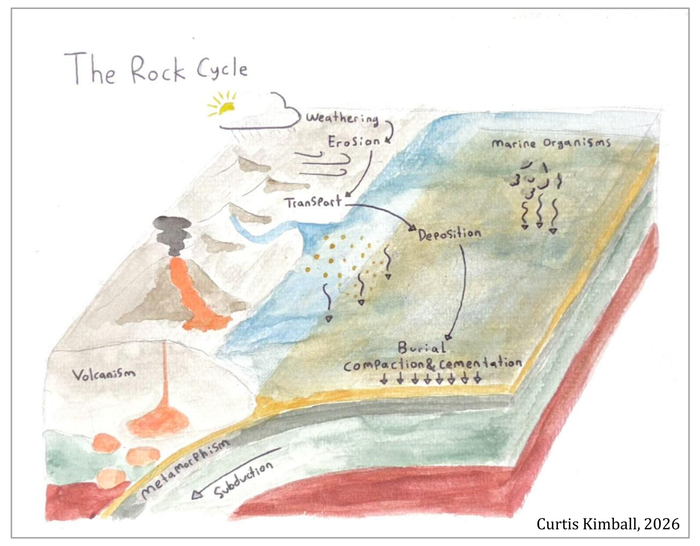


Figure 2: Diagram of sediment depositional factors

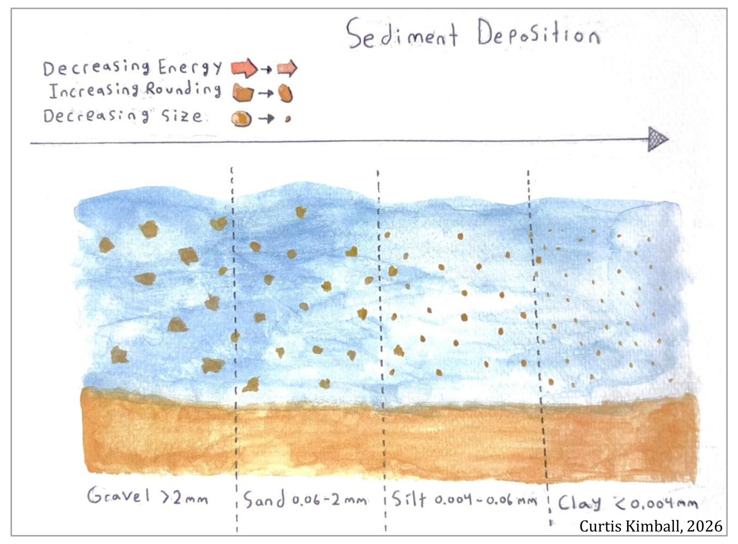


Figure 7: Radiolarian microfossil presence from microscope analysis

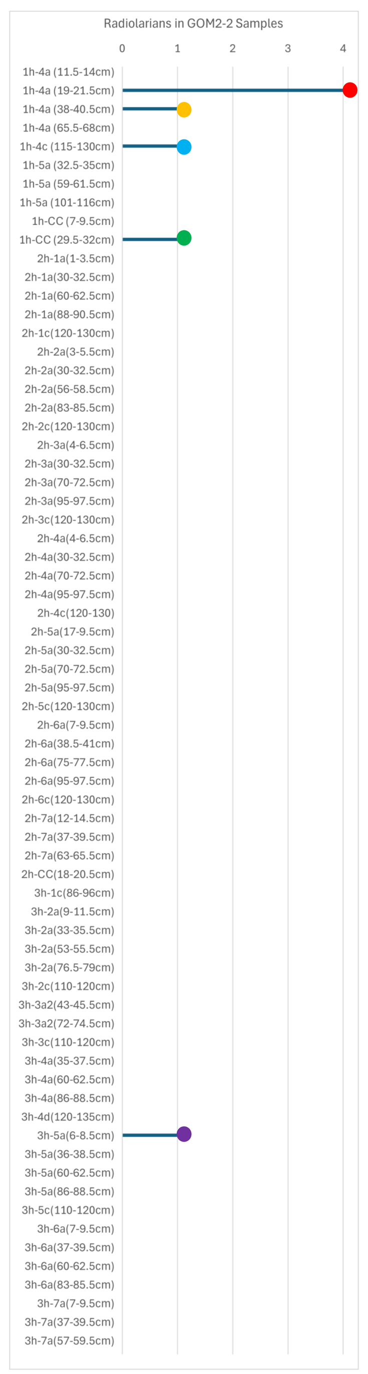


Figure 3: Sediment deposition as a function of velocity and size [3]

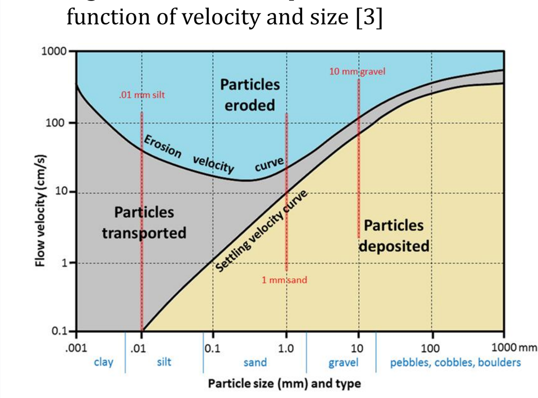


Figure 4: Cretaceous Aged Radiolarian Tests [7]

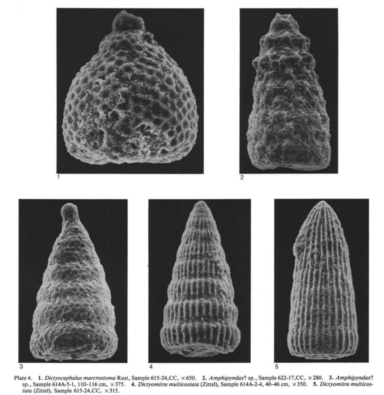


Figure 5: Map of the Terrebonne Basin and UT-GOM2-2 expedition study area [4]

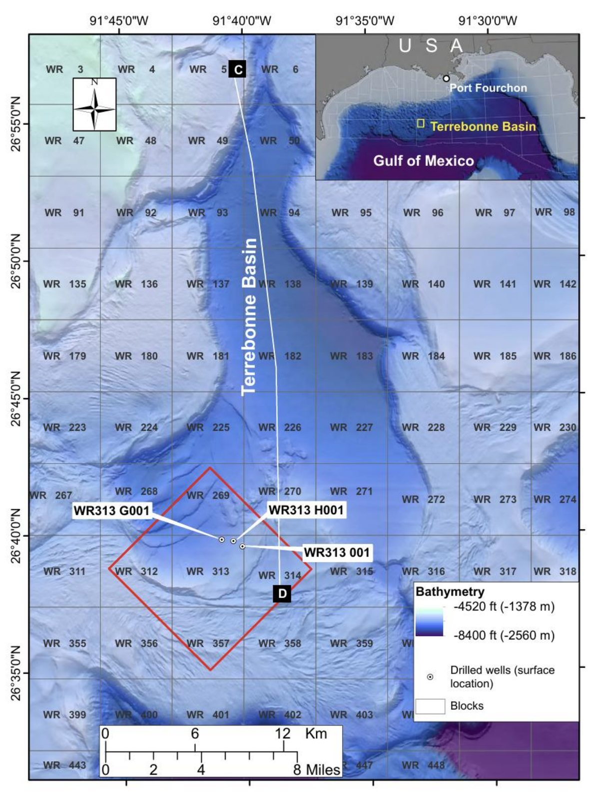
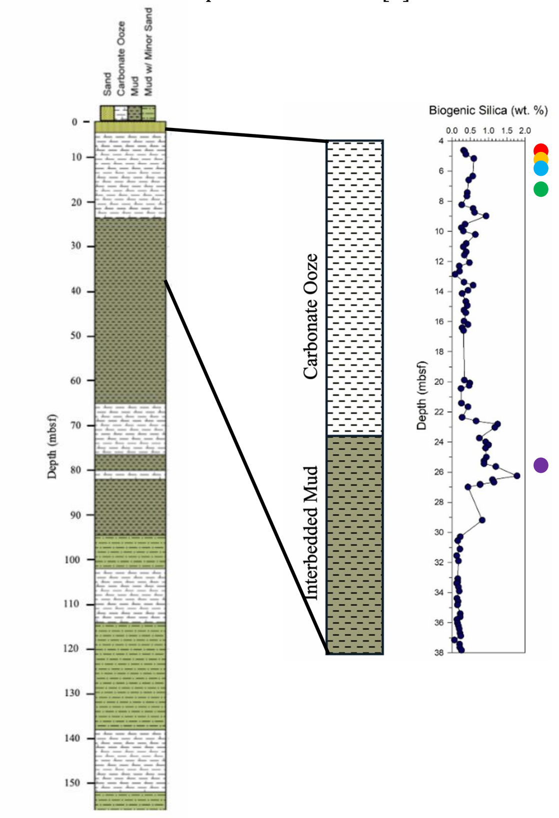
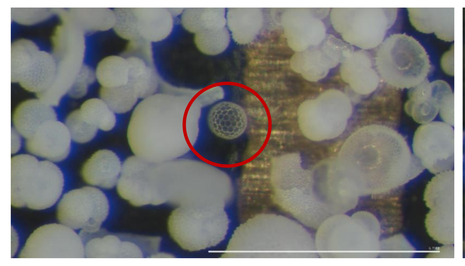


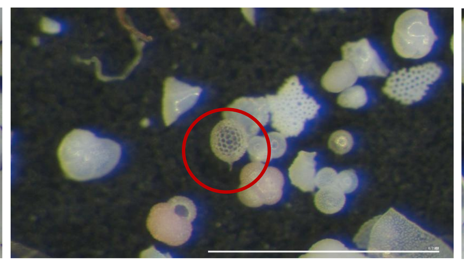
Figure 6: Diagram of GOM2-2 H003 core sediment intervals and amorphous silica data [9]



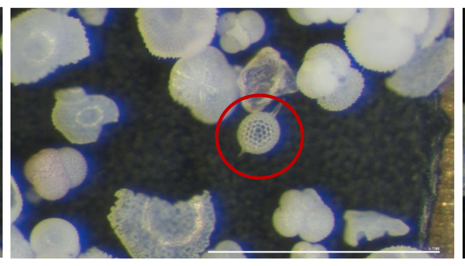
Photomicrographs of UT GOM2-2 Sediment Coarse Fractions



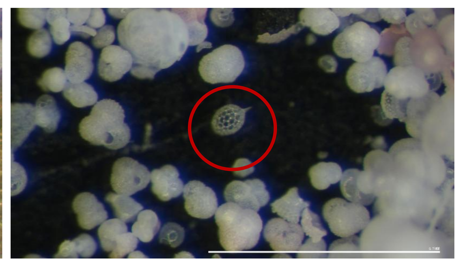
Radiolaria, 1h-4a (19-21.5cm)



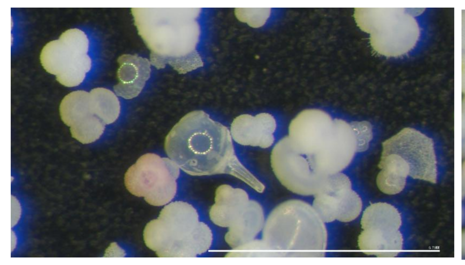
Radiolaria, 1h-4a (19-21.5cm)



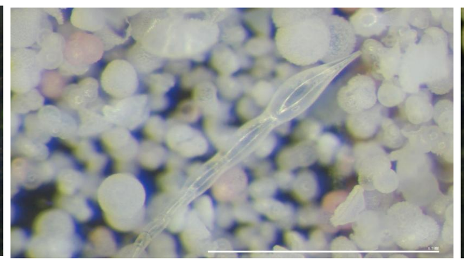
Radiolaria, 1h-4a (19-21.5cm)



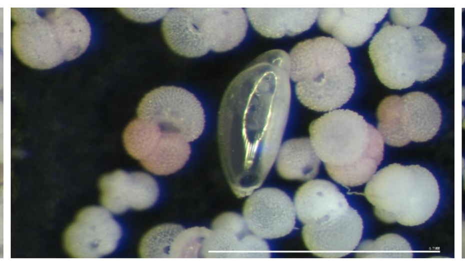
Radiolaria, 1h-4c (115-130cm)



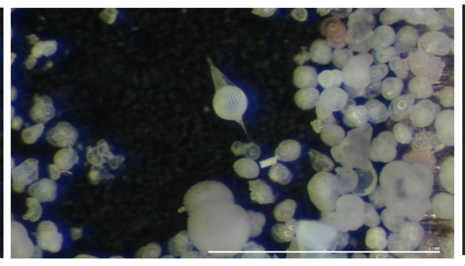
Foraminifera, 1h-4a (19-21.5cm)



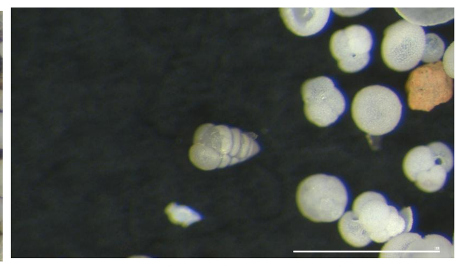
Foraminifera, 1h-4a (65.5-68cm)



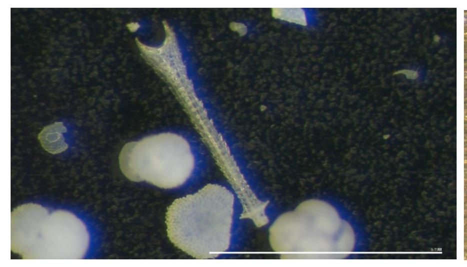
Foraminifera, 1h-4c (115-130cm)



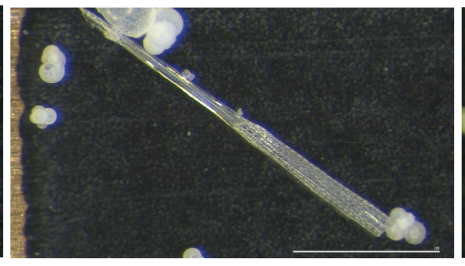
Foraminifera, 1h-4c (115-130cm)



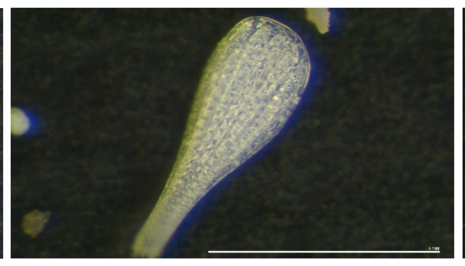
Foraminifera, 2h-4a (95-97.5cm)



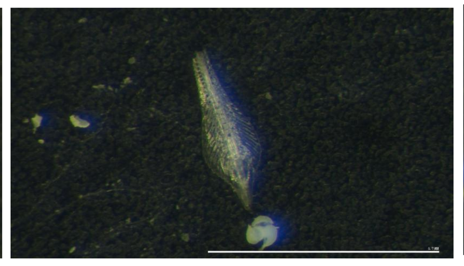
Echinoid Spine, 1h-4a (65.5-68cm)



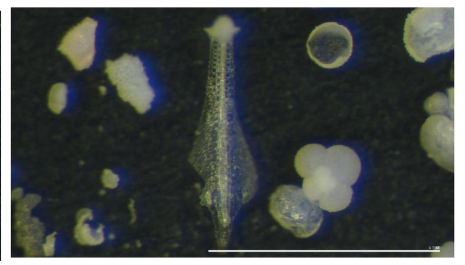
Echinoid Spine, 1h-4a (65.5-68cm)



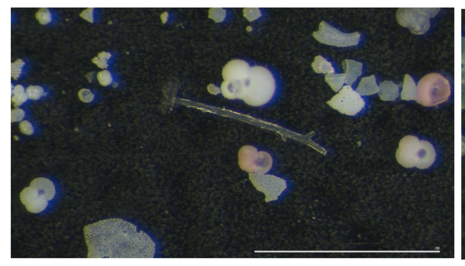
Echinoid Spine, 2h-2a (30-32.5cm)



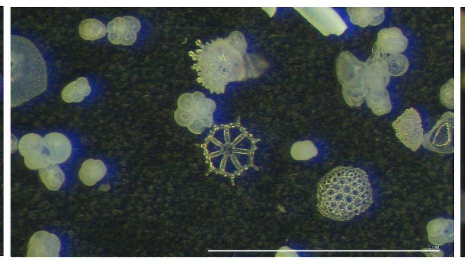
Echinoid Spine, 2h-5a (30-32.5cm)



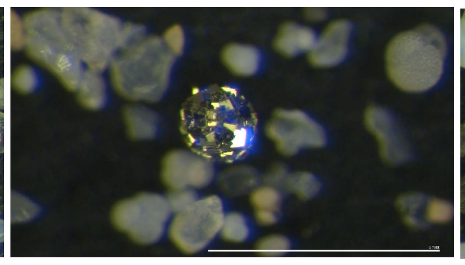
Echinoid Spine, 2h-5c (120-130cm)



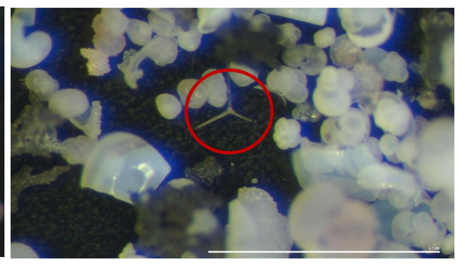
Sponge Spicule, 1h-4a (19-21.5cm)



Sea Cucumber Sclerite, 1h-CC (29.5-32cm)



Pyrite Crystals, 2h-4a (4-6.5cm)

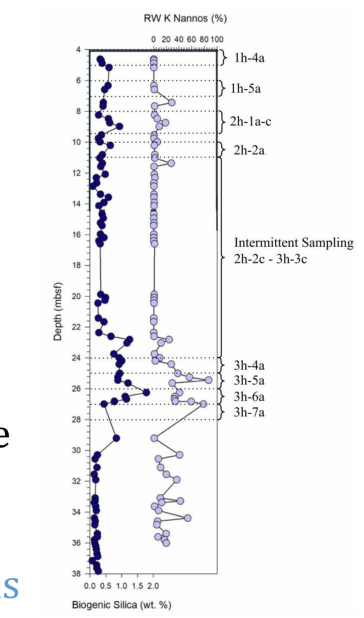


Sponge Spicule, 2h-CC (18-20.5cm)

Approach

- Samples from the 4-38 mbsf interval of the cores were analyzed with a microscope to assess microfossil content
- Samples were from the coarse fraction (63-250nm)

Figure 8: Microscope analysis sampling regions alongside amorphous silica and reworked nano fossil data [9]



Moving Forward

- Pursuing additional funding to extend amorphous silica records
  - Taking more measurements would require further microscope analysis
  - Encompassing an additional meltwater pulse increases paleoclimate modeling potential
- Correlating data with oxygen isotope, calcareous nano fossil and XRF datasets
  - Establish absolute time and further correlation to reworked fossils
  - Establish degree of correlation to other glacial meltwater indicators

Results and Implications

- Very few identifiable radiolarian tests were found (Fig. 7)
- The few tests identified do not seem to be Cretaceous in origin (Fig. 4)
- Much of the finer material in samples is left behind in the sieving process
- Potential drivers of amorphous silica could include:
  - Sponge Spicules
  - Radiolarian test fragments in finer fractions

Acknowledgements

I would like to thank the 2023 UT GOM2-2 expedition for core acquisition, as well as Joel Johnson, Marcie Purkey-Phillips, Steve Phillips, and Kayla Tozier, without their hard work this research would not be possible. To Alex Lawrence, Sophia Scaccia, Amelia Hauer and Wally Bothner, thank you for making the third floor of James hall such a welcoming place. Finally, to Ivy Young, thank you for always listening to me ramble about fossils.

References

[1] Armstrong, H. A., & Brasier, M. D. (2005). Microfossils (Second). Blackwell Publishing.

[2] DeMaster, D.J., (1981). The supply and accumulation of silica in the marine environment. Geochemica et Cosmochimica Acta 45, 1715–1732. https://doi.org/10.1016/0016-7037 (81)90006-5.

[3] Earle, S. (2019). Physical Geology – 2nd Edition. Victoria, B.C.: BCcampus. https://opentextbc.ca/physicalgeology2

[4] Flemings, P., Thomas, C., Phillips, S. Collett, T., Cook, A., Solomon, E., Colwell, F., Johnson, J., Awwiller, D., Aylward, I., Bhandari, A., Brooks, D., Cardona, A., Casso, M., Coyte, R., Darrah, T., Davis, M., Dugan, B., Duncan, D., Germaine, J., Holland, M., Houghton, J., Mills, N.T., Mimitz, M., Minarich, D., Morono, Y., Murphy, Z., O'Connell, J., Petrou, E., Pettigrew, T., Pohlman, J., Portnov, A., Purkey Phillips, M., Redd, T., Sawyer, D., Schultheiss, P., Shannon, K., Sullivan, C., Small, C., Tozier, K., Tsang, M., Van Der Maal, C., Waite, W., Walton, T., (2024), UT-GOM2-2 Preliminary Report Terrebonne Basin Northern Gulf of Mexico, The University of Texas Institute for Geophysics, https://doi.org/10.5281/zenodo.13648253.

[5] Haq, B. U., Boersma, A., Berggren, W. A., Brood, K., Burckle, L., Herman, Y., Heusser, L., Jasonius, J., Jenkins, W., Kling, S., Muller, K., Pokorny, V., Remane, J., Williams, G., & Wray, J. (1998). Introduction to Marine Micropaleontology (Second). Elsevier Science.

[6] Kenneth J. McMillen, Richard E. Casey, Distribution of living polycystine radiolarians in the Gulf of Mexico and Caribbean Sea, and comparison with the sedimentary record, Marine Micropaleontology, Volume 3, Issue 2, 1978, Pages 121-145, https://doi.org/10.1016/0377-8398(78)90002-6.

[7] Morley, J. J., & Kohl, B. (1986). RADIOLARIANS FROM DEEP-SEA-DRILLING-PROJECT LEG-96. Initial Reports of the Deep Sea Drilling Project, 96, 649-656.

[8] National Geographic Society. (2025, June 4). The Rock Cycle. Education | National Geographic; National Geographic Society. https://education.nationalgeographic.org/resource/rock-cycle/

[9] Tozier, K., (2024), Investigating Late Pleistocene to Recent Bimodal Sedimentation in The Terrebonne Basin, Gulf of Mexico, MS Thesis, University of New Hampshire.

[10] Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: Journal of Geology, v. 30, p. 377-392.