PALEOENVIRONMENTAL RECONSTRUCTION OF HOLOCENE-ERA LAKE INCHIQUIN, WESTERN IRELAND, USING GRAIN SIZE, LOSS-ON-IGNITION AND DIATOM ANALYSES

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INTRODUCTION

Peat bogs are a common feature of the landscape in much of western Ireland. They began to form after the end of the Younger Dryas period approximately 11,500 years ago, during which time much of western Ireland was covered by large expanses of open water. Throughout the remainder of the Holocene era, the combined effects of detritus and mud gathering on the lake floors and increased evaporation caused the expanses of water to become progressively more shallow shallower. Eventually, the lakes dried up and were replaced by today's peat bogs (Mitchell and Ryan, 2001). The sedimentary record below these bogs reflects the process of lake infilling: dark clay signifying the end of the Younger Dryas is overlain by detritus-mud, which eventually becomes peat.

A number of key questions concerning the sedimentary material of these lake basins remain unanswered. These questions include how the sedimentary particle size within these lake basins varies from the end of the Younger Dryas until today; how the sedimentary particle size within these lake basins differs among individual layers of sediment; and to what extent the particle size within these lake basins can be correlated with amounts of organic, carbonate, inorganic, and diatomic content.

I conducted extensive grain size analysis on sediment from an eight-meter long core taken near Lake Inchiquin, western Ireland. This core was once part of the nearby lake, but has been infilled with subsequent peat bog formation. In analyzing the particle size data, I looked for variations in grain size on large and small scales, and I also attempted to correlate grain size variation with other qualities of the core. After considering my results within the context of these specific analyses, I proceeded to explore what my results indicate about the paleoenvironmental and paleoclimatic patterns of Holocene-era western Ireland.

MATERIALS AND METHODS

Sediment Core

Using Livingston Square coring equipment, we pulled an eight-meter long core near Lake Inchiquin. We subsequently logged all eight meters of the core. Afterwards, I cut out samples of the core at centimeter-long intervals and shipped these samples to Pomona College for grain size analysis.

The beginning of the core fluctuates between dark clay-silt and organic-rich, tan-colored marl. Approximately two meters from the base of the core, the dark clay-silt is permanently replaced by the marl. Gastropod and bivalve shells become prevalent throughout much of the core at this time. Laminations come and go, although they generally are more prevalent in sections of the core where microfossils are rare. Homogeneous, microfossil-rich marl predominates between four and five meters from the base of the core. Approximately five and a half meters from the base of the core, the transition from marl to peat begins. Once again, it is an unstable transition that includes many fluctuations between tan-colored, homogeneous marl; brown, partially humified marl-peat; faintly laminated marl with much organic material and microfossils; and highly fossiliferous, black, fully-developed peat. The fully-developed peat predominates in the upper 1.25 meters of the core.

Grain size analysis

Prior to testing samples for grain size, I removed organic material from the sediments through treatment with 30% H2O2, removed shelly content from the sediments through sieving, and deflocculated the sediments through treatment with Calgon® water softener. The sieving may have removed some coarse particles in the shallower parts of the core, but the effects of this on my results are negligible.

Grain size analysis was completed through use of the Coulter LS200 Particle Size Analyzer at Pomona College. I tested almost every sample twice, using different specimens, to ensure that I was getting reproducible results. When the two results for one sample diverged significantly, I tested the sample a third time.

Loss-on-ignition and diatom testing

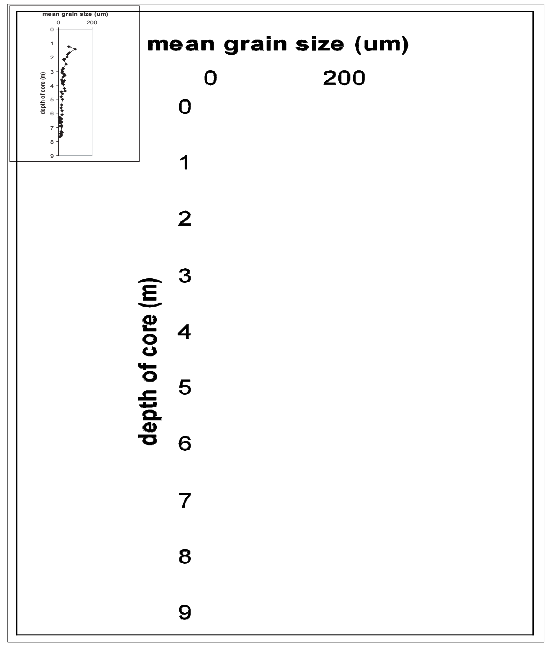
Loss-on-ignition testing of the core was conducted in Galway, Ireland. Samples were desiccated in a hot box at 50 degrees Celsius, and then were burned inside a furnace at 550 and 1000 degrees celsius. Carbonate, organic, and inorganic contents were then determined using standard formulas.

Diatom analysis to assess the relationship between diatom concentration and grain size is currently being conducted.

RESULTS

Mean grain size

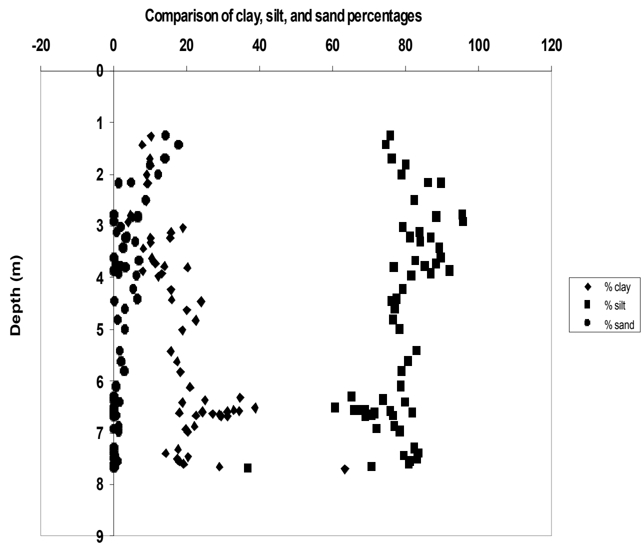
Figure 1: Mean grain size versus depth



Overall, the mean grain size (MGS) of the core tends to coarsen toward the top. When the results are considered more carefully, however, many small changes in the mean grain size are noticed. The MGS at the base of the core is extremely small, but by a depth of 7.58 m the MGS becomes relatively stabilized at 13-17 um. Then, at the 7-6 meter depth, the MGS values become rather somewhat unpredictable, varying between seven and twenty um. Between the six-meter and five-meter depth, MGS stabilizes again at between seventeen and twenty um. Grain size appears to increase greatly at a depth of 4.4 meters, followed by a greater instability in grain size between 4-meter and 3-meter depths. At this section of the core, grain size tends to vary between 20 and 40 um. The section of the core between a three-meter depth and a two-meter depths shows a general coarsening of grain size, and the section of the core between two meters and one meter continuous this trend, with average mean grain sizes of between 50 um and 100 um. The final section of the core, between a one-meter depth and the top of the core, was mostly fully-developed peat and therefore was not tested.

Percentages of clay, silt, and sand

Figure 2: Clay, silt, and sand percentages vs. depth



As figure 2 shows, the percentages of clay and silt are inversely proportional to each other, and their trends divergent, throughout the beginning and middle of the core. At 2.57 m, the clay and silt percentages cease to be inversely proportional, and sand becomes more prominent within the core.

Grain size versus loss-on-ignition data

Many of the changes in % total organic matter and % total carbonate matter that occur in the core occur between the one-meter depth and the top of the core, where there is no sedimentary content. Hence, little association between these two characteristics of the core and its grain size can be made.

At the same time, the core's mean grain size generally appears to be inversely proportional to its % total inorganic matter. Whereas % total inorganic matter tends to decrease throughout the core, the mean grain size tends to increase. This is especially true at the beginning of the core. Mean grain size jumps about 10 cm from the base of the core, at which time % total inorganic matter plunges. Between a depth of 7.5 meters and 6.9 meters, both mean grain size and % total inorganic matter stabilize while tending to either increase (in the case of mean grain size) or decrease (in the case of % total inorganic matter).

DISCUSSION

The increase in grain-size up-core is probably due to the fact that the deposition of coarse materials in lakes is mostly confined to their shallow nearshore zone (Sly, 1978). Mechanisms such as underflow, turbidity, or slump conditions can carry coarser materials to deeper areas within a lake, but they were probably absent in this particular setting. Thus, as the lake became progressively shallower, it became more possible for coarse materials to be deposited in its deepest areas.

Clay and silt content are inversely proportional to each other in most of the core because they constitute the only types of particles in most of the core. Given that they are the only two sedimentary components of the core, when the percentage of one drops a certain amount, the percentage of the others increases by that same amount. When sand begins to appear in the core, at a 2.57 m depth, the percentage of silt within the core drops but the percentage of clay remains constant. This indicates that the source of clay for the lake is continuous but that the sources of silt and sand for the lake are dependent on a variety of factors, such as precipitation and climate change. The presence of sand in the shallowest parts of the core probably owes to the fact that clastics are generally brought into a lake basin in nearshore areas, either by influents or by shoreline erosion (Reeves 1968).

Grain size changes within the core can be related to depositional changes within it. The most prominent example of this occurs at a depth of between 2.7-2.5m , when the core changes from an unlaminated, tan-colored marl to an organic-rich, brown-colored peat-marl. At this part of the core, mean grain size jumps from 12-27 um to 30-52 um. This change may be due to a sudden increase in precipitation, producing the combined effects of increased sediment inflow (causing the larger grain size) and increased biological productivity (causing the greater humification).

Between a depth of 2m and 1m, the core exhibits fluctuation between brown and darker brown areas, the latter representing more heavily humified peat-marl. Grain size analysis of this part of the core reveals large-scale fluctuations as well (although every one of the samples tested from this part of the core has a very large mean grain size relative to other parts of the core). This may indicate fluctuations in precipitation, with an increase in precipitation resulting in changes in sediment inflow and biological productivity as outlined in the previous two paragraphs.

The inverse proportionality of percent inorganic matter and grain size can be explained by the fact that, in lacustrine systems, grain size is smallest in the deepest areas. In the case of Lake Inchiquin, the lake was deepest immediately after the end of a glacial period. At this time, since temperatures were too low for much biological activity, the lake collected much clastic material. As temperatures warmed, biological activity increased, as is reflected in the higher organic carbon rates that are found up-core. At the same time as temperatures warmed, the lake became shallower, allowing for increased deposition of more coarse-grained materials. Hence, although clastics constituted much of the material that was deposited in the lake bottom in the deepest parts of the core, they were generally much finer-grained than the sediment that was to come.

CONCLUSION

The results of this study indicate that grain size in this core can be correlated with the environmental and climatic changes that occurred in Lake Inchiquin during the Holocene era. The overall increase in grain size from the base to the top of the core, the appearance of sand in the core at the same time as the onset of peat-marl, and the inverse proportionality of inorganic sediment and grain size all indicate that environmental processes occurred in this area which linked particle size with other physical, geological or biological qualities. Moreover, it is clear that the overall lake-infilling process which leads to the formation of peat bogs has had a profound effect on the variation of particle size found within the examined core.

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