Measuring Modern Sedimentation Rates in Caddo Lake (LA, TX) Using ^{137}Cs Depth Profile

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ABSTRACT

Modern sedimentation rates were measured by using gamma ray spectroscopy to measure the depth profile of ^{137}Cs activity in sample cores from Caddo Lake. Seven cores were taken from various environments including a fresh water delta, back bays, and midlake channels, and also near inlet bayous and near the dam. The sedimentation rates vary from 0.56 ± 0.03 cm/yr (0.22 ± 0.01 in/yr) in a stream channel, 0.22 ± 0.03 cm/yr (0.09 ± 0.01 in/yr) in the freshwater delta region to unobservable amounts in the back bay and near the dam. Future work will involve more measurements of cores and modeling the data.

INTRODUCTION

This paper discusses using a High purity Germanium (HpGe) detector to locate and measure the 661.7 keV gamma ray of the radioactive nucleus ^{137}Cs in sediment cores taken from the bottom of Caddo lake in order to measure modern sedimentation rates. These rates indicate the recent history of the lake in the area that each core was taken. These sedimentation rates can be useful for future planning concerning the lake and in understanding the modern evolution of the lake environment.

SELECTION OF CADDO LAKE AND RADIOACTIVE DATING OF SEDIMENT

Caddo Lake straddles the Texas-Louisiana border as shown in Figure 1. It is the only naturally-formed lake in Texas. It is one of fifteen wetlands areas in the United States identified by the Ramsar Convention "as a wetlands of international importance especially as a wildfowl habitat." This lake has been studied by several geologists (Barrett, 1995), most recently for the proposed dredging of deep channels to form part of the waterway for the Red River lock and dam project. The measurement of the modern sedimentation rates that this paper will discuss forms one part of the larger study of the lake's sediment history (Barrett, 1995).

The modern sedimentation rates are studied by examining the activity of ^{137}Cs as a function of the sediment depth. This nucleus is not a naturally occurring radioisotope; it is created in the fission of U or Pu isotopes. During thermonuclear tests that occurred in the atmosphere during the 1950's and early 1960's this isotope was produced and then atmospherically transported over the globe. One assumes that the ^{137}Cs that eventually reached the ground was initially distributed uniformly. Atmospheric weapons tests ceased in 1963 due to

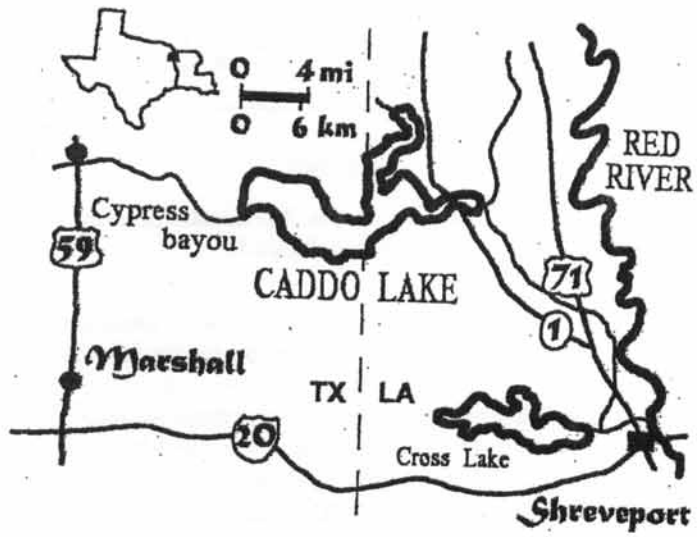

Figure 1. *The location of Caddo Lake.*

the Atmospheric Test Ban Treaty signed that year by the major nuclear powers. Thus one assumes that no more ^{137}Cs was deposited in the atmosphere after that year (Walling and Quine, 1993).

The half-life of ^{137}Cs is 30.2 years, so it is still present in the environment. By measuring the activity of ^{137}Cs as a function of depth of the sediment one can obtain an average rate of sedimentation for the period from 1963 to the present. When the activity is plotted versus the depth of the core sample as shown in Figure 2 what is generally observed is a fairly constant activity as one travels downward from the surface. At a particular depth the activity drops off in a smooth manner until a low level is reached. Where the activity begins to drop off is where the amount of ^{137}Cs produced reached a maximum. This corresponds to the 1963 point. The drop off below this projects backward from 1963 to 1952, the time of the first thermonuclear test. The amount of sediment above the point where the drop off begins is the sediment accumulation since 1963. Thus a modern sedimentation rate can be obtained. The reliability of this method to determine sedimentation rates has been tested by comparing results from ^{137}Cs to those obtained by using ^{210}Pb (Meriwether, personal communication, 1994). The sedimentation rates obtained from measurements of both radionuclei agree with each other. This technique and the above observations assume that the deposited sediment has not been re-worked or bioturbated.

The measurement of activity as a function of depth of each complete core takes almost two months so site selection is important. The reason for the long time is that each core is cut into 2 centimeter (0.79 in) sections and for each section

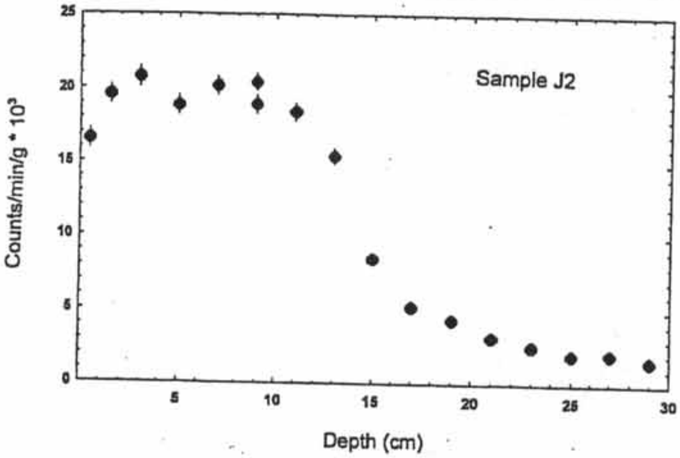

Figure 2. *A typical profile for a sample. The location of where the sample was taken is given in Figure 3.*

sufficient statistics are needed for the 661.7 keV gamma ray peak. An extensive number of locations on Caddo lake have been recently examined (Barrett, 1995). The seven cores that were taken in this work were selected from these locations so as to get a complete overall data base for the lake with a minimum number of cores taken. These samples included locations near the freshwater delta where the Big Cyprus bayou enters the lake, a small bay, near the middle of the lake along a line of sediment sample sites, in a large bay that was once James Bayou which has a history of oil activity, and near the dam. A more extensive discussion of the sediment history and a more global study of the lake is in (Barrett, 1995).

EXPERIMENTAL PROCEDURE

Cores are taken with a coring device that is a modification of a previously used device (Meriwether, personal communication, 1994). Basically, two 5 cm (2 in) diameter PVC pipes are connected with a soft rubber collar and held fixed by a hose clamp. The top piece of the device is fitted for a screw-on cap, the bottom part of the top piece near the coupling has a fitting with a hole on the side that is capped with a rubber stopper. Before collecting the sample the screw cap is left off and the rubber stopper is in place. The bottom piece of PVC pipe is then lowered into the water (depth of the lake where samples were taken ranged from 1 to 3 m (3 to 10 ft)) and then pushed down into the lake bottom to obtain the core, usually a piece 45 to 60 centimeters (18 to 24 in) long. Once in place, the screw-on cap is put on the top to form a seal that creates a partial vacuum in the coring device. The device is quickly pulled to the surface and a cap is quickly placed on the bottom of the sample. The rubber stopper is then removed so as to lighten the device and to allow for the uncoupling of the core sample taken. The bottom piece that contains the core is then removed and the top part is capped. Thus one has a 5 cm (2 in) PVC pipe approximately 45 to 60 centimeters (18 to 24 in) long that contains the sediment. Care is taken to keep the sample upright so that the sediment will not mix.

The core is first frozen and then 2 centimeter (0.79 in) sections using a band saw. Each core section is then placed into a Pyrex petri dish. These samples are then dried in an oven at approximately 150° C (300° F) for about one day. The sample is ground into a powder using a mortar and pestle and then its mass is measured. A petri dish is containing the sample is placed approximately 1 cm (0.39 in) from the HpGe detector which is inside a Pb brick castle.

The sample is counted for three to four days in order to obtain good statistics and then peak fit using Gammavision. The absolute efficiency of the detector is not known due to a lack of a standard. Therefore, the data is reported in the form of counts/min/g (counts per minute per gram of material). Thus the time of the counting period and the mass of the sample is taken into account. In order to ensure that the efficiency of the detector does not change appreciably during the counting of the core samples, occasionally a section is recounted twice after about few weeks have elasped. These different values agree with one another, therefore one assumes a relatively constant efficiency of detection for each core sample.

The detector is an EG&G Ortec GEM model 10175-P with a 10% efficiency, housed in a vertical configuration cryostat placed in a 30 liter dewar. The detector is supplied high voltage and interfaced to a PC using the EG&G Ortec Model 92X Spectrum master along with Gammavision software.

RESULTS

The location and labels of the coring sites is shown in Figure 3. The labeling matches a previous designation given to the coring sites (Barrett, 1995). Sedimentation rates determined by the earlier mentioned method are given in Table 1 for the seven coring sites.

Figure 3. *Sample locations sites on Caddo Lake. The dots represent sample sites from Barrett (1995). The labeled areas mark the core sites for this study.*

Location	Sedimentation Rate (cm/yr)
J1	0.22
J2	0.30
G-6A	0.18
G-8A	0.56
G-9A	not measurable
1	not measurable
4	0.22

Table 1 *Modern sedimentation rates for the sample sites. All measurements have an uncertainty of ± 0.03 cm/yr.*

Two of the samples 1 and G-9A, exhibit no shoulder in the data. The activity as a function of depth just steadily decreases from the surface. Thus, no measurable sediment has occurred in these two regions since 1963. This is understandable due to their locations in the lake. Sample one was taken in a back shallow bay that has no major source of incoming water such as a bayou, while sample G-9A was taken near the dam. Barrett (1995) also lists these areas as having a low sedimentation rate after 1873, the time when the Red River log-jams that formed Caddo Lake were finally cleared.

Samples 4 and J1 were taken on the Texas side of the lake near the freshwater delta that formed where the Big Cyprus Bayou enters the lake. Both have the same sedimentation rate of 0.22 ± 0.03 cm/yr (0.09 ± 0.01 in/yr) . Sample J2 was taken in a location along the line of site series of measurements previously obtained (Barrett, 1995). The results here are 0.30 ± 0.03 cm/yr (0.12 ± 0.01 in/yr). Samples G-6A and G-8A were taken in the James Bayou area with G-8A taken in a channel in the bayou and located near a number of homes with docks and boathouses. James Bayou is the second largest input source of water into Caddo Lake. Sample G-8A has the highest sedimentation rate observed in the lake 0.56 ± 0.03 cm/yr (0.22 ± 0.01). This maybe due to its location in a channel along the bayou and also due to human activity in this area. Sample G-6A was taken away from the channel near an island and exhibits a rate of 0.18 ± 0.03 cm/yr (0.07 ± 0.01 in/yr).

CONCLUSIONS

The sedimentation rate from 1963 to the present varies among locations in Caddo Lake from unobservable in a back bay and near the dam to 0.56 cm/yr (0.22 in/yr) in a channel in James Bayou. It was expected that this rate in the bayou should be comparable to those taken in the freshwater delta region, 0.22 cm/yr (0.09 in/yr) since these are the two main water inputs to the lake. However, in the delta the sedimentation rate is less than one-half of the 0.56 cm/yr (0.22 in/yr) rate, and is comparable to the other location taken in James Bayou. It would be interesting to take more samples in the freshwater delta region and in James Bayou to further explore these differences and this maybe done in a future study. Finally, computer modeling of the data will be attempted sedimentation models.

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