Laser Diffraction Particle Size Analysis of Little Lake, Oregon

By: Rebecca A Puta, Advisor – J Elmo Rawling III

Paleolimnology is the study of ancient lake sediments and the significant paleoenvironmental records preserved in them. Examining these sediments and the organic remains in them gives us a better understanding of how vegetation, climate and forest-fire systems respond to changes similar in scale to those predicted for the near future. Although these studies are common, the linkage between these systems and landscape evolution is less understood. This project used a 16-meter core from a previously studied lake to test the relationship between changes in median particle-size and other paleoenvironmental proxy. Particle-size analysis was performed every ten centimeters using a Malvern Mastersizer 2000E laser diffraction particle-size analyzer after pretreatment for organic matter. Some changes in particle-size distribution correlate well with previously published periods of climatic, vegetation and forest fire frequency change.

Introduction

Records of climate and vegetation change over time in an area are found from many sources, including lake and ocean sediments, wind-blown deposits, ice cores, tree rings, coral, and historical documents (US Global Change Research Program, 2003). Paleolimnology (Cohen, 2003) is the study of ancient lake sediments and the significant paleoenvironmental records preserved in them. These deposits are records of past vegetation, climate and forest fire frequency changes that span several thousands of years. Examining these sediments and the organic remains in them gives us a better understanding of how these systems respond to changes similar in scale to those predicted to occur in the near future (i.e. global warming). Although lake studies are common, the linkage between these systems and landscape evolution are not. This study will analyze sediments from Little Lake to compare with charcoal analysis conducted by Dr. Colin Long of UW-Oshkosh to test if there are correlations between them.

Previous charcoal, pollen and organic matter analyses of Little Lake has led to the determination that the climate of this area was colder and drier approximately 42,000 years ago, and that the land supported an array of vegetation much different from that of the present day. Previous charcoal analyses of Little Lake sediments also correlate to changes in forest fire frequency and intensity over time (Long and Whitlock, 2002). However, analysis of particle-size analysis distribution of Little Lake sediment has not been conducted. This analysis could provide valuable insight into sediments have on the immediate landscape and deposition into the lake from various sources and events.

Study Area

Little Lake is a small, landslide-dammed lake located in western Oregon, nestled in the Coastal Range forests between the Pacific Ocean coast and the Cascade Mountains at 44°10’03” N, 123°35’01”W (Figure 1). Cool wet winters and warm dry summers characterize the climate of the Oregon Coast Range (Hemstrom and Logan, 1986). The lightning storms that occur during the dry summer period are most likely the main source of the forest fires that are quite common in this area, but the logging industry has also provided the area with an effective ignition source over the last 200 years (Agee, 1993). The Little Lake area is now predominantly covered by a second-growth Douglas fir forest. Several other species of hardwood trees occupy the area, but rushes, sedges, and grasses comprise the land within 60 meters of Little Lake (Worona and Whitlock, 1995).

Figure 1 – A photo of Little Lake, Oregon taken by Dr. Colin Long of UW-Oshkosh.

Methods

Core 06A was collected from the fen of Little Lake in June of 2006. The 06A coring site was within 5 meters of two other published long core records that were collected in 1991 (Worona and Whitlock 1995) and 1997 (Grigg and Whitlock 1998, 2000). There was also a long core collected from the lake itself in 1993 (Long et al. 1998). The age model presented here is based on three unpublished ^{14}C AMS ages, the Mazama tephra, and the age models from the nearby cores. All ages used and presented were calibrated using CALIB version 5.0.2html (Stuiver and Reimer 1993).

Laser diffraction particle-size analysis of the Little Lake samples was performed following Sperazza (2004), to determine the size of the sediments in each of the samples and how the size changes among the samples. A Malvern Mastersizer 2000E laser diffraction particle-size analyzer was used to perform this test. The samples were dispersed by chemical treatment (NaHMP) and ultrasound, and organics were oxidized with a pre-treatment of sodium hypochlorite (NaClO). Each sample took approximately ten minutes to analyze. The data for the samples were then represented on a graph that show the particle size of the sediment (in micrometers, µm) and change in volume. The peak of the curve indicates what the sediment is primarily comprised of, and as the curves from other samples are also placed on the graph, it is easy to see the minute or significant changes in the particle size from sample to sample. Median particle-size (d50) was then plotted by age and compared to previously published paleoenvironmental phases.

Results

Age control for the core was derived from previously published age-depth models, three AMS radiocarbon ages and the Mazama tephra (Figure 2). In general, median grain-size coarsens upward but there are periods when there is little change or the variance changes. The following means and standard deviations (SD) are reported in microns and the description of variance (low, moderate and high) is relative to this core only. Between ~30.0 and 23.5 ka BP sediment is fine with low variability (m= 5.6; SD=0.37). Between ~23.5 and 16.0 ka BP sediment is also fine with slightly more variability (m=5.8; SD=0.48). Between ~16.0 and 11.0 ka BP median grain-size increases from 6.0-9.0 microns with moderate variability (m=7.0;

SD=0.95). Between ~11 and 9.0 ka BP median grain-size increases from 8.6-14.0 microns with high variability (m=10.5; SD=2.3). Between ~9.0 and 5.0 median grain size is slightly coarser with high variability (m=12.8; SD=2.0). Between ~5.0 and 2.0 ka BP median grain-size changes little but the variance decreases (m=12.1; SD=0.90). Between ~2000-1000 ka BP median grain-size increases from 15-21 microns with the most variability (m=16.9; SD=2.6). Median grain-size decreases after ~1000 ka BP from 12-8.5 microns with more moderate variability (m=9.5; SD=1.4). Some of these periods correlate well with previously published periods of climatic, vegetation and forest fire frequency change (Figure 3).

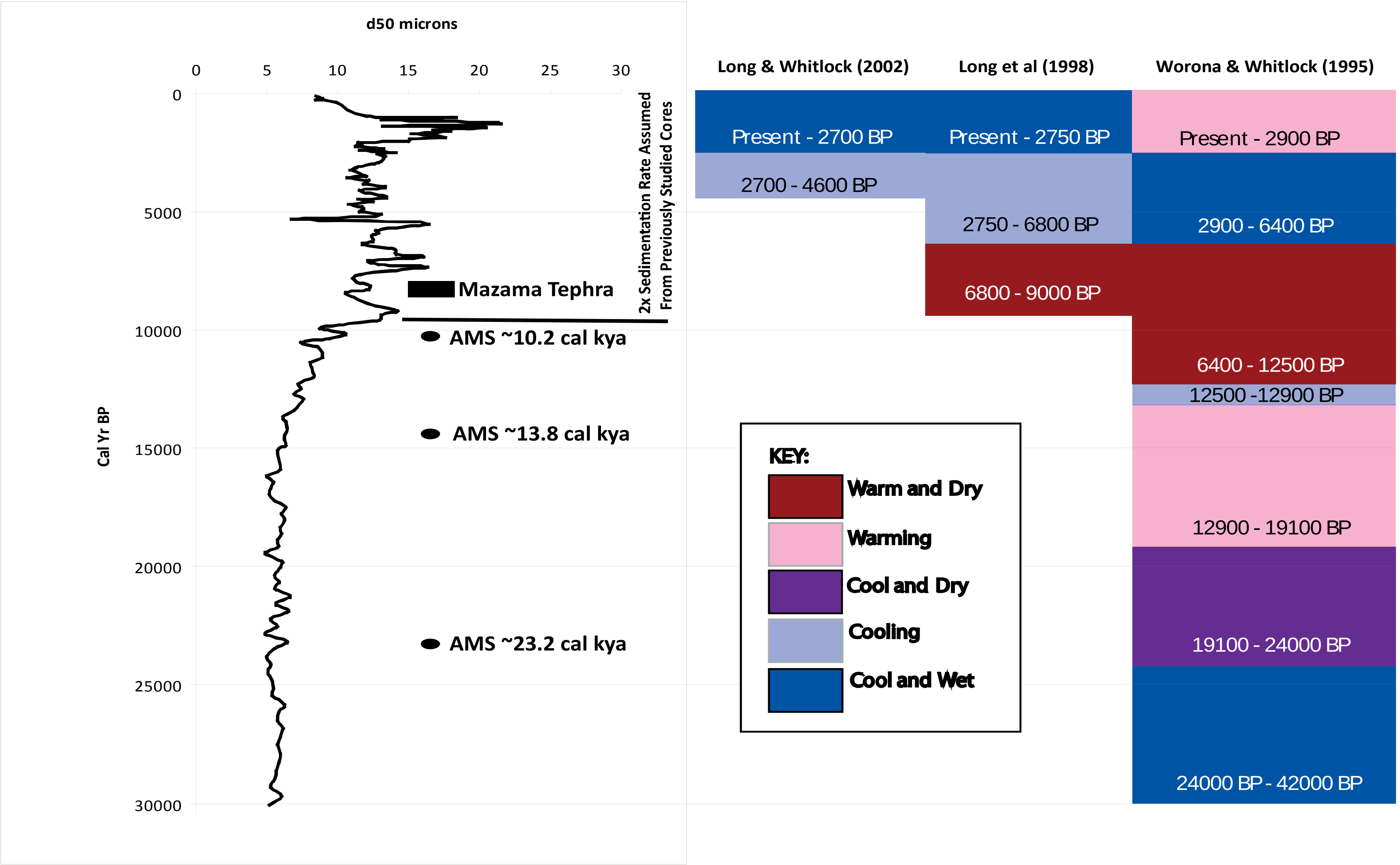

Figure 2 – Three AMS ages and the Mazama Tephra as age control for the samples, compared to previously published works on the past climate and vegetation regimes of Little Lake.

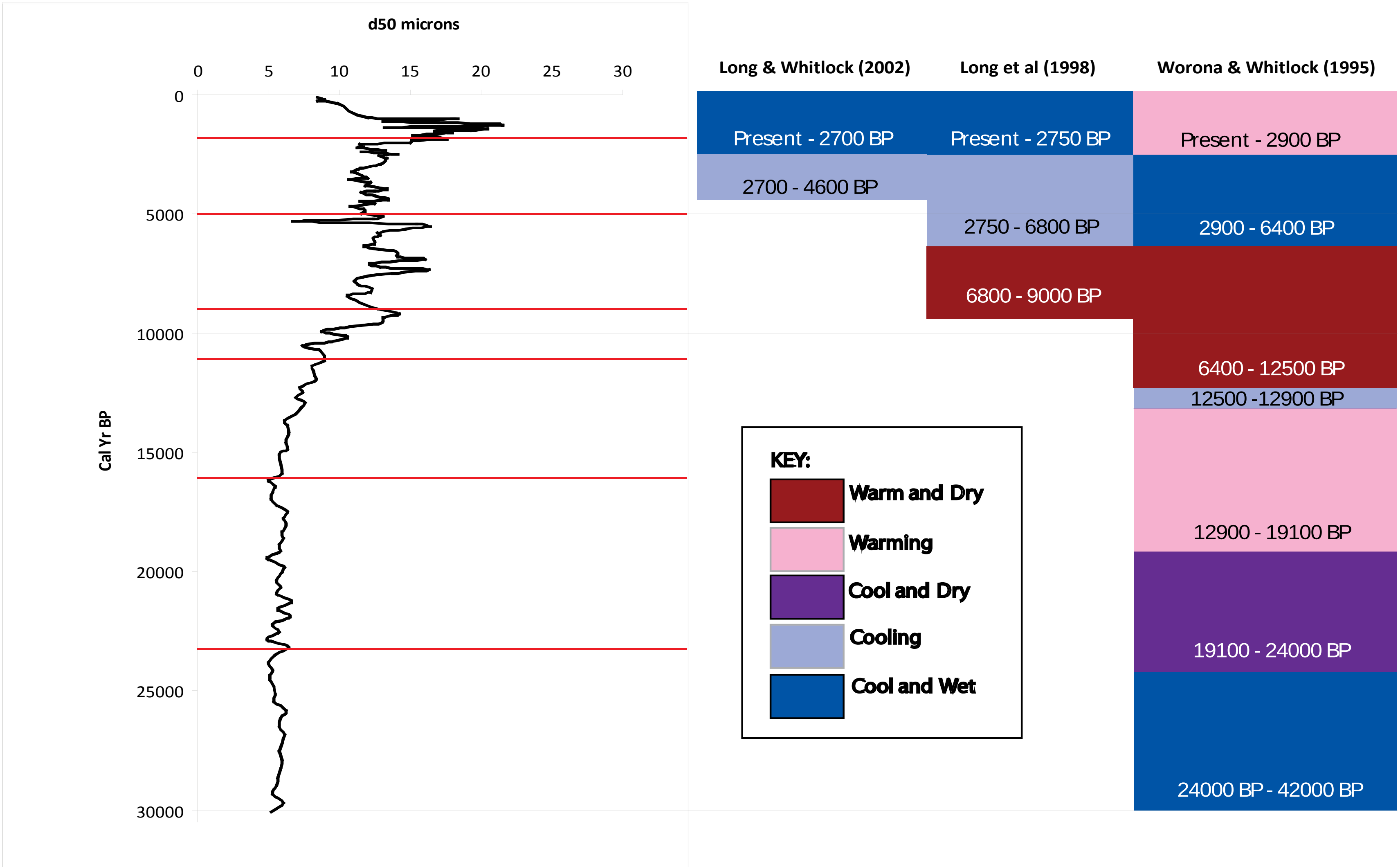

Figure 3 – Distinct periods of change in particle-size variability, compared to previously published works on the past climate and vegetation regimes of Little Lake.

Conclusions

Based on these analyses there are correlations between paleoenvironmental changes and particle-size distribution (median particle-size and variability). These interpretations are based on previously published studies of Little Lake (Grigg and Whitlock 1998, 2001; Long and Whitlock 2002; Long et al. 1998; and Worona and Whitlock 1995). Correlations occur within three distinct periods, the Late Pleistocene (30-11 cal kya), the Early Holocene (11-5 cal kya) and the Late Holocene (2 cal kya-present). During the Late Pleistocene, sediment is relatively fine grained likely due to dryer climatic conditions and less efficient overland flow to the lake. In the Early Holocene, though, sediment becomes coarser likely due to better overland flow from increased forest fire frequency. Finally, in the Late Holocene, the coarsest and most variable sediments were deposited likely due to an increase in fire size, due to biomass increases from cooler and wetter climatic conditions. Comparisons of the particle-size graphs and charcoal analyses from this core are pending, and these may help refine our paleoenvironmental interpretations. In addition, the depth model for Little Lake may have to be reevaluated because periods with coarser deposition likely also included faster sedimentation.

Acknowledgements

Special thanks goes to the UW-Platteville Office of Sponsored Programs and the Pioneer Undergraduate Research Fellowship committee for providing funding and support for this study, as well as to Drs. J Elmo Rawling III, Rich Waugh, H Todd Stradford, and Colin Long (UW-Oshkosh) for academic and professional advice. Thanks to Edward and Rhonda Puta, Becky Trewartha, Erica Boatman, Sam Miller, Jacob McCulley, Megan Walsh, and Evan Larson as well for advice and constructive criticisms while conducting and analyzing research.

References

Agee J.K. 1993. "Fire ecology of Pacific Northwest forests." *Island Press: Washington, D.C.*

Cohen, A.S. 2003. Paleolimnology. *Oxford University Press*. 3-5.

Grigg, Laurie D. and Whitlock, Cathy. 2001. Evidence for Millennial-Scale Climate Change During Marine Isotope Stages 2 and 3 at Little Lake, Western Oregon, U.S.A. *Quaternary Research.* 56: 10-22.

Grigg, Laurie D. and Whitlock, Cathy. 1998. Late Glacial Vegetation and Climate Change in Western Oregon. *Quaternary Research.* 49: 287-298.

Hemstrom, M.A., and Logan, S.E. 1986. "Plant association and management guide Siuslaw National Forest." USDA For. Serv. Rep. No. R6-Ecol 220.1986a.

Long, Colin et al. 1998. A 9000-year fire history from the Oregon Coast Range, based on a high-resolution charcoal study. *Canadian Journal for Forest Research*. 28:774-787.

Long, Colin and Whitlock, Cathy. 2002. Fire and Vegetation History from the Coastal Range Forest of the Western Oregon Coast Range. *Quaternary Research*. 58: 215-225.

Sperazza, M., Moore, J.E., and Hendrix, M.S. 2004. "High-resolution particle size analysis of naturally occurring very fine-grained sediment through laser diffractometry." *Journal of Sedimentary Research*. 74: 736-743.

Stuiver, M. and Reimer, P.J. 1993. Extended 14C database and revised CALIB radiocarbon calibration program. *Radiocarbon.* 35: 215-230.

US Climate Change Science Program: Paleoenvironment and Paleoclimate.

http://www.usgcrp.gov/usgcrp/ProgramElements/paleo.htm October 12, 2003

Worona, Mark and Whitlock, Cathy. 1995. Late Quaternary vegetation and climate history near Little Lake, central Coast Range, Oregon. *GSA Bulletin*. 107, 7: 867-876.