T26-47

USING X-RAY COMPUTED TOMOGRAPHY TO PROVIDE UNDERGRADUATE RESEARCH OPPORTUNITIES

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Introduction

X-ray computed tomography (XRCT) is a nondestructive method that is used in numerous research disciplines, including Earth Sciences. Acquiring data is relatively simple, cost effective, and requires little (if any) sample preparation. 2D radiographs are collected and then reconstructed to render a 3D representation of the sample. The resulting 3D volume is useful for both visual inspection and for more quantitative analysis. After separating the object of interest from the rest of the sample a variety of measurements are possible. At the University of Minnesota (UMN) the XRCT lab has become an integral part of undergraduate research. Research projects are tailored to the experience level, time constraints, and interests of the student(s). Several Research Experiences for Undergraduates (REU) interns (a National Science Foundation program) have recently finished 10 week summer research projects that included XRCT data. We also have students from nearby colleges that are using XRCT as part of their senior research projects. In some cases XRCT is used to develop and test techniques prior to field work. This allows the student to collect better data in while in the field, it maximizes their chance to succeed, and gives them confidence in the field. After collecting samples the student will come back to the lab to scan their samples and use our image processing lab to analyze their data. For longer term projects students can enroll in directed studies classes and work in the lab on an ongoing basis, meeting periodically with their adviser. Working in the XRCT lab has allowed students to gain valuable research experience, attend conferences to present their results, and in the near future will likely allow students to coauthor papers with their adviser. The 3D aspect of XRCT helps students better visualize and understand problems in Earth Sciences.

Acknowledgments

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References

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6. Liu, L., Puolamäki, K., Eronen, J. T., Ataabadi, M. M., Hernesniemi, E., Puolama, K., & Fortelius, M. (2012). Dental functional traits of mammals resolve productivity in terrestrial ecosystems past and present. Proceedings of the Royal Society, 279, 2793–2899. doi:10.1098/rspb.2012.0211.
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More Student Research Posters

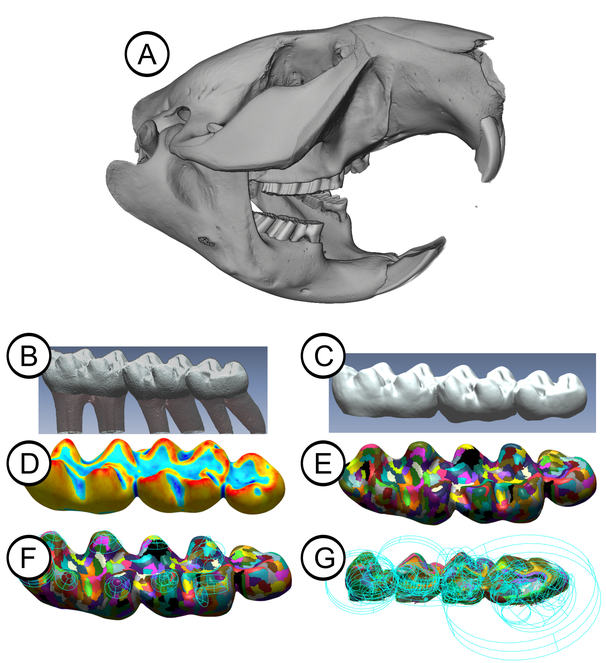
Armendarez, H. and Bagley B., *Investigation of Chondrules and Metal in Allende (CV3) and Jelica (LL6) Using X-ray Computed Tomography*, T165-247. Sigma Gamma Epsilon Undergraduate Research (Posters), Tuesday, 29 October 2013: 2 - 4 PM, and 5 - 6:30 PM -booth 320.

Heywood, L.J., Nachlas, William O., Teyssier, C., and Whitney, D.L., *The effect of Deformation on Accessory Phase Distribution in a Quartzite Mylonite*, T213-255. Through the Looking Glass: Microstructural Insights into Tectonic Processes, Tuesday, 29 October 2013: 9:00 AM-6:30 PM Hall D.

Society of Vertebrate Paleontology Annual Meeting November 2, 2013
Keller, J. and Fox D.L., *Dental morphometrics predict specific trophic categories in rodents,* 841-B78. Westin Bonaventure Hotel, 4:15-6:15pm.

Directed Studies

Jonathan Keller is working on a directed studies project under the supervision of David Fox. Dental morphology of more than 50 scanned rodent species was quantified as Dirichlet normal energy (DNE, a measure of curvature), orientation patch count rotated (OPCR, a measure of tooth complexity), planimetric relief index (RFI), volumetric hypsodonty index (HI, a measure of relative crown height), shape extraction, and region count (a measure of composite tooth shapes). We thresholded initial tooth volumes to produce two surfaces: one surfaced at the greyscale value for dentin, one at the value for enamel. A spline was fit to the enamel mesh, which allowed us to functionally define the crown surface and to reliably crop the dentin mesh by the enamel-dentin junction (EDJ). These surfaces then underwent iterative smoothing and were downsampled to a standardized number of poly-faces. Others have also used OPCR, RFI, and/or DNE to characterize diet in carnivorans, chiropterans, multituberculates, and primates [1,2,3, 4].These ecometrics allow accurate prediction of diet in extant species. We attempted to differentiate fine trophic categories: folivores, granivores, insectivores, and omnivores across 8 families within Rodentia. Paleoclimates of extinct ecosystems containing fossil rodent teeth may then be predicted by niche-modeling data derived from biogeography of extinct species and diet predicted from these dental morphometrics [5]. Recent research has also correlated important ecosystem variables such as average rainfall and temperature with dental morphology of ungulates [6].



A. 3D reconstructed volume of Castor canadensis (American beaver). B. EDJ delineation of Peromyscus gossypinus (cotton mouse). C. Final dentin mesh of P. gossypinus that has been cropped and smoothed. D. Tooth row of Onychomys leucogaster (killer mouse) mapped by curvature. Red indicates high, positive curvature while blue indicates low, negative curvature. E. Region count view of O. leucogaster. F. Partial shape extraction map of O. leucogaster: preliminary results associate cones with insectivory and cylinders with forms of herbivory. G. Full shape extraction of cylinders for Cynomys ludovicianus (black-tailed prairie dog).

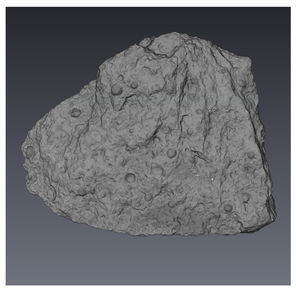
Jonathan will be presenting at SVP 2013

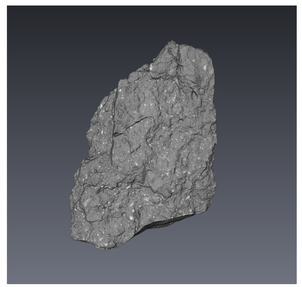
Research Experiences for Undergraduates

The Research Experiences for Undergraduates program is a 10 week summer internship funded by the National Science Foundation. During the summer of 2013 Hannah Armendarez studied two chondrites (Allende and Jelica) from the meteorite collection at the University of Minnesota. After some initial training Hannah was able to scan all of her samples independently. After scanning she used Avizo Fire for image processing. The goal was to separate the chondrules and metal phases and look at the abundance, distribution, shape, and orientation of each.

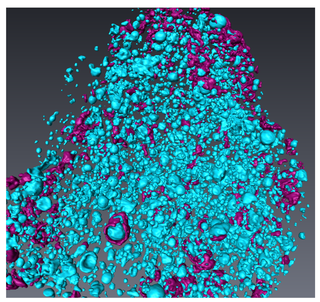
Allende - CV3
Carbonaceous Chondrite

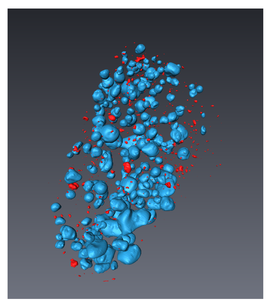
Jelica - LL6
Ordinary Chondrite





3D volume renderings of Allende (Left) and Jelica (right).





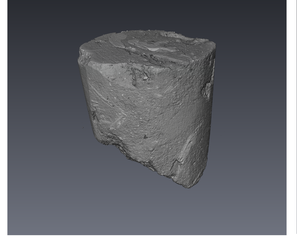
Left) 3D volume rendering of Allende after segmentation and separation of the chondrules (blue) and the metal phases (purple). Right) 3D volume rendering of Jelica after segmentation and separation of the chondrules (blue) and the metal phases (red).

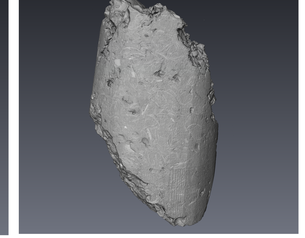
Hannah will be presenting more details on Tuesday at booth 320

Senior Thesis

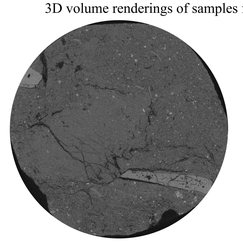
For her senior thesis Tori Lewis is studying microfossil bonebeds in the Judith River Formation of north-central Montana [7]. Tori and her adviser (Ray Rogers) are trying to establish how microfossil bonebeds form. Working in the XRCT lab Tori established the best sample size and shape so that she would be prepared for collecting samples in the field. During the summer of 2013 Tori traveled to Montana with her adviser and other students from Macalester to collect oriented samples. She is currently working to scan and analyze all of the samples in the XRCT lab. She will also be processing the some of the samples in the wet lab at Macalester to compare the results from XRCT to what is actually present in the rock.

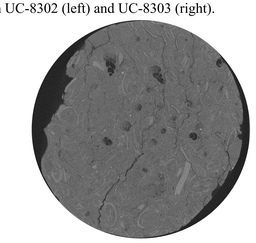
Field photos of sites UC-8302 (left) and UC-8303 (right) in the Judith River Formation of north-central Montana.



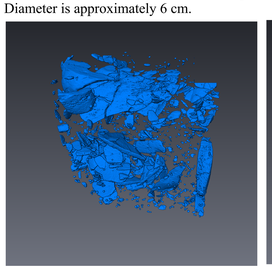


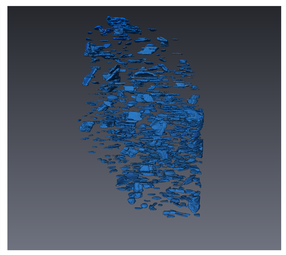
3D volume renderings of samples from UC-8302 (left) and UC-8303 (right).





Slices through the 3D volumes of samples UC-8302 (left) and UC-8303 (right). Sample Diameter is approximately 6 cm.





3D volume renderings of samples after segmentation and separation using Avizo Fire.