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New Technology, New Opportunities: Development of a National Chert Characterization Database

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Executive Summary

Source attribution of chert artifacts was undertaken through the use of a portable X-Ray Fluorescence instrument in the development of a national database for chert characterization. The long duration of the formation process for chert, however, confounds such simple analysis. Although the source materials were able to be distinguished from one another, attribution of artifacts from unknown sources to the database proved elusive.

Source materials were collected from both primary and secondary deposit locations. Secondary deposit locations were determined from early screening analysis to have considerable diversity within the samples. The within-source variation was greater than variation between sources, probably resulting from the highly diverse origins for the gravels.

Primary source material was collected from sites across the southeastern US, and additional material from Ohio was provided from a mineral collector. The collection is incomplete, and could be augmented in the future from amateur and professional collectors. Nevertheless, the material collected allowed for the elemental analysis of source materials to see if the elemental makeup of source materials could be distinguished using pXRF.

The result of the initial analysis was the identification of differences among sources. Materials collected from disparate locations were distinguished from one another using principal component analysis (PCA). There remained, however, considerable overlap among the different source materials.

A collection of materials from across the southeastern US was then analyzed to see if artifacts of unknown source material could be attributed to specific sources. Once elemental

analysis was completed for the artifacts, identical post-analysis methods were used to compare the artifacts to the array of source analyses previously completed. The result of the artifact analysis was a broad spectrum of PCA graph points that coincided better with the results of secondary source materials, instead of clustering around the primary source arrays. The artifacts were not able to be attributed to a source.

One factor that could impact the analysis is the leaching of minerals from artifacts as a result of weathering. Source materials were analyzed using the pXRF instrument on fresh breaks, providing an analysis of unweathered cherts. Artifacts, however, were analyzed on weathered surfaces; one of the advantages of the XRF technology is that it does not require the destruction of the artifact for analysis. The coincidence of PCA distribution of artifacts from the Pohler collection with the secondary deposits from the Baby Ruth #2 site suggests that the overlap could result from long-term weathering, which could leach minerals from the surface of the artifact. Future testing on recently broken artifacts could assist in determining whether leaching provides a confounding effect on the elemental analysis of artifacts.

The artifacts from the Pohler collection were not able to be attributed to source based on the pXRF instrument. As the technology improves, however, additional work with the trace elements might provide an opportunity to revisit the analysis.

Introduction

The hardest reports to write are the ones that show data that fail to answer the question raised by the research. Even though they can provide valuable information, these reports and the data that they contain are often relegated to the scrapheap of academic research. The hard truth of academia is that the excitement of discovery seldom accompanies the negative test. For that reason, negative reports do not get published, dissertation drafts get turned down, and everyone associated with the project moves on to other things.

Negative data are associated with failure of a peculiar sort.

The unintended consequence of this approach is that science, as a whole, suffers from the loss. Negative data provide valuable information that can be used in any number of ways. The failure to publish these data is a significant loss, in a number of ways. It creates situations where there is unnecessary duplication of effort, it reduces the understanding that we have of the field of research, and it limits the opportunities for follow-up studies.

Researchers undertake thorough background research prior to initiating a study. The results of that literature review provide the foundation for all of the decisions made in the study – the background is the setting for all of the decisions that follow. But when negative results are not reported, the resulting omissions in the study are great, and the decisions of that study are skewed in favor of only the successful attempts.

When I was in graduate school, I heard an apocryphal account of an archaeological researcher who had received a series of dates associated with a structure, and the dates made no

sense whatsoever. After an appropriate amount of headscratching, the dates were omitted from the final report, and the next phase of the project was initiated. The nonconforming dates were filed away.

Fast-forward several years, and another researcher on an unaffiliated project received dates for a similar structure that are consistent with the first research. When she published the results, the data were met with skepticism, until the first researcher read about it, and provided additional confirmation of the unexpected dates. The unpublished research provided valuable information that was simply not available through a literature review.

The following report is an attempt to describe the results of a study that did not proceed in the way the project was conceived. From the initial interactions with the instrument provider to the final results of the analysis, the LEAP project was filled with learning experiences. And learning experiences build character, but they do not guarantee tenure.

Funded by NCPTT grant # MT-2210-08-NC-04, the report provides the results of a failed effort to characterize cryptocrystalline chert through the use of portable X-Ray Fluorescence instrument. The results are reported in their entirety, and the data are available on the website https://sites.google.com/site/leapcrorey/

This report is not, however, simply a cautionary tale. The data represent several years' worth of work to develop a national database for the elemental characterization of North American chert. The data do not paint a nice, easy picture of easily classifiable chert source fingerprints.

The data do represent, however, a starting point for additional research. And with the raw data available on the website, I intend for it to provide the ability for others to use the

elemental data as a resource – the basis for the future research. This pilot study can be used in its entirety as a building stone for additional research. Or it might just provide a researcher with the knowledge necessary to avoid following the same path.

Either way, the reporting of these negative results should be considered a success.

Materials

Materials were collected from a number of secondary locations (Figure 1) – places where gravel deposits had been deposited following glacial outflow events (Russell 1987:2). Materials collected from sites associated with "Pre-loess terrace deposits" (Bicker 1966:30) and Citronelle deposits (Matson 1916; Doering 1956; Mellon 1959) were analyzed with the pXrf instrument, and the intra-source variation far exceeded the inter-source variability. These results were not surprising, as "the gravels have a complex genesis and transportation history, and have been transported long distances from their source area" (Russell 1987: 2).

Figure 1. Secondary deposit near Natchitoches, Louisiana.

Additional cherts were acquired from primary contexts, as interest in the project spread. The resulting distribution of chert source locations was patchy, as individuals interested in the work provided materials from their personal collections. The following materials are represented in the chert source analysis:

- Onondaga
- Vanport
- Fort Payne Long Creek
- Fort Payne Chert A and C
- Warsaw Chert Long Creek
- Parker site Arkansas Novaculite
- Vinton County/Zaleski chert
- Upper Mercer
- 40SW64
- 40SW67.015
- 40SW66
- 40SW64.011

In addition to the source materials, chert artifacts were analyzed from a number of locations to test whether they would be affiliated with any of the source materials. The Pohler collection was sampled extensively, with lithic materials from all over the southeast analyzed to attribute the material to source.

The Pohler collection is a donated collection of lithic artifacts housed in the Louisiana State Museum. The collection was not provenienced beyond the level of the state in which it was collected, making it a perfect example of the kind of analysis the pXRF analysis could be useful for. A sample of the vast collection was analyzed using the pXRF device, with material from New Jersey, North Carolina, Texas, Indiana, Alabama, and Arkansas. The collection also included material without state provenience associated with it.

Methods of analysis

Physical analysis of the lithic materials was as simple as pressing a button. The materials to be analyzed were cleaned prior to the analysis, but the actual analysis required the placement of a clean surface of the material to be analyzed atop the pXRF unit (Figure 2), the pressing of a button, and awaiting the results, provided 500 seconds later. The output was a spectrum of photons that could be read through the proprietary Bruker software (which the company will provide to researchers upon request). The output is also generated as a .txt file that can be loaded as a spreadsheet.

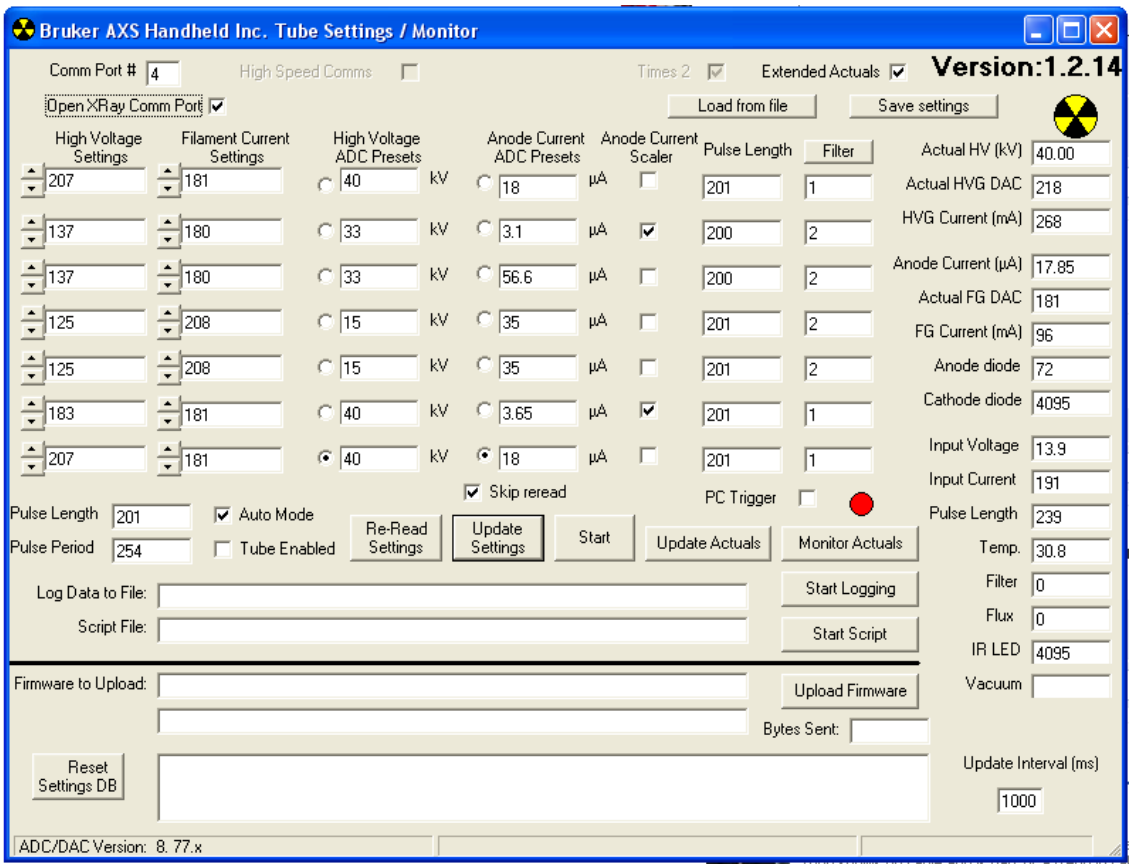

Figure 2. pXRF settings used in the analysis.

Each sample was bombarded with the electron beam at these settings for 500 seconds, and the resulting files were given a unique identifier. Five locations per sample were analyzed, and then the energy readings were averaged, to counteract any within-sample variation.

Once all five samples were completed for the artifact (or source material), the output was a spreadsheet that recorded all of the photons recorded on the rhodium plate in the instrument, with each energy level corresponding to a different element. These energy levels were plotted using the S1PXRF software (Figure 3 provides an example of the plot shows the difference between readings from a chert sample collected from two different source samples).

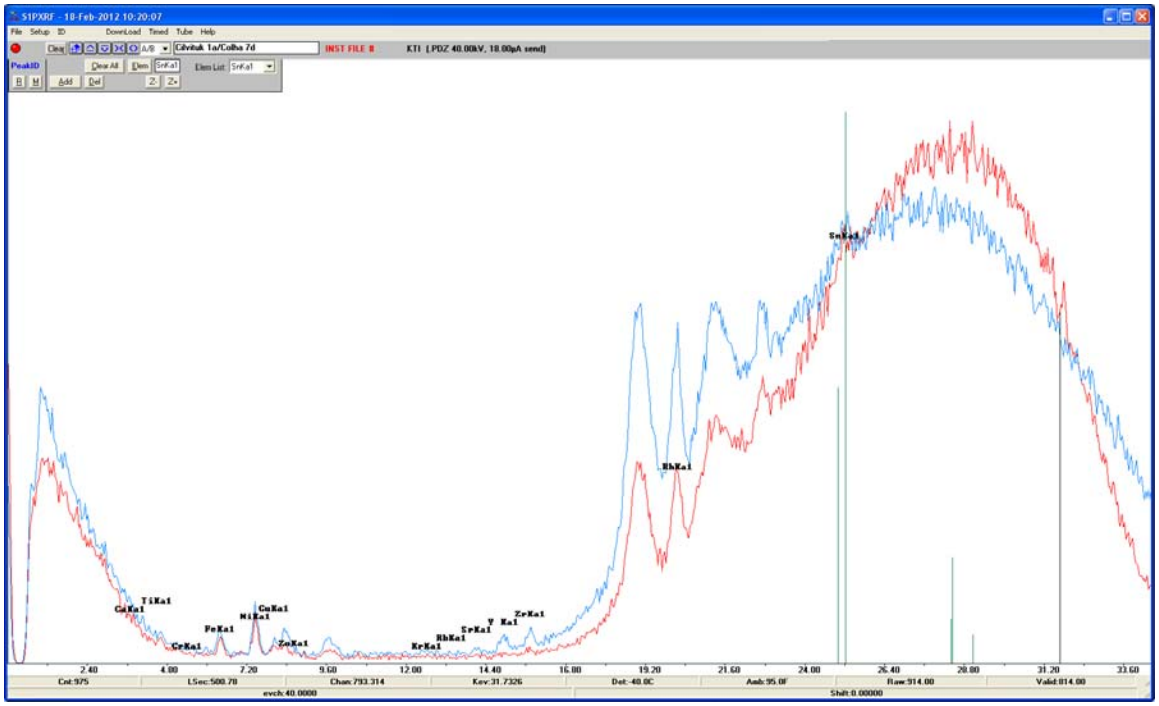

Figure 3. Spectra from two cherts.

Once the specimen had been analyzed, the next step involved the 'deconvolution' of the data through the proprietary ARTAX software distributed by Bruker. Essentially, there are two ways of measuring the "area under the curve" associated with a specific element: the "region of

interest" (ROI) analysis, and the deconvolution process. The ROI analysis measures all of the area under the curve associated with a specific element (each element would need to be identified separately), providing a precise quantity of spectrum change between two samples. The ROI does not allow for the parsing of overlapping elements, where peak interference happens. By reporting the absolute differences in photons between samples, this method avoids some of the error common in deconvolution.

Deconvolution, on the other hand, involves the removal of the backscatter, with curve fitting based on the individual element signature. Deconvolution uses the entire emission of each atom to subtract elemental interference from each element identified within the sample. The area under the curve reported for each element, therefore, is only the area attributed to that given element, regardless of the overlay between curves from different elements. By removing the backscatter and the influence of other overlapping elements, the deconvolution process identifies the net number of photons that were measured for the identified element for the duration of the analysis.

The analysis involved the identification of peaks from analyses of samples that occurred from various contexts, to ensure the inclusion of all peaks that could provide important variation. Peaks included K-peaks from cobalt, chromium, iron, nickel, tin, strontium, titanium, yttrium, zinc, and zirconium. Additional peaks – the K peaks for calcium and rhodium - were included in the deconvolution process to assist in curve-fitting (thereby maximizing the accuracy of the removal of the backscatter). These elements were subsequently removed from the analysis: calcium because of its variable presence related to cortex, rhodium because of its presence in the instrument.

Once the raw readings had been deconvoluted, the remaining energy counts were attributable to variations of elemental concentrations in the sample. Following the lead of Glascock et al. (2004), the results were then transformed to base-10 logarithms, because of the tendency of PCA to weight elements measured at high concentrations unequally (Glascock et al. 2004:100). The base-10 logarithm mitigates the effects of the dominant elements. The samples were then submitted for principal component analysis and graphed.

Results and Discussion

The results of the source material analysis showed some differentiation among the elemental readings of source materials. It was possible to identify patterns in the data through the use of principal component analysis.

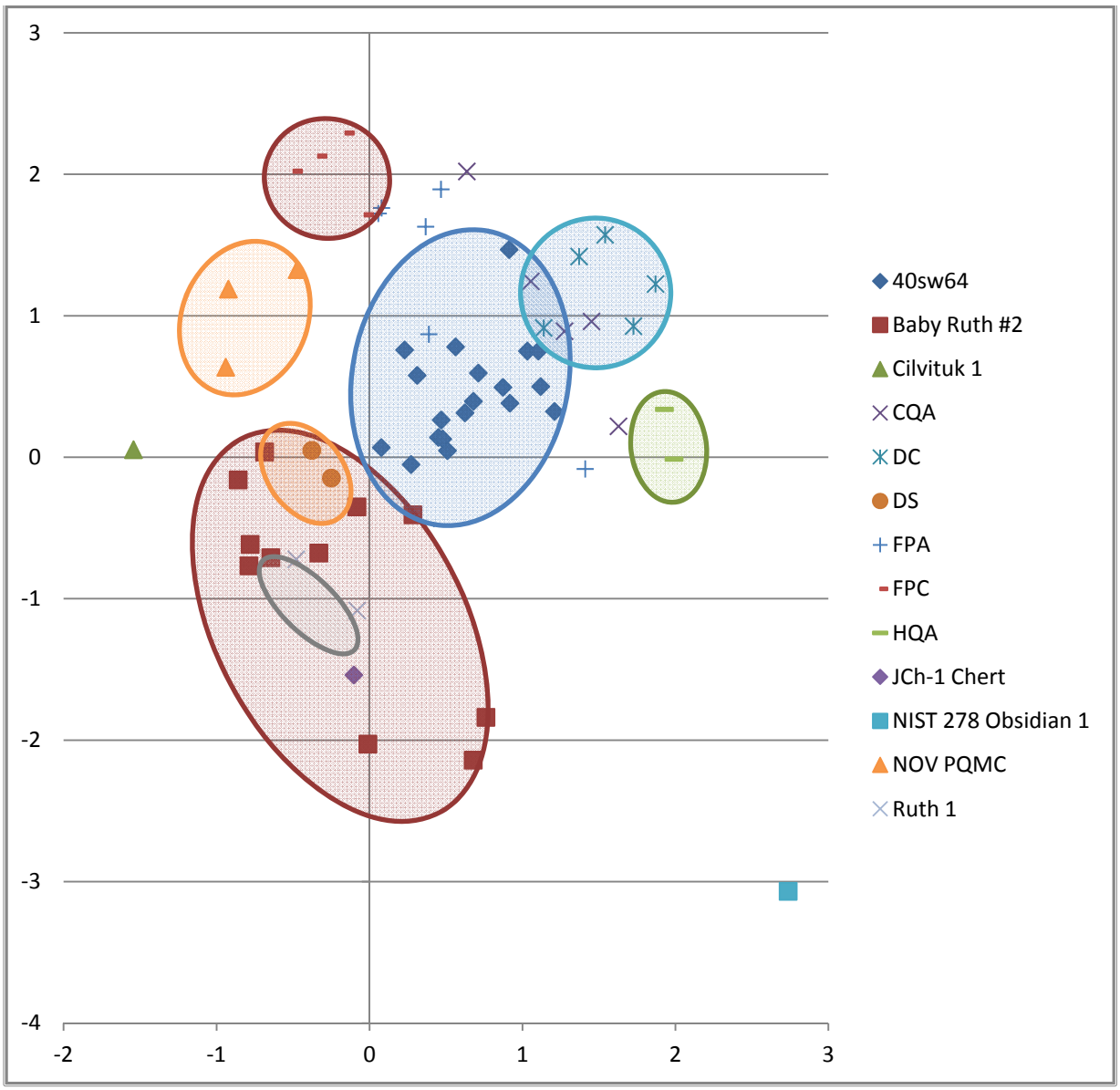

Figure 4. Principal Component Analysis of source materials.

Several of the sources clustered in tight groupings, when graphed along the two principal component axes. The cherts from the site of 40sw are tightly clustered, as are the Dover chert source materials (DC), the Fort Payne C material, and the Novaculite materials. Unsurprisingly, the Dover chert materials and the 40sw site materials (collected by Ryan Parish from quarry sites in Stewart County, Tennessee[1]) overlap considerably, since they are from similar geological context. The materials from the Baby Ruth (a secondary source deposit) and the Fort Payne A both have broader distribution across the principal component graph, and are harder to isolate. Additional outgroup comparisons (the obsidian source material, the Japanese chert, the Cilvituk chert, and the two quartzites – Hattiesburg and Catahoula quartzites) mostly lay outside the clusters of the other source materials.

The Dover materials, however, showed no clear internal differentiation among the different sources, either from the quarry sites or source materials (Figure 5). The differentiation of individual quarries within a regional collection of chert remains beyond the ability of the pXRF instrument.

[1] The sites collected by Parish are available online at: http://infosys.murraystate.edu/KWesler/Student%20research/Parish,%20Ryan%20GIS%20of%20Dover%20Quarries.pdf .

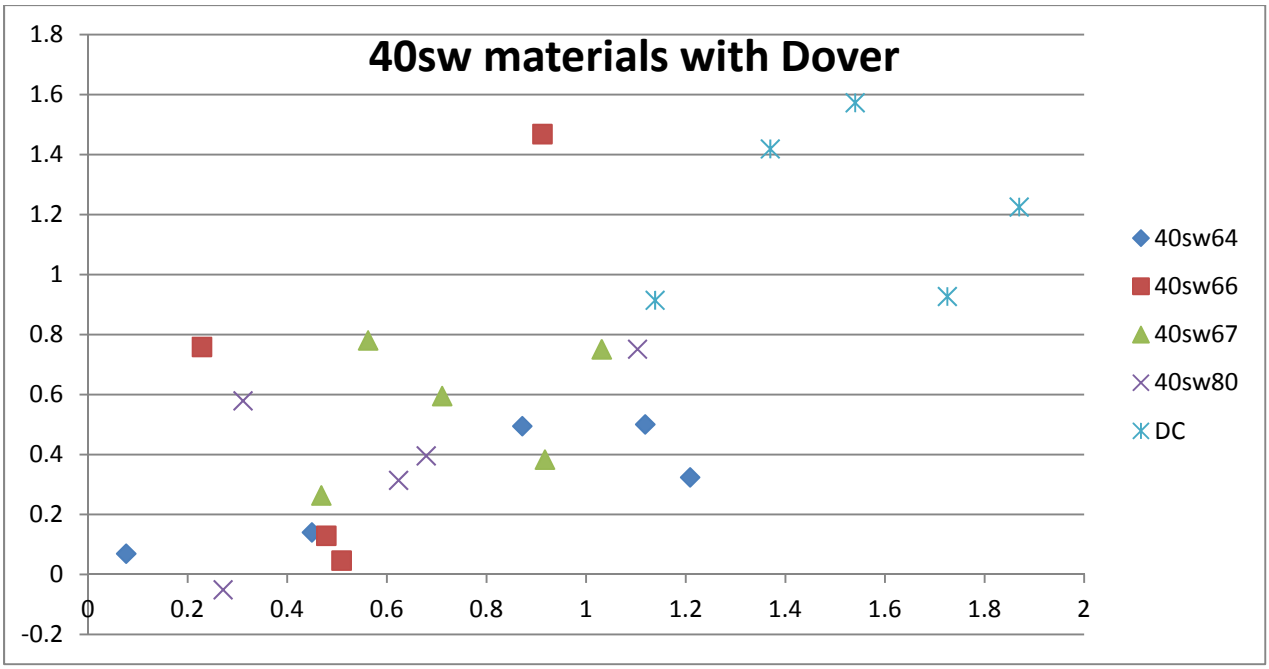

Figure 5. Tennessee cherts - Dover and 40 sw materials.

Artifacts

In 1982 and 1985, Mr. Roy Pohler donated collections of lithic materials and pottery vessels to the Louisiana Department of Culture, Recreation, and Tourism, Division of Archaeology. Ms. Sherry Wagener, director of the curation facility, has curated the artifacts from the donation in 1982 and 1985 of the Pohler collections. The collections, which consist largely of whole vessels and lithics, contain over 34,000 artifacts. Most of the artifacts are from other states and obtained by the Pohlers on the open market. The Pohler collection samples represent collected artifacts from across the southeastern United States, and provide a good test case for attributing source to sample.

Artifacts from this collection were analyzed using the methods described above. The results were not sufficient to attribute artifact to source. I grouped artifacts according to state,

and analyzed each as a unit. Each of the state groupings were analyzed using PCA, and the resulting principal components were plotted against the results from the source material.

The results did not identify clear demarcations of associations between artifacts and source materials. Each of the state-based collections overlapped multiple sources, and were loosely correlated to each other, but not to a specific source.

The material from Arkansas, labeled as being collected from Fort Smith, Arkansas, closely resembled the Novaculite materials collected from Magnet Cove, Arkansas. The elemental analysis, however, more closely resembled the distribution of the Baby Ruth #2 site, a secondary pre-loess deposit in Mississippi, and did not overlap at all with the Novaculite Parker Quarry Magnet Cove materials (Figure 6.)

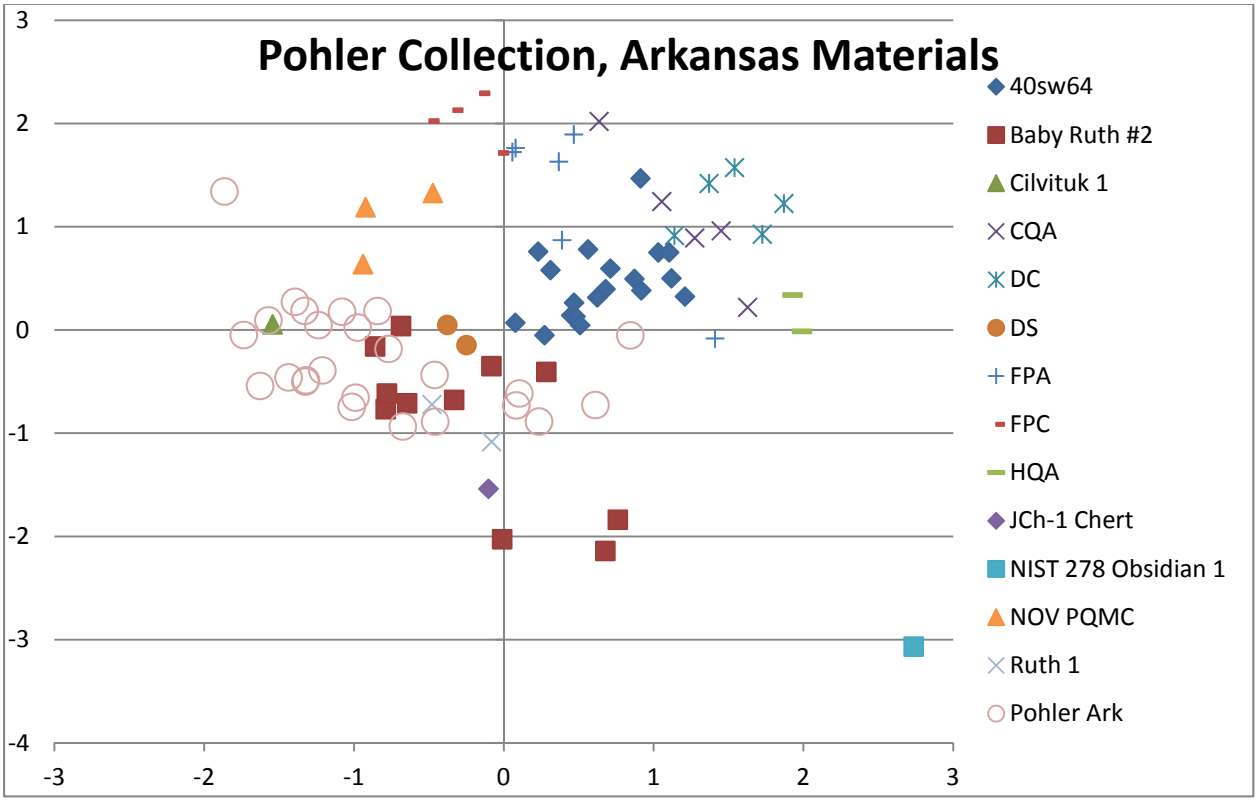

Figure 6. Pohler collection, Arkansas materials. Pohler collection artifacts are represented with a circle.

Analysis of materials from other states had similar results, with each distribution following the distribution of the secondary source more closely than any of the sources analyzed. (Figures 7-10).

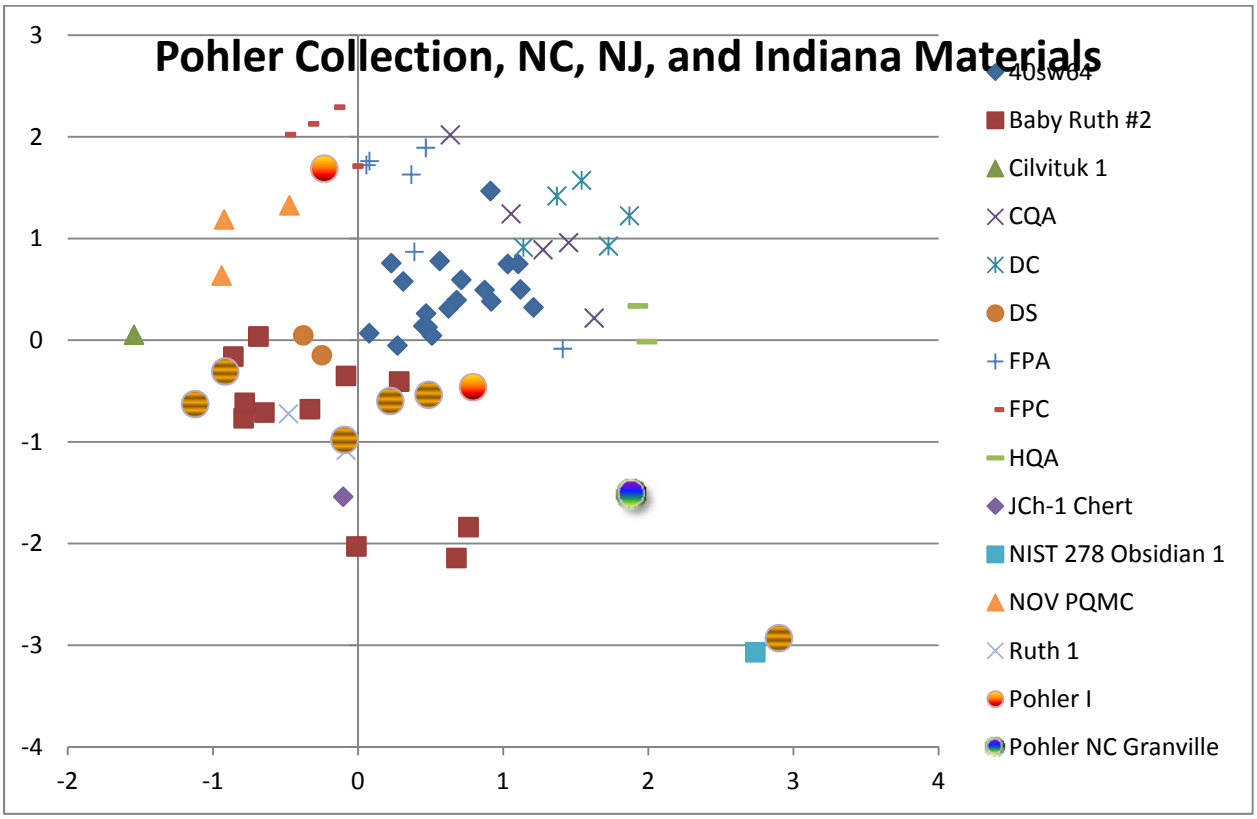

Figure 7. Pohler collection of artifacts from NC, NJ and IN.

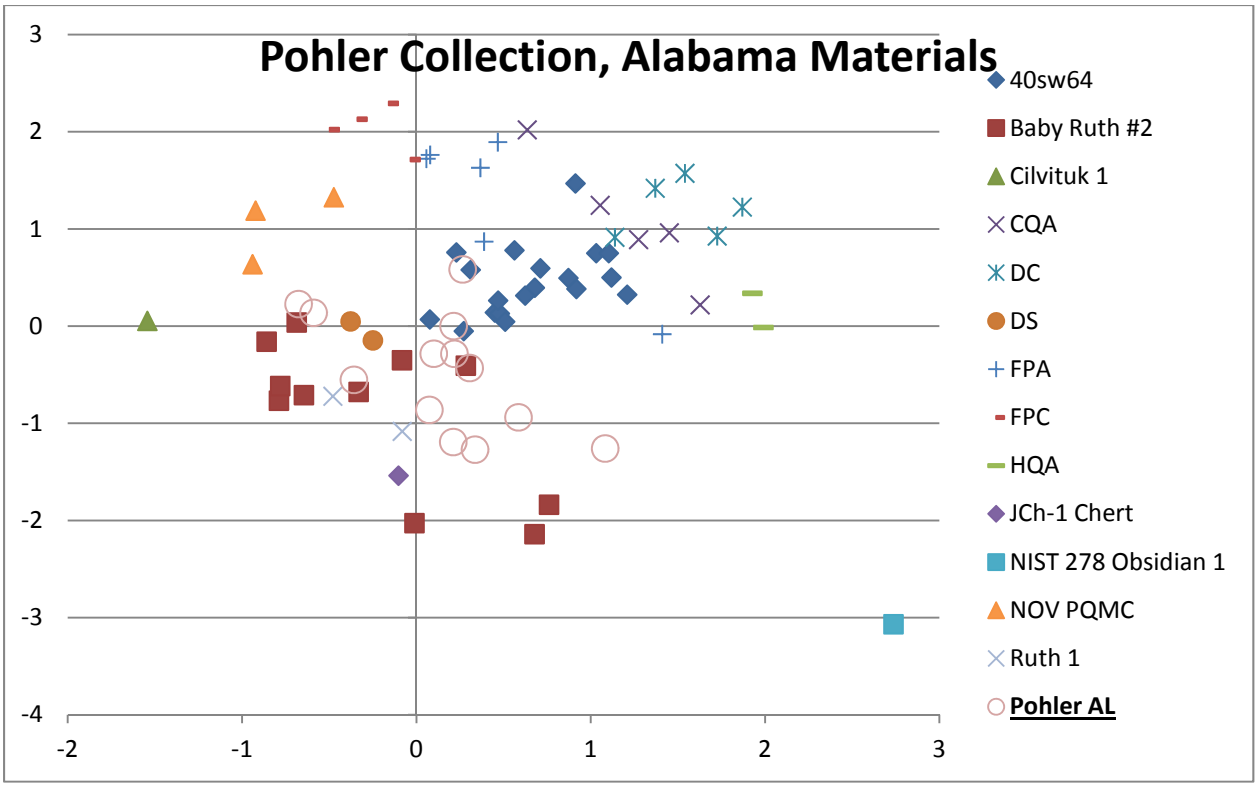

Figure 8. Pohler materials from Alabama.

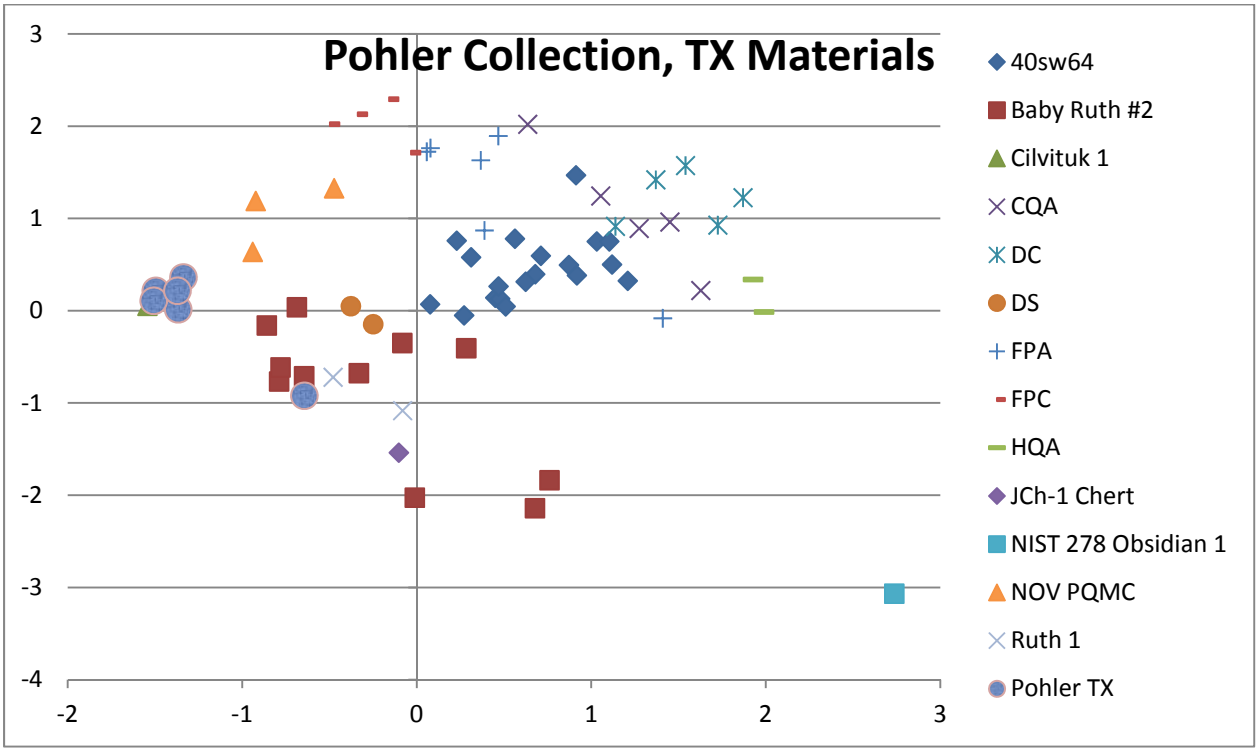

Figure 9. Pohler materials from Texas.

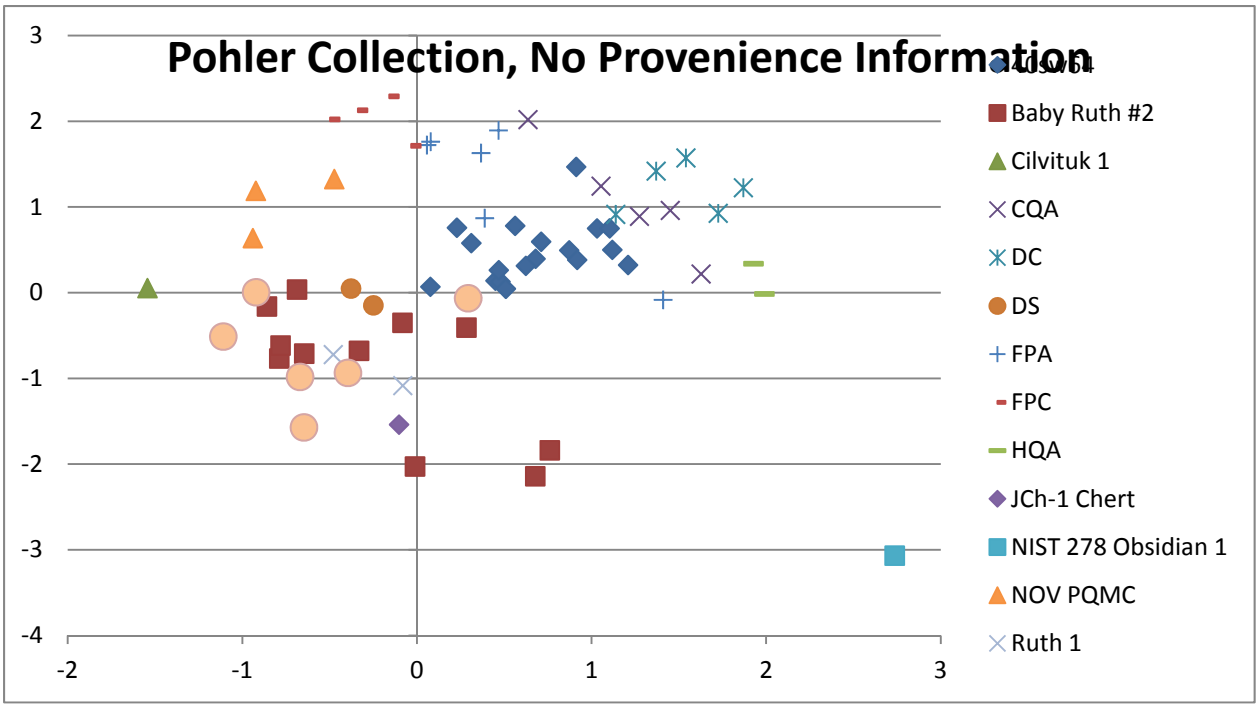

Figure 10. Pohler artifacts, no provenience.

The analysis of the artifacts appears to demonstrate no correlation between the artifact analyzed and any source material that was identified using the pXRF instrument.

Conclusions

The pXRF analysis shows promise in providing additional information for lithic analysis. Between sources, variation in the elements is enough to parse out the differences between sources.

The promise, however, remains no more than a promise. The data from the study do not allow for the easy attribution of source to artifact. Moving from the known source to the unknown artifact involves too much overlap among sources, and clustering between artifacts that is too broad to affix to a single source.

Part of the challenge of source attribution of chert has always been complications resulting from its formation (Luedtke 1992:49). The result is a material that is less uniform than obsidian, explaining its more common use in source studies. Previous success in such analyses (Luedtke 1992) have been the result of trace element analyses that use limits of detection lower than is possible for pXRF. As the portable technology improves, additional studies can re-assess the application of this technology to this intractable problem.

Acknowledgements

Thanks are due to the Middle American Research Institute, which provided funds for the acquisition of two source samples from NIST and the JCh-1 chert source. Thanks also to Pierre Burnside of the Coordinated Instrumentation Facility at Tulane for his help in undertaking the EDXRF for the project and for the conversations where he helped out a neophyte.

References

Bicker, A. R.

1966 Claiborne County Geology and Mineral Resources. *Mississippi Geological Survey*, Bulletin 107.

Doering. J. A.

1956 Review of Quaternary Surface Formations of Gulf Coast Region. *American Association of Petroleum Geologists Bulletin* 65:424.

Glascock, Michael D.

2004 Neutron activation analysis of chert artifacts from a Hopewell mound. *Journal of Radioanalytical and Nuclear Chemistry*, 262(1): 97–102.

Luedtke, Barbara E.

1992 *An Archaeologist's Guide to Chert and Flint.* Archaeological Research Tools 7, Institute of Archaeology, University of California, Los Angeles.

Matson, G. C.

1916 Pliocene Citronelle Formation of the Gulf Coastal Plain. *US Geological Survey, Professional Paper* 98: 167-192.

Mellon, F. F.

1959 Mississippi Mineral Resources. *Mississippi Geological Survey.* Bulletin 86:100.

Russell, Ernest E.

1987 Gravel Aggregate in Mississippi – Its Origin and Distribution. *Mississippi Geology,* 7(3):1-7.

Appendix A. Deconvoluted output of elements from analysis of source materials.

	CoK12	CrK12	FeK12	NiK12	RbK12	SrK12	TiK12	YK12	ZnK12	ZrK12	FAC 1	FAC2
40sw64007[2]	0.91381	0.73239	3.08207	2.89053	2.19201	3.18684	2.16732	3.1329	2.37475	2.78161	1.11856	0.50056
40sw64011	1.20412	0.65321	2.94226	2.84479	2.09517	3.11611	1.92942	2.3784	2.26482	2.71809	0.44931	0.1406
40sw64016	0.76343	0.88081	3.15884	2.84086	2.31175	3.04595	1.98677	3.38998	2.26293	2.82595	0.87169	0.49477
40sw64018	1.39445	0.76343	3.24194	2.87169	2.344	3.03205	1.9722	3.06318	2.39724	2.90773	1.20867	0.32398
40sw64002	1.01703	1.25527	2.97552	2.84807	2.16376	2.79407	2.2052	1.5682	2.25672	2.49996	0.07657	0.06949
40sw66001	0.53148	1.39445	3.01828	2.84856	2.18865	3.24709	2.13418	2.00689	2.21801	2.79099	0.22862	0.75895
40sw66003	1.20952	1.04922	3.09089	2.87726	2.21005	3.27962	2.08279	1.89982	2.20466	2.78803	0.47815	0.12942
40sw66006	1.39094	1.35793	3.29044	2.86546	2.19312	3.31404	2.09621	1.82737	2.19976	2.81823	0.50897	0.04644
40sw66015	0.30103	0.81954	3.11294	2.88093	2.23401	3.31154	1.92324	3.35862	2.40824	2.81544	0.91214	1.46847
40sw67007	1.13988	1.1271	3.03455	2.87564	2.21906	3.38209	2.03019	2.53908	2.25334	2.83721	0.71092	0.59519
40sw67009	1.41162	1.15836	3.19179	2.88717	2.276	3.38735	1.96848	2.70978	2.36624	2.8815	1.03124	0.75082
40sw67011	1.13988	1.36922	3.16364	2.85431	2.16435	3.32862	2.13988	1.96379	2.22531	2.77974	0.46834	0.26372
40sw67015	1.12057	1.36173	3.00234	2.85528	2.22324	3.35207	2.0799	1.99211	2.36248	2.75572	0.56223	0.78043
40sw67016	1.07188	0.89209	3.05084	2.86735	2.22063	3.37981	2.06819	2.97782	2.25624	2.81902	0.91722	0.38306
40sw80004	0.91645	1.11394	3.02898	2.85869	2.233	2.88352	1.97313	2.21352	2.25588	2.79187	0.31109	0.5793
40sw80006	1.08636	0.76343	3.07173	2.85745	2.21643	2.9709	2.02938	1.53656	2.25864	2.77452	0.27108	-0.05086
40sw80013	1.33041	1.26007	3.33244	2.86022	2.3969	3.09489	1.92737	2.14613	2.28058	2.94998	0.67892	0.39571
40sw80018	1.06446	1.26951	3.17114	2.87552	2.31555	2.97571	2.19479	1.98318	2.30449	2.81875	0.62339	0.31416
40sw80020	1.67394	1.21484	3.05812	2.88615	2.28058	3.08027	1.97772	3.04634	2.41229	2.78419	1.10311	0.75127
Baby Ruth #2 1	0.50515	1.15836	3.36545	2.8334	1.80346	2.13098	2.03902	1.15836	2.18355	2.09132	-0.85943	-0.15976
Baby Ruth #2 2	2.0306	0.72428	3.83796	2.8173	2.03981	2.47144	2.27416	1.7796	2.17869	2.72313	0.67723	-2.14059
Baby Ruth #2 3	1.47422	1.22531	3.34416	2.84683	1.93752	2.76403	2.11327	1.79239	2.18184	2.96577	0.28314	-0.40614
Baby Ruth #2 4	1.18469	1.11394	3.31719	2.8396	1.87795	3.07033	2.05308	1.55023	2.14551	2.4853	-0.08324	-0.35026
Baby Ruth #2 5	1.20683	1.20952	3.30782	2.83391	1.83123	2.07882	2.16435	1.60853	2.17143	2.38184	-0.33209	-0.67698
Baby Ruth #2 6	1.1271	1.16435	3.01199	2.82465	1.80482	2.0187	2.16495	1.35025	2.10175	1.99826	-0.7892	-0.76693
Baby Ruth #2 7	1.14613	1.07188	3.44691	2.84671	1.64345	1.98677	2.01703	1.52892	2.10857	2.3006	-0.64574	-0.70992
Baby Ruth #2 8	0.50515	1.38382	3.26834	2.83455	1.89209	1.94349	2.09412	1.61066	2.16554	2.29667	-0.68704	0.03777

[2] Each line represents the mean of the five samples taken from the samples. Results have been log normalized.

Baby Ruth #2 9	0.98227	1.12057	3.31622	2.80305	1.88762	1.9284	1.96473	1.56585	2.14489	1.96848	-0.78121	-0.6153
Baby Ruth #2 10	2.01199	1.25527	3.87123	2.74617	1.71933	2.25479	2.1784	1.79239	2.16017	2.25959	-0.0114	-2.02704
Baby Ruth #2 12	1.82106	0.86378	3.85409	2.78082	2.02023	2.93702	2.21606	1.99225	2.15487	2.92989	0.76038	-1.83778
Cilvituk 1	1.04922	1.37658	2.45939	2.72362	1.66087	1.85854	1.75282	1.75435	2.10721	1.74819	-1.5438	0.05374
CQA 1	1.38739	1.35793	3.27802	2.94724	2.31806	2.92262	1.91803	2.36661	2.36661	3.59796	1.05398	1.24385
CQA 2	1.60206	1.17609	3.34721	2.92252	2.55437	3.07137	2.23603	2.38561	2.33766	3.77791	1.62709	0.219
CQA 3	1.02531	0.716	3.12607	2.92747	2.5227	3.40442	2.05538	2.25188	2.4484	3.62449	1.45057	0.96056
CQA 4	1.18752	1.22011	3.23935	2.94645	2.33646	3.00217	2.20575	2.13925	2.41027	3.66094	1.27408	0.89086
CQA 6	0.92428	1.51851	2.74492	2.97359	2.19866	3.12516	2.0461	2	2.40002	3.26905	0.63551	2.02037
DC Sample 1	1.67578	1.48001	3.41202	2.91866	2.48883	3.49446	1.83759	2.81796	2.57519	3.09712	1.53997	1.57294
DC Sample 2	1.77085	1.42488	3.40033	2.92096	2.43008	3.37938	2.13609	2.78803	2.56277	3.08622	1.72506	0.92704
DC Sample 3	1.5611	1.45637	3.42765	2.8776	2.44248	3.23437	1.92942	2.33405	2.47914	3.0202	1.13835	0.91442
DC Sample 4	1.52375	1.0086	3.40582	2.94359	2.40993	3.40295	2.00432	3.28122	2.60531	3.07482	1.86924	1.22522
DC Sample 5	1.34635	1.12057	3.45679	2.93409	2.42127	3.3504	1.86332	2.45271	2.5832	3.09517	1.36962	1.41906
DS 1	1.50786	1.35793	3.2026	2.85358	1.94743	2.50759	1.95904	1.74974	2.17026	2.27646	-0.24997	-0.14667
DS cortex 1	1.15836	1.16435	3.19673	2.86759	1.82217	2.5193	1.94349	1.67761	2.17551	2.32879	-0.37797	0.04879
FPA1	0.91381	1.34635	2.83315	2.93581	1.77085	3.22639	1.89432	1.89653	2.36474	2.79934	0.0783	1.76256
FPA2	1.33846	1.13988	2.31597	2.95046	2.03902	2.95914	1.85854	1.63548	2.39759	2.72444	0.05694	1.72345
FPA3	0.41497	0.60206	2.87703	2.95837	2.18241	3.16785	1.81823	1.71933	2.3483	3.2697	0.36667	1.62998
FPA4	2.17725	1.21484	4.00547	2.92044	2.31345	2.77641	2.02284	2.08493	2.55169	2.89862	1.40958	-0.08263
FPA5	1.0086	1.42488	2.74974	2.96209	2.03503	3.46129	1.97772	1.74036	2.3587	3.21112	0.46685	1.89402
FPA6	1.60206	1.33445	3.2249	2.91297	2.25431	2.56703	1.80346	1.94151	2.39058	2.71063	0.38773	0.86996
FPC 1	0.97313	1.45939	2.11992	2.91824	2.08422	2.77466	1.80754	1.33445	2.29973	2.73014	-0.49761	2.02289
FPC 2	1.07918	1.72916	2.35334	2.92085	2.02776	2.71299	1.79657	1.70927	2.30792	2.80983	-0.33806	2.12935
FPC 3	0.53148	1.5563	2.60681	2.935	2.01115	2.89154	1.83632	1.68664	2.31091	3.18241	-0.15891	2.29248
FPC 4	0.99123	1.08636	2.48087	2.90331	2.00945	3.36582	1.71433	1.76042	2.276	3.00182	-0.03336	1.71426
HQA 1	1.26007	0.97313	2.9433	2.90816	2.22737	3.01469	2.65552	2.96595	2.31723	4.43788	1.98993	-0.01311
HQA 2	1.13033	1.0607	2.94448	2.93827	2.21617	3.02531	2.62221	2.9619	2.30428	4.45995	1.92696	0.33888
JCh-1 Chert 1	1.75128	0.9345	3.23208	2.67247	2.3032	2.00945	1.93044	1.79099	2.24502	2.39515	-0.10296	-1.53869
NIST 278 Obs 1	2.19257	-0.22185	3.93267	2.67633	3.37931	3.10209	2.23502	2.98784	2.32593	3.9136	2.736	-3.06756
NOV PQMC 1	1.02531	1.07188	1.86094	2.88218	1.88874	2.12516	2.03663	1.53148	2.08063	2.39933	-0.94024	0.63709

NOV PQMC 2	1.26007	1.36549	1.83506	2.87656	1.85612	2.4387	1.8451	1.6902	2.09132	2.4961	-0.92313	1.18902
NOV PQMC 5	1.23045	1.45332	2.04922	2.8912	1.91487	2.61215	1.97035	1.79099	2.21748	2.57357	-0.47402	1.32678
Ruth 1	1.25042	0.44716	3.13188	2.88795	1.78104	2.11992	1.96473	1.49969	2.16017	2.12905	-0.47965	-0.72149
Ruth cortex 1	1.98046	1.29667	3.75415	2.86153	1.90956	2.19479	1.97955	1.66839	2.12775	2.31218	-0.08154	-1.08315