Micromorphology: A 'How-To' Guide for Amateurs and Cheapskates

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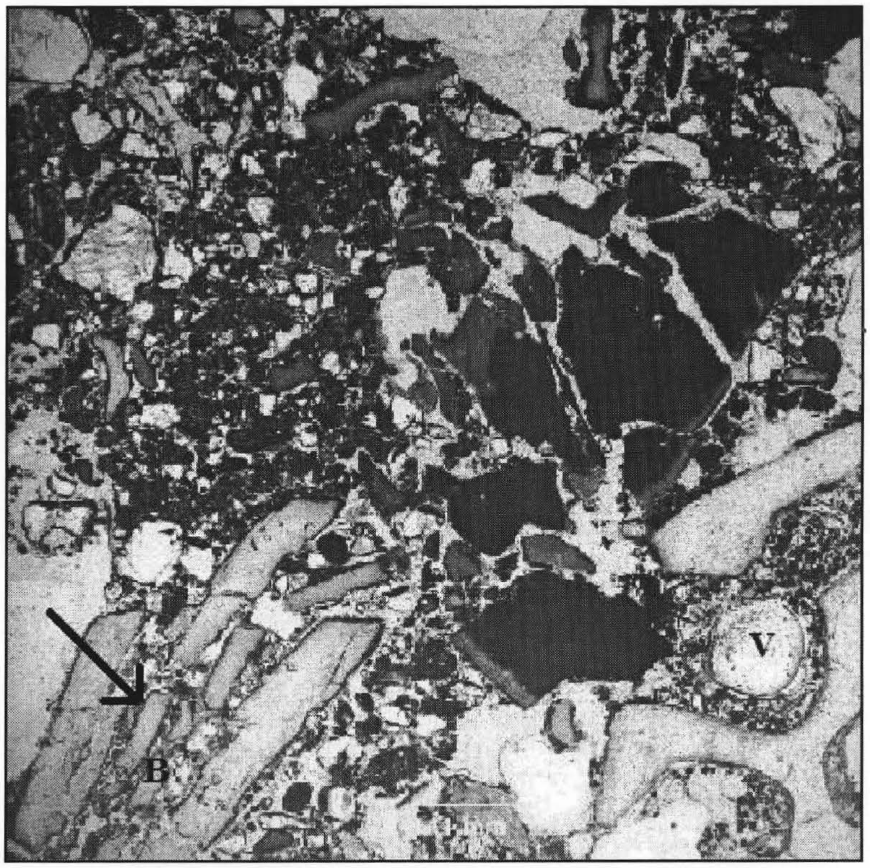

Figure 1. "Scissor Fractures" (indicated by arrow) in bone (B) are likely the result of trampling. This slide also clearly shows artificial voids (V), which are commonly created when resin forms bubbles during embedding (Photo by Paul Goldberg).

When I decided last summer to undertake a new project exploring an aspect of geo-archaeology that had always fascinated me, I didn't expect to produce anything other than an elaborate doorstop and several squarish holes....

Those few who had actually heard of the method were similarly skeptical of my chances, but, in spite of this, by the following afternoon, I stood proudly before a twisted heap of 'tools.' Most had been quietly slipped from kitchen drawers: a bread knife; a long-armed spatula; a baking tin, long not wide; while others had to be liberated from the faded blue Smithrite at the end of the road. If anyone had asked me at that moment what kind of archaeology I was planning to do with everything splayed before me, I was ready to exclaim "Micromorphology!"

Despite the fact that micromorphology has a history in archaeology as old as many other analytical techniques that are now mainstays in the discipline, such as x-ray fluorescence and radiocarbon dating, here in North America it remains largely ignored due to its reputation for being "prohibitively expensive" (Sherwood and Ousley 1995) and difficult. This is not actually the case, and in an effort to illustrate that fact, I decided to extract, process, and analyse several samples with a meagre budget and no previous experience. It is my hope that by showing how accessible micromorphology can be, others will be encouraged to get their hands on a petrographic microscope and try it themselves. Therefore the following is intended to be a 'how-to' guide for any budget-conscious individual, outlining the procedure from start to finish for deposits one would likely encounter in British Columbia, particularly those containing shell midden.

Step 1: Removing the Sample Block

Where soils are richly humic, intact blocks are much easier to remove as they'll stick together. Unfortunately, shell midden deposits are the opposite—whole, broken, and even crushed shell form unique shapes which rarely fit together flush, and between each shell element is a void, which will weaken a sample's integrity. To overcome this and avoid displacement, increase the margins on either side of the 10cm sample to act as cushioning. However, a larger sample will require more resin, raising the cost, so an alternative is to use plaster bandages to wrap the sample's exposed face, which should hold any loose material in place until embedding is possible.

Sampling begins by carving a gap around the margins of the block using a serrated knife (a Hori-Hori, or Japanese soil knife, works very well here; Figure 2). You will eventually use this space to surround the suspended block with packing material, so it should at least be wide enough for your fingers to easily fit inside. How deep you make the gap will determine the depth of your sample, and thus it should be decided relative to the sample's length in order to maintain strength.

Before proceeding, be sure to record the sample's provenience into the unit profile, as once you have begun wrapping the block, it becomes increasingly difficult to precisely measure depth below surface; and because you will be applying microscopy while identifying palimpsests, observations are measured to the millimetre. Next, start applying the many layers

Figure 2 (above). Carving a space around the block using a soil knife courtesy of Chris Springer (Photo by author).
Figure 3 (above right). Example of a sampled block just prior to removal. I decided to feature this section not only because it included several transitional contacts between layers, but also to determine if the mixed midden above the ash deposit was made up of more than one depositional event (Photo by author).

that will both hold the sample together, and prevent any material from moving during transport. Wrapping the block instead of placing it in a container saves money on supplies and affords more control over the sample's size and shape. Using the gap, begin wrapping toilet paper around the block's sides, keeping it as tight as possible without tearing the end. If the sample is very dry, lightly dampen the block with a spray bottle, or drape a separate piece of toilet paper over top since the paper's fibres are designed to stick to one another. The amount of paper needed is entirely dependent on the stability of the sample material; however try to use as little as possible since the entire sample block, packing and all, will be immersed in resin, and too much paper may result in an uneven embedding.

Wrap the block again, this time using clear packing tape. Avoid duct tape or others with course fabrics and heavy glues as they will only make cutting through the wrappings more difficult later. While wrapping the block's sides, use the tape to also fasten toilet paper to the remaining exposed front face (Figure 3). Next, use a marker and draw a small arrow directly on the sample, indicating which direction is up. I cannot stress enough how important it is to clearly orient your sample, since as more of the block is shaved away to prepare for thin sectioning, it becomes increasingly difficult to identify each layer, eventually becoming impossible once the slides are mounted. The final step is to gently jiggle the suspended block loose from the wall and finish covering the remaining face. As an extra precaution, plastic wrap can be stretched around the sample, helping it maintain its shape while also allowing any directional labels and other notes to remain visible.

Step 2: Embedding the Sample

Once back in the lab, samples must be prepped before any embedding is possible. Using an oven, dry the blocks with low heat for several days. Any moisture remaining in the sediment after the resin has been added will turn in to isolated, circular voids, which could be incorrectly interpreted as natural features. It can be difficult to determine if sample material is completely dry, so err on the side of caution and cook the blocks a few extra days. If time is an issue, gently prod the matrix: a fully dried sample should have its non-shell portions feeling firm, not spongy. The next step is to open some holes in the wrappings to allow the resin to enter. You will be primarily pouring over the top, so peel off anything covering the main face, exposing it completely. In addition, cut several slits along the sample's sides to allow any excess resin that flows off the top panel to still be used. Pores in the sediment will draw the resin upwards into the matrix via diffusion, ensuring the block is fully impregnated.

Now that you are ready to start embedding, you have a choice. Any petrographics lab will offer to embed your samples for you. The fee they charge with materials usually ends up only costing 25% more than it would if you decide to do the work yourself, if you don't make any mistakes and waste material. If even one batch of mixed resin is botched, you will end up spending just as much as you would at a lab, and the sample to which it was applied would likely be ruined. Furthermore, some labs are very particular about what resin they will work with and may even refuse to do thin sections, or at least force you to pay for them to re-embed the samples. So, in sum, unless you feel extremely confident with the embedding procedure and your resin formula, and you know the lab you are working with is willing to process that formula, it is generally more cost-effective and safer to leave embedding to the professionals, who may also be able to provide some insights into improving your sampling strategy to better coordinate with the lab's particular embedding technique. Unfortunately, few petrographics labs have worked with anything featuring shell middens, and there are a number of unique challenges involved in processing them. One such issue of particular concern is the midden's porous, unstable matrix.

As mentioned, shell in midden is rarely as compact as other geologic deposits. In order to compensate, the resin's viscosity must be just low enough to be capable of penetrating the sample's mass, but not so low as to inhibit drying, and thereby increase the risk of some particles being displaced in suspension. The mixture I found to be the most successful used a marble bonding resin as a base, then was thinned down using liquid styrene. To encourage air-drying, a chemical additive is available and should be used as any thinning will prolong drying time. The necessary amount of each ingredient can vary depending on the particular deposit, so much so that even the most accomplished researchers in the field liken the process to art, rather than science (Cady et al. 1986). While this provides increased control, it makes experimentation very unpredictable and eventually expensive. The formula included in Table 1 is suitable for many soil types and should ideally save you some time and money.

It should take three to five days for the resin to set, at which point the block should be completely solid. If any part still feels soft, it may be possible to re-embed the whole sample by slicing a few centimetres off the top and repeating the procedure. In order to select which areas specifically to thin section, you will need to cut the blocks in to longitudinal slabs, and unless you have ready access to a wet rock/tile saw, it is also more economical to leave this to the petrographics lab. Once this is done, try to scan the slabs in to a computer, ideally using at least 1200 dpi. These scans will be the only high-res reference of the intact sample, since the blocks will be cut up during thin-sectioning. You can use the scans, or simply a hand lens to select which areas you would like to be mounted as slides. Of course what you choose to feature will depend on your particular research; however it is usually a good idea to include the contacts between deposits as it can sometimes reveal whether the layer was exposed and subjected to any degree of trampling. Finished thin sections should be polished, which you can do using fine grained sand paper, or the lab can include it for a small fee. With the polished thin sections in hand, you are now ready to begin analysis.

Step 4: Micromorphological Analysis

Much of the alleged exorbitant costs involved in micromorphological studies come from consultants hired out to perform analysis on the prepared thin sections. On average, you'll pay $100 to $200 per slide, as well as an additional several hundred for the researcher to become familiarized with the site area. What the consultant brings to the table is his/her background in geosciences, describing mineralogy and soil structure, leading to inferences on paleoclimate, and the effects of past vegetation as well as past and present land use. While these observations are a major asset micromorphology provides, there are countless additional things you can glean from your slides even with a rudimentary understanding, thereby avoiding the extra costs. Many of the observations you can do rely on the deposit's physical characteristics, or microfabric (Brewer 1976). For example, if some layers appear more compacted than others, or contain wood or bone fragments with scissor fractures (Figure 1) then they may have been exposed for a length of time, and potentially trampled by the site's occupants. By increasing the resolution of your observations, you can detect subtle differences between the microfabrics of adjacent deposits which may have been impossible to distinguish in the field. This is particularly effective with shell middens, which often appear as continuous homogeneous units. When basketloads of shell are deposited, particularly with whole shells, it often results in a series of interconnected lamina. Any abrupt changes in the orientation or interconnectivity of shells making up the thin layers likely occurred after deposition, and if they exhibit visible patterns, these can be interpreted as the occupants using the midden for something other than a refuse dump, such as terrace construction. Researchers in South America have taken this strategy so far as to differentiate between components of a structure composed of shell midden, and record how the components were assembled and repaired (Balbo et al. 2010).

If this still seems too difficult, the high magnification can also aid in botanical and faunal identification. When wood charcoal is intersected along the correct planes, soft and hardwood varieties can easily be distinguished from each other, and genus level identification may even be possible. Highly fragmented and/or microscopic remains of fish and molluscs can be differentiated from other mineral inclusions based on their orangey-yellow colour when viewed under plane polarized light, and occasionally these too may be distinguished based on their unique structures. Whatever the approach, it should be clear that there are many ways in which micromorphology can aid archaeologists, and that its interpretive potential is not limited by a researcher's lack of training.

Embedding Formula	Price*
3.7L Polyester Resin FT-152 (1 gallon can)	$61.30
1L Styrene	$9.75
100 ml air dry additive **	$7.90 (250ml)
25 ml catalyst BPO Paste (Benzoyl Peroxide)***	$4.15 (4oz=118ml)
5 ml DMA (Dimethylaniline)	$4.45 (55ml)
* Prices gathered from Fibre-Tek, Burnaby B.C.	
** Quantities can differ depending on desired drying times	
*** Always allow 1/2 hour for resin to sit before adding catalyst	

Table 1: Embedding formula used, showing prices and some caveats

Conclusion

The procedure described above is only part of an arsenal of possible strategies available (Goldberg & Macphail 2003), each designed to accommodate soil conditions and logistical constraints faced in the field. Experimenting with several sampling methods is a key way to ensure you walk away with an intact block. While this may seem prohibitively expensive, most approaches use tools which can be found in dollar stores or salvaged from the local dump (think of it as urban archaeology). The reality is that micromorphology is not expensive, nor is it difficult to produce meaningful results regardless of your skillset. Unfortunately, most instruction is only accessible via other specialists with experience removing, processing and analysing the samples, which has rendered archaeological micromorphology a sort of trade-secret, and one obviously vulnerable to unfair speculation. It is my hope that along with other guides like this one, we may begin debunking the myths that surround this valuable heuristic tool.

Aaron is a recent graduate from Simon Fraser University's Department of Archaeology, who claims "the only thing he enjoys more than looking at shell middens is looking at them under a petrographic microscope."

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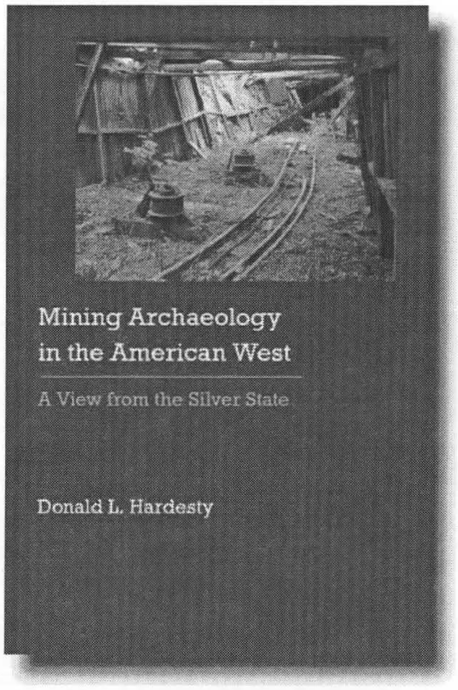
BOOK REVIEW: *Mining Archaeology in the American West: A View from the Silver State*

Donald L. Hardesty. University of Nebraska Press and the Society for Historical Archaeology, Lincoln, Nebraska. xvii+220 pp., 108 illus., 19 tables, 10 figures, bibliog., index. ISBN: 978-0-8032-2440-7 (hardcover). $45.00. 2010.



Donald Hardesty, a professor of anthropology at University of Nevada, Reno and author of *Ecological Anthropology* and *The Archaeology of the Donner Party*, has been conducting historical archaeology in the Great Basin since the 1970s and exploring the archaeology of Nevada's mining frontier at sites such as the Comstock Lode, the Cortez Mining District, and Virginia City since 1980. In *Mining Archaeology in the American West*, an updated edition of his 1988 SHA Special Publication *The Archaeology of Mining and Miners: A View from the Silver State*, he draws from archaeological and documentary sources to make sense of the technological and social processes of mining and creates a co-evolutionary model of adaptive change for the region.

Mining Archaeology in the American West is divided into four chapters. In the first, Hardesty outlines the historical and archaeological lines of evidence used to study mining sites, then applies in the second and third chapters these sources to the examination of their technology and social structure. In the final chapter, he applies ecological anthropology and evolutionary theory to the information previously presented to create his co-evolutionary model.

Hardesty begins by reviewing the various resources that can be utilized to learn about Nevada's mining past in order to illustrate the utility of historical archaeology's multifaceted approach. Historical documentation for the region exists through photographs, maps, company and government records, newspaper and professional journal articles, and personal journals. Information is also contained in mining landscapes, which are described as "the material expressions of the history of human-environmental interactions" (8). Mining architecture, including the buildings, structures, and objects used for resource extraction, transportation, power, and communication systems necessary for mining operations, provides an additional line of evidence. Finally, archaeology supplies another means for studying the past. Hardesty devotes several pages to describing how mining sites look in the archaeological record, how archaeological features fit into larger feature systems, and how mining sites are located. For anyone beginning mining site-related research, this chapter provides an excellent list of potential sources of information.

In the next section, Hardesty divides his discussion of the technology associated with mining to examine the steps in the processes of extraction, beneficiation, and refining separately. Each of these steps is considered a technological subsystem within the sociotechnical system