

PETROGLYPHS IN PETRIFIED FOREST NATIONAL PARK: ROLE OF ROCK COATING IN AS AGENTS OF SUSTAINABILITY AND AS INDICATORS OF ANTIQUITY

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ABSTRACT – Rock coatings formed on petroglyphs at Petrified Forest National Park both preserve the art from erosional processes and provide tools to understand the art’s chronology. Erosional processes of rock fall from fissuresol wedging, splintering of sandstone, and flaking are somewhat offset by case hardening surfaces by addition of rock coatings. 20th century graffiti can be distinguished from truly ancient petroglyphs by lead-profile dating. Microlaminations dating reveals that park engravings range in age from at least the early Holocene prior to about 8000 yr B.P. to the late Holocene in the last 2000 years. The next step in the research process is to utilize a Rock Art Stability Index to identify those panels in the greatest danger from loss through erosion, and then use available methods to record and sample petroglyphs to preserve knowledge while we can.

Keywords: Archaeology, Petrified Forest, rock art, Rock Art Stability Index

INTRODUCTION

SUSTAINABILITY RESTS at the heart of the National Park movement around the globe, first instituted in the United States at Yellowstone National Park. Preservation of cultural resources, in particular, remains a global focus no matter whether the setting is urban (Warke et al., 2003), wilderness (Whitley, 2001), or systemic research (Striegel et al., 2003). The most endangered cultural resources remain those exposed at or near Earth’s surface, in surficial, already-excavated sites, or rock art that has no place to hide. Petrified Forest National Park’s rich prehistoric tradition of rock art, unfortunately, remains at risk from both natural processes and people.

A vital research imperative must be to understand what rock art sites are most in danger and then to record and analyze what we can before these priceless cultural resources are lost forever. Sustainability in the context of rock art, therefore, must involve two elements of rock art research: develop a better way to identify endangered panels; and then once the panels are identified to then “mine” insight from the art.

This paper provides an overview of both of these sides of rock art in Petrified Forest National Park through the lens of rock coating research. Rock coatings provide a means by which scientists can understand panel erosion and also obtain chronometric insight from the rock art. A rich variety of rock coatings found in nature (Dorn, 1998) exist in Petrified Forest National Park, and Table 1 summarizes the more common ones found inside the park.

The first section of this paper explores rock coatings as a vital ingredient in protecting Petrified Forest National Park’s rock art from erosion. The second section of this pa-

per then turns to rock coatings as a means of providing chronometric insight into the antiquity of the art.

ROCK COATINGS AS AGENT OF SUSTAINING CULTURAL RESOURCES

Most cultural resource managers focused on stone conservation follow guidelines put in place for the preservation of stone buildings (Fitzner et al., 1997; Price, 1996; Striegel et al., 2003; Warke et al., 2003). Conservators then turn to techniques tried successfully on building stone. The circumstance for rock art, however, is much more complicated.

Whereas the stone material used in monuments and buildings starts out in a relatively unweathered state, the panel faces used for petroglyphs and pictographs typically start out in an already decayed state inherited from a deep position in a weathering profile (Ehlen, 2002). In the case of Petrified Forest National Park, panels hosting the rock art were weathered long before erosion exposed the joint faces at the surface (Fig. 1). The “inherited” rock decay creates an inevitable circumstance of enhanced erosion of panel faces.

One of the most worrisome processes of panel erosion at Petrified Forest National Park comes from the wedging apart of blocks by fissuresols. A fissuresol is a sequence of deposits that accrete within rock fractures (Coudé-Gaussen et al., 1984, Villa et al., 1995). The deposition of calcrete and dust inside a fracture leads to expansion and contraction of the carbonate and clays and eventually pushes blocks apart. Little can be done to halt this style of erosion. However, the process typically repeats again and again at the same panel. So where fissuresol wedging takes place (Fig. 2), cultural resource managers

Table 1. Most common rock coatings found at Petrified Forest National Park.

General type	Description	Related terms
Carbonate Skin	Coating composed primarily of carbonate, usually calcium carbonate, but could be combined with magnesium or other cations	Caliche, calcrete, patina, travertine, carbonate skin, dolocrete, dolomite
Case Hardening Agents	Addition of cementing agent to rock matrix material; the agent may be manganese, sulfate, carbonate, silica, iron, oxalate, organisms, or anthropogenic	Sometimes called a particular type of rock coating
Dust Film	Light powder of clay- and silt-sized particles attached to rough surfaces and in rock fractures	Gesetz der Wüstenbildung; clay skins; clay films; soiling
Iron Film	Composed primarily of iron oxides or oxyhydroxides; does not have clay as a major constituent	Ground patina, ferric oxide, staining, iron staining
Lithobiontic Coatings	Organic remains form the rock coating, for example lichens, moss, fungi, cyanobacteria, algae	Organic mat, biofilms, biotic crusts
Oxalate Crust	Mostly calcium oxalate and silica with variable concentrations of Mg, Al, K, P, S, Ba, and Mn. Often found forming near or with lichens.	Oxalate patina, lichen-produced crusts, patina, scialbatura
Rock Varnish	Clay minerals, Mn and Fe oxides, and minor and trace elements; color ranges from orange to black in color produced by variable concentrations of different manganese and iron oxides	Desert varnish, desert lacquer, patina, manteau protecteur, Wüstenlack, Schutzrinden, cataract films
Salt Crust	The precipitation of sodium salts on rock surfaces	Halite crust, sub-florescence efflorescence
Silica Glaze	Usually clear white to orange shiny luster, but can be darker in appearance, composed primarily of amorphous silica and aluminum, but often with iron.	Desert glaze, turtle-skin patina, siliceous crusts, silica-alumina coating, silica skins

can expect that the process will repeat and take the form of rock fall.

Less dramatic weathering and erosion processes also lead to the loss of the park's rock art. Some of the more common processes are splintering of sandstone along bedding planes and flaking (Fig. 3). Countering these destructive processes is the case hardening of sandstone (Conca and Rossman, 1982; Dorn, 2004a). Case hardening at Petrified Forest National Park starts in the subsurface where silica glaze (cf. Table 1) forms a weak cement. Upon panel exposure at the surface, rock varnish and clay minerals add additional

cementation. Without the sort of case hardening exemplified in Figure 3, panel faces hosting the art would quickly disintegrate and crumble away.

Even with case hardening, the inevitable erosion takes place just as soon as the case hardened layer erodes. Figure 4 summarizes the general behavior of sandstone, the rock type that hosts much of the park's rock art. Case hardening is able to preserve the surface even as a weathering rind continues to decay underneath the miniature caprock (Turkington and Paradise, 2005). However, just as soon as the protective millimeter-scale case-hardened cap erodes away, ero-

sion is rapid because the weathering rind underneath the case hardening has very little to no cohesion. Figure 5 illustrates a typical example at Petrified Forest National Park, where the cycle of case hardening formation and then rapid excavation of the decayed weathering rind underneath repeats again and again.

While it is technically true that rock art is not a sustainable cultural resource, given the inevitability of these natural erosional processes and the sad reality of anthropogenic destruction, rock weathering specialists can certainly do a much better job of identifying those panels most susceptible to erosion. In essence, this “triage” would permit cultural resource managers and researchers to focus their efforts on the most endangered panels. An effort is underway amongst weathering researchers, centered at Arizona State University, to utilize a “Rock Art Stability Index” that rates panel stability for the purpose of assisting site cultural resource managers (Dorn and Cervený, 2005).

Please do not misunderstand me. I am not advocating that panels be identified so that stone conservators can mitigate the loss. That could be a major mistake. Because some stone conservator methods have only been tested on building stone, such methods could exacerbate erosion if applied to already decayed stone (cf. Figure 1). Instead, I argue for a program of simply identifying those panels most in danger of erosion. The purpose of such an effort would be to focus research efforts on those endangered motifs. For we can still sustain cultural resources by recording and archiving samples of the art for future research before a priceless cultural resource is lost to erosion.

A large host of research strategies exist to understand rock art prior to its erosion, including ^{14}C dating (Rowe, 2001a), foreign material analysis (Dragovich and Susino, 2001; Whitley et al., 1999), oxalate residue analysis (Russ et al., 2000), pigment analysis (Edwards et al., 1998; Rowe, 2001b), classification and recording strategies (Francis, 2001; Keyser, 2001; Loendorf, 2001; Tratebas, 1991), ethnographic analyses (Whitley, 1998; Whitley, 2001), and other approaches (Whitley, 2005). The next section illustrates a few strategies by which we have gained some experimental insight into prehistoric peoples at Petrified Forest National Park through the scientific study of rock coatings on petroglyphs (Dorn, 2001).

ROCK COATINGS AS AN INDICATOR OF ANTIQUITY

The chronometric study of petroglyphs at Petrified Forest National Park has been limited by site circumstances,

logistics and funds to only three of the wide variety of experimental dating methods that could be applied (Dorn 2001): lead dating; microlaminations; and radiocarbon dating. All dating methods rely on the rock coatings that accrete on top of the engraved surfaces.

Historic or Prehistoric? Lead Profile Dating

Is the art real or is it recent graffiti? This qualitative yes/no judgement has led to a wide variety of false claims. In my experience, archaeologists have called as “prehistoric”, bulldozer scrapings, earth in a desert pavement arranged as a fisherman, historic engravings in Portugal made in the style of European Paleolithic art, rock cairns, and other engravings in the western United States.

This is not to say that all archaeological judgements are wrong. In fact, most published claims of prehistoric antiquity that I am aware of have been correct when compared with results from objective testing; however, enough mistakes have been made that it is important to indicate here that there is a pretty simple test that is at the disposal of site managers faced with having to figure out if an engraving falls within ARPA guidelines of being one hundred years old. The power rests in

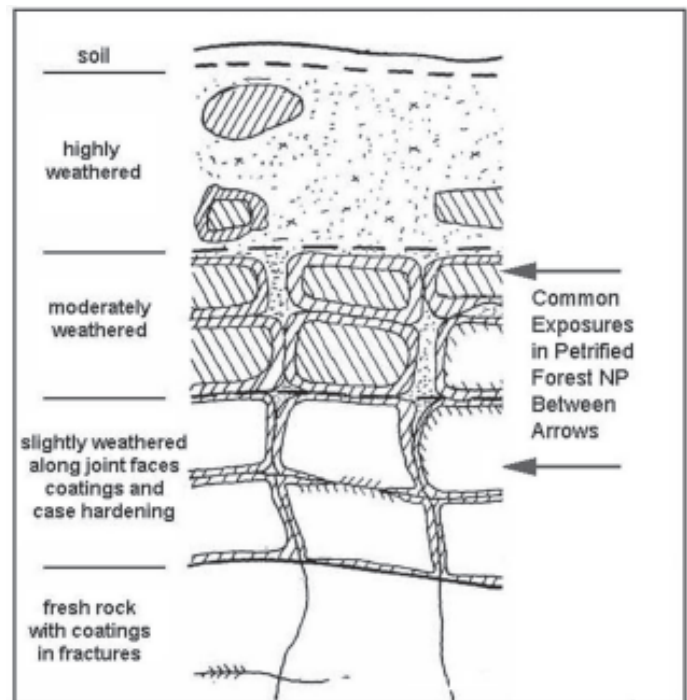


Figure 1. Weathering profiles develop in a fashion generalized in this diagram adapted from Ehlen (2005). Enhanced rates of erosion, from such geomorphology processes as base level lowering or cliff retreat, then led to the exposure of rock. The panel faces hosting rock art at Petrified Forest National Park were mostly slightly weathered or moderately weathered before manufacturing of the art.

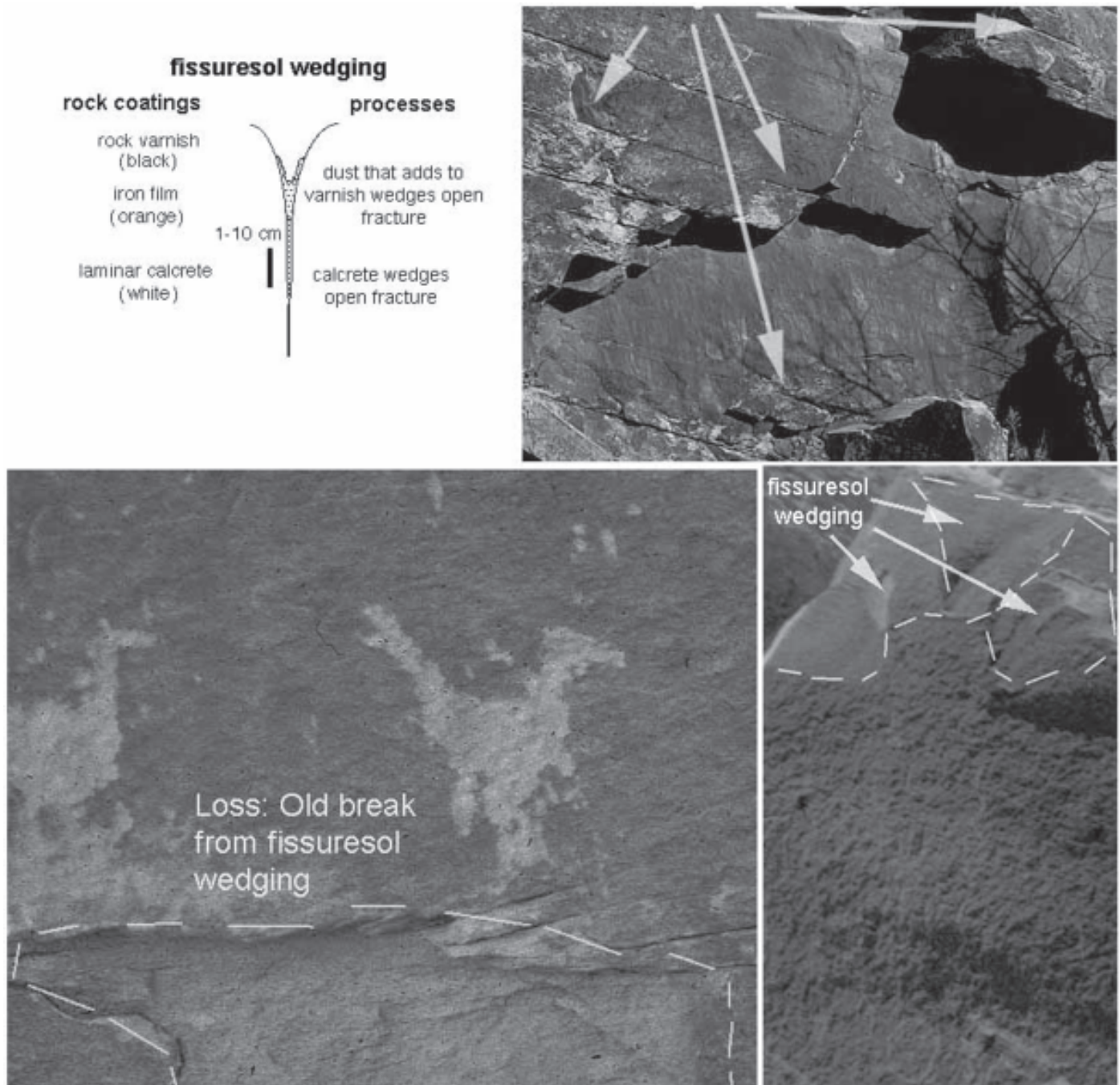


Figure 2. Mostly closed rock fractures accumulate carbonate and dust, that over time, wedges the fracture open enough to generate erosion of a panel by rock fall.

its relatively lower cost and the ability to analyze very small samples to obtain an objective judgement on whether the art is likely 20th century.

Dorn (1998) introduced the notion that 20th century anthropogenic heavy metal pollution leaves its signal in the surface layer of rock coatings in desert locations distant from cities. The simple idea was that if polar snow and Danish bogs host higher levels of 20th century lead pollution (Andersen, 1994; Boutron et al., 1994), why not rock coat-

ings in the desert southwest? The method is aided by the heavy metal scavenging ability of iron and manganese oxydryoxides found in rock varnish and iron films. The uppermost micron of rock coatings, indeed, showed a “spike” in lead pollution (Dorn, 1998:136-139). This observation has been replicated by several different teams of researchers in the past few years (Fleisher et al., 1999; Hodge et al., 2005; Liu and Broecker, 2001; Thiagarajan and Lee, 2004). A variety of techniques can be used to measure the heavy

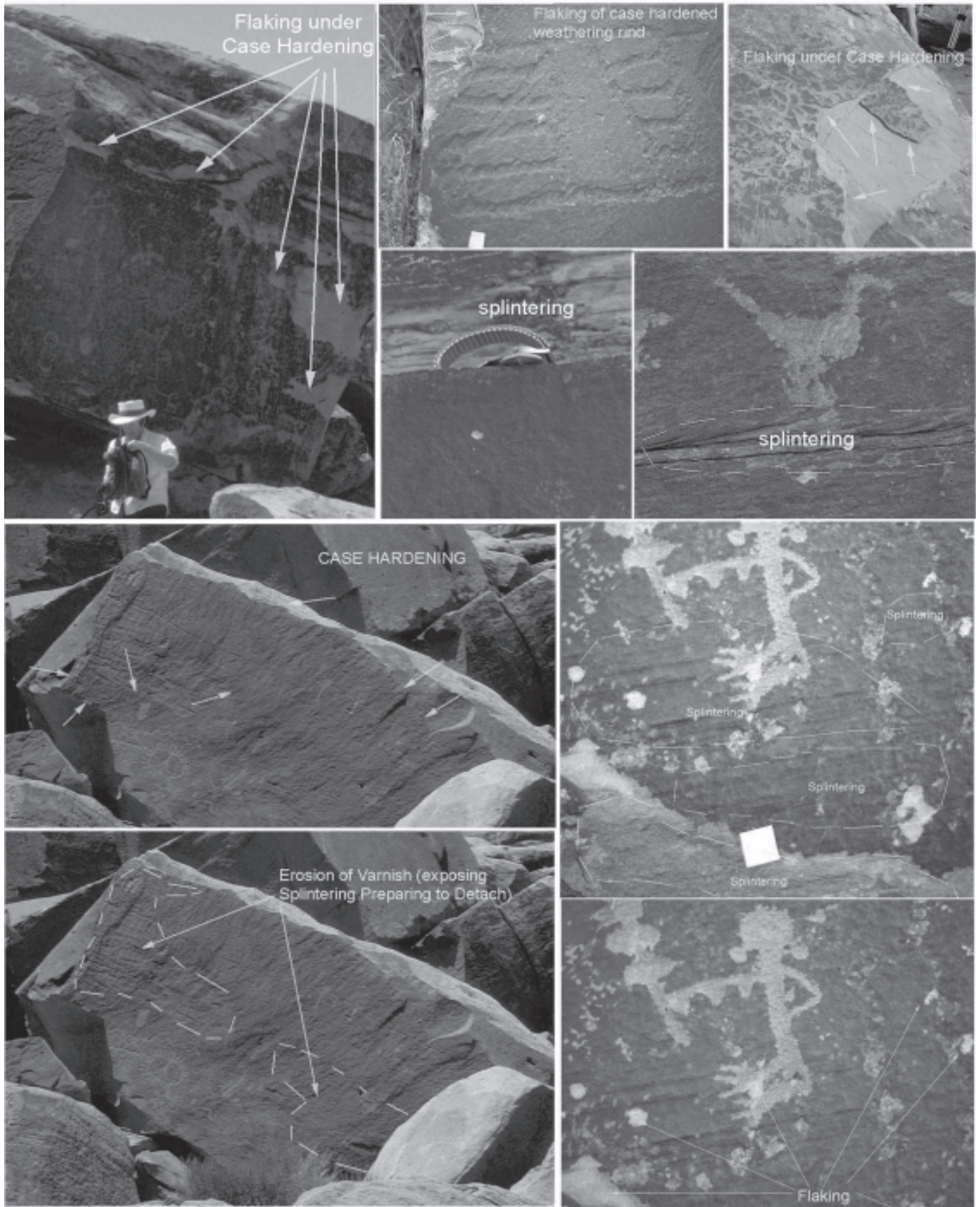


Figure 3. A variety of weathering and erosional processes result in the loss of petroglyphs at Petrified Forest National Park.

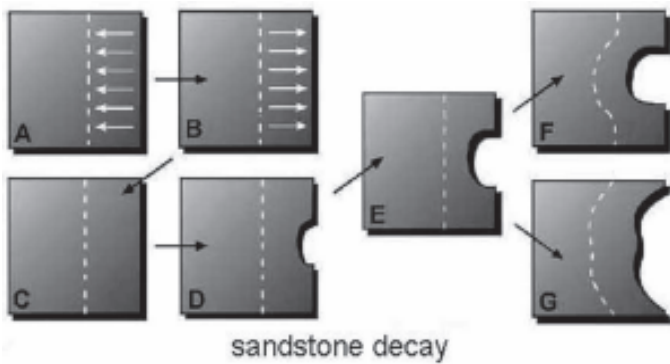


Figure 4. Sandstone hosts many petroglyph panels in northern Arizona, including Petrified Forest National Park. This figure generalizes the morphological sequence in the weathering and erosion of sandstone joint faces, adapted from Turkington and Paradise (2005) as being:

- A: subsurface dissolution, alteration and removal creating weathering rind
- B: surface reprecipitation of minerals, deposition of clays, biological activity
- C: case-hardening of surface layer
- D: breaching of case-hardened weathering rind
- E: rapid material loss (crumbly disintegration) beneath exposed area
- F: continued material loss and enlargement of form
- G: stabilization of newly exposed surface

metal pollution spike, from the long counting times of an electron microprobe used here to more sophisticated and more expensive analytical tools.

The lead profile dating method appears to work at Petrified Forest National Park. Lead profiles show an anthropogenic signal in rock varnish collected from an anthropomorph with staff motif (Figure 6). The petroglyph was carved into the Newspaper Sandstone in the Blue Mesa Member of the Chinle Formation (Woody, 2003). This is a nominal dating method that can, at best, yield a “yes or no” as to whether the petroglyph is pre-20th century. Since the rock coating records background levels of lead underneath the surface “lead spiked” layer, as seen in Figure 6, we have enhanced confidence that the art is prehistoric. If the rock coating records only the lead spike (e.g., stars in Figure 6 measured for graffiti), the art is likely 20th century.

Microlaminations

The most powerful dating method available to petroglyph researchers is the study of microlaminations in rock varnishes formed on top of petroglyphs. The method is powerful for two reasons. First, the researcher obtains insight into the general climate (wetter or drier) since the petroglyph was engraved. Second, and most importantly, out of the more than dozen methods yet used to analyze petroglyphs chro-

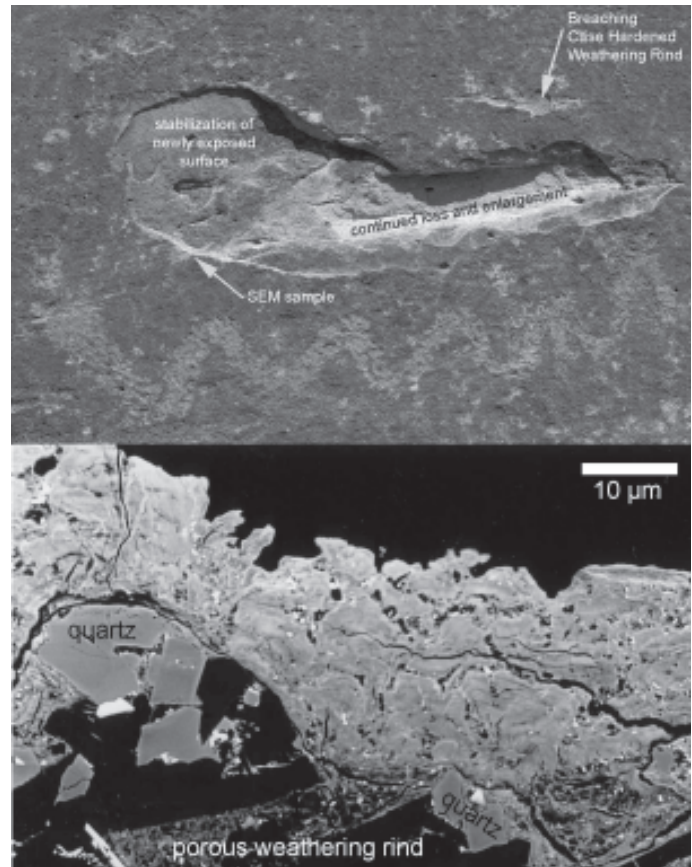


Figure 5. Example of Turkington and Paradise (2005) model (Figure 4) operating at Petrified Forest National Park. Despite ongoing weathering of the sandstone, this panel face has been stabilized by case hardening (see Chapter 7 in Dorn, 1998). But eventually, a breach takes place, following by rapid loss of material (e.g., see “breaching case hardened weathering rind”). The backscattered electron micrograph shows why rapid loss occurs: the weathering rind is typically weakened by the formation of giant pores. The hole keeps growing until the rock itself is less weathered, at which time a new round of case hardening takes place (e.g., “stabilization of newly exposed surface”). The cycle can continue when this new case hardening is breached (e.g., “continued loss and enlargement”).

nometry (Dorn, 2001), this method has seen the greatest success in independent and blind testing:

“This issue contains two articles that together constitute a blind test of the utility of rock varnish microstratigraphy as an indicator of the age of a Quaternary basalt flow in the Mohave Desert. This test should be of special interest to those who have followed the debate over whether varnish microstratigraphy provides a reliable dating tool, a debate that has reached disturbing levels of acrimony in the literature. Fred Phillips (New Mexico Tech) utilized cosmogenic ^{36}Cl dating (Phillips, 2003), and Liu (Lamont-Doherty Earth Observatory, Columbia University) (Liu, 2003) utilized rock varnish

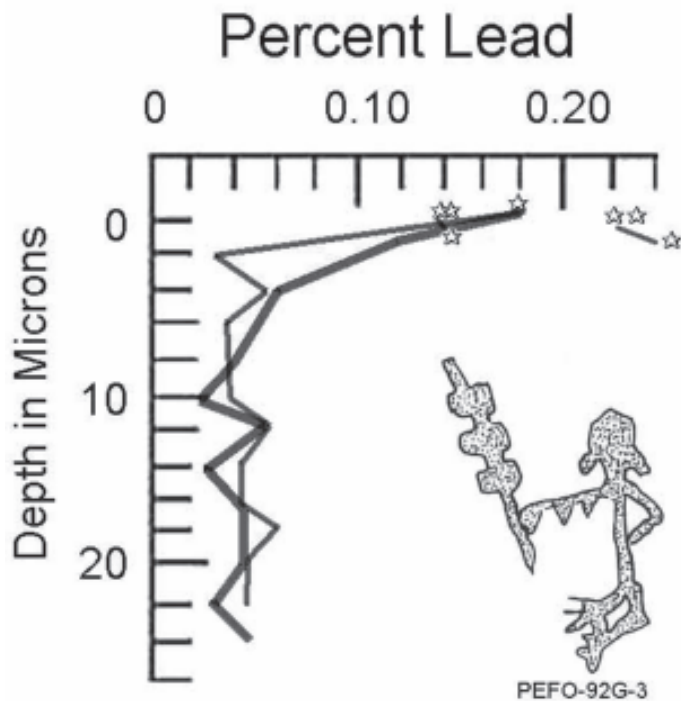


Figure 6. Lead profiles of rock varnish on an “Anthropomorph with Staff”. Two of the two profiles show the lead spike in the surface most varnish. A control sample of an iron film rock coating formed on a nearby graffiti petroglyph shows only the lead spike in replicate analyses (stars) where the thickest coating was only a few microns.

microstratigraphy to obtain the ages of five different flows, two of which had been dated in previous work and three of which had never been dated. The manuscripts were submitted and reviewed with neither author aware of the results of the other. Once the manuscripts were revised and accepted, the results were shared so each author could compare and contrast results obtained by the two methods. In four of the five cases, dates obtained by the two methods were in close agreement. Independent dates obtained by Phillips and Liu on the Cima “I” flow did not agree as well, but this may be attributed to the two authors having sampled at slightly different sites, which may have in fact been from flows of contrasting age. Results of the blind test provide convincing evidence that varnish microstratigraphy is a valid dating tool to estimate surface exposure ages.” (Marston, 2003: 197).

Another positive aspect of this method is that it has seen utility in rock art research in a variety of settings (Cervený et al., 2006; Cremaschi, 1996; Tratebas et al., 2004).

The largest limitation is that microlaminations require calibration. This correlative (Colman et al., 1987) dating

method matches climatic events that take place over centuries to millennia with rock varnish laminae. Fortunately, a new calibration has been developed for the Holocene that is usable throughout the Mojave Desert, Great Basin, and Colorado Plateau (Liu and Broecker, n.d.).

Four petroglyphs at Petrified Forest National Park illustrate the potential of microlaminations to compile a chronometry (Fig. 7). A “bird” engraving (PEFO-91-E-2) shows only the latest Holocene sequence of the last 1100 years in two ultrathin-sections. An anthropomorphic figure with a staff (PEFO-92G-3) shows a slightly older sequence of the last 1400 years. PEFO-92G-3 is superimposed into an anthropomorph (PEFO-92G-4) that in turn could show an older sequence. However, only one thin section survived the preparation process and replicate sections would be needed for confidence. All of these three engravings rest within the late Holocene moist phase (Hasbargen, 1994).

A fourth petroglyph, a grid form, shows a much more complicated lamination sequence. The two ultrathin-sections prepared for PEFO-91-E-7 record an early Holocene moist phase that took place prior to about 8500 ^{14}C years ago (Hasbargen 1994). A relatively lengthy mid-Holocene dry phase can be seen in the microlamination sequence as the thick lighter orange layer. Three other ultra-thin sections were made of varnish on PEFO-91-E-7 that show even more complicated sequences that could possibly place the petroglyph into the late Pleistocene; however, these more complex layering patterns do not show the relatively even stratigraphic layering of Holocene wet periods in Figure 7 needed for chronometric analysis. Assessment of a possible late Pleistocene microlamination pattern must await further sectioning.

Radiocarbon Dating

A prior study of radiocarbon dating petroglyphs at Petrified Forest National Park (Dorn et al., 1993) presented five ^{14}C ages for the petroglyphs analyzed for microlaminations: PEFO 91E-2 709±52 yr B.P. (NZA 2114); PEFO 92G-3 628±99 yr B.P. (NZA 2641); PEFO-92G-4 1649±91 yr B.P. (NZA 2540); PEFO-91E-7 18,180±190 yr B.P. (NZA 2115) and 16,600±120 yr B.P. (NZA 2191).

At that time, we presented a number of uncertainties regarding these radiocarbon ages. One issue in particular has since undermined the entire strategy of radiocarbon dating petroglyphs:

“The depth profiles from these controls indicate that organic carbon was probably present in the weathering rind that existed before the petroglyph was en-

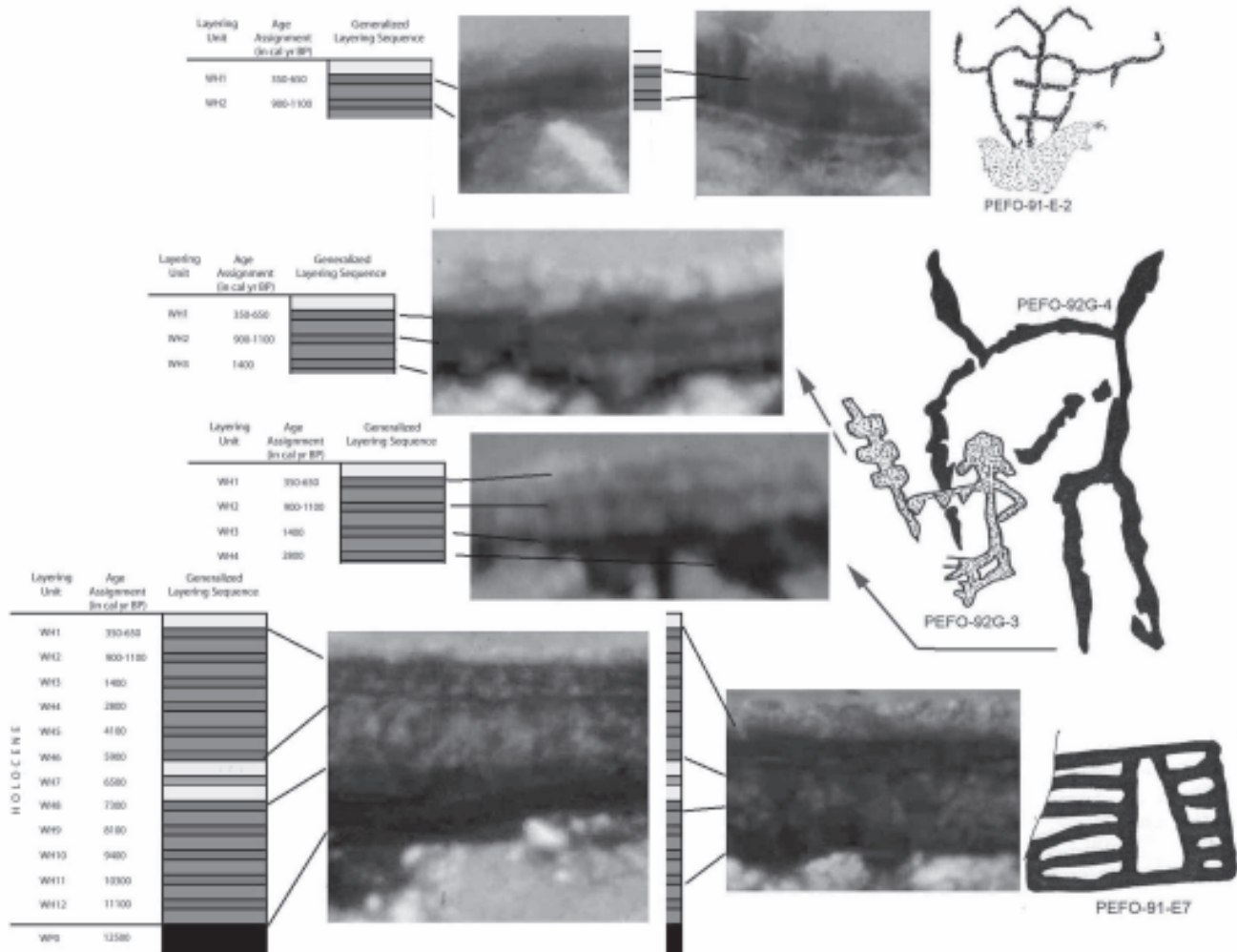


Figure 7. Microlaminations of rock varnish formed on top of four petroglyphs at Petrified Forest National Park. These black and white images cannot capture the dramatic changes seen in color views of the cross-sections. However, the basics can be seen. Black layers record wetter periods and light (orange and yellow) layers recording dry phases. The calibration is courtesy of T. Liu (pers. commun., 2006) from Liu and Broecker (n.d.).

graved. The carbon concentrations in the weathering rind immediately underneath the pre-existing varnish vary from a little over two percent to about seven percent.” (Dorn et al. 1993:36)

It was a double blind test, again the foundation of solid science, that revealed the fundamental flaw in the radiocarbon strategy. My participation in an earlier blind test (Loendorf, 1991) led me to participate in the first and only blind testing of petroglyph radiocarbon dating with A. Watchman, conducted by Portuguese authorities in 1995. The test took place on petroglyphs in the Côa Valley, Portugal (Bednarik, 1995). Watchman and I both obtained statistically identical mid-Holocene radiocarbon ages for the Côa engravings (Bednarik, 1995). Watchman provided accurate details in 1997:

“Although [Dorn and Watchman’s] methods of sampling Côa petroglyphs were different the compositions of the components dated were essentially the same. Rock chips of surface accretions and weathering rinds taken from petroglyphs contain “organic matter” of two types: modern microorganisms, charcoal and pollen debris in the soft surface accretions and fine-grained crystalline old graphite from the sub-surface weathering rinds. Dates on separate fractions of these components give dates reflecting modern and old carbon (almost 30,000 years), but mixtures of the two components give results that average about 4500 years”. (Watchman, 1997: 7)

Based on these results, I argued at the May 1996 American Rock Art Research Association meetings that ra-

Table 2. Uncertainties in radiocarbon dating that are relevant to the dating of organics associated with petroglyphs.

Uncertainty	Discussion	Reference
Younger carbon can be added	<p>"Fungi or micro-organisms may easily be incorporated into a [plant macrofossil] sample."</p> <p>Cellulose undergoing microbial degradation could introduce a high percentage of younger carbon into a sample.</p> <p>"In an open system, C-14 ages become younger when rates of exchange increase...Younger carbon is added over time, as demonstrated by comparisons of panel 14C ages and panel 36C1 ages."</p>	<p>(Wohlfarth et al. 1998: 137)</p> <p>(Ljungdahl and Eriksson 1985)</p> <p>(Dorn 1997: 110,112)</p>
Different types of processing in radiocarbon labs can result in different ages	<p>"Results yielded an inconsistent chronology, affected by contamination with younger humic materials...A more consistent and older chronology was achieved using AMS dating of rigorously pretreated samples of fine-grained charcoal."</p>	<p>(Gilespie et al., 1992: 29)</p>
Multiple types of carbon co-occur	<p>"Charred tissue that has no discernible composition is common amongst preserved plant remains. This often appears as extremely vesicular, or solid glassy carbon..."</p> <p>In desert regions, where laminar calcrete forms in rock fractures that intersect rock art panels, the calcrete contains both inertinite (carbonized plant tissues) and vitrinite (shiny, coal-like particles). "Abundant vitrinite and inertinite strongly suggests the presence of roots and possibly of fungi from the calcrete laminae."</p> <p>Truly inert fractions of soil organic matter are almost certainly a mixture of charcoal, ancient coal, and organic materials trapped within clays.</p>	<p>(Hather 1991: 673)</p> <p>(Chitale 1986: v-vi)</p> <p>(Falloon and Smith 2000: 389)</p>
Multiple ages of carbon co-occurs	<p>"Dates on separate fractions of these components give dates reflecting modern and old carbon (almost 30,000 years), but mixtures of the two components give results that average about 4500 years."</p> <p>"It is difficult to define an refractory soil organic matter pool physically. There is much evidence from modelling and from the radiocarbon dating of various chemically isolated fractions that soils contain small amounts of recalcitrant materials of great age...A wide range of compounds have been identified as "high resistant" compounds of soil organic matter... with radiocarbon ages of several thousand years.</p> <p>"[A Soil Organic Matter {SOM} pool] is stabilized by its inherent or acquired biochemical resistance to decomposition. This pool is akin to that referred to as the 'passive' SOM pool ... Several studies have found that the non-hydrolyzable fraction in temperate soils includes very old C ... The stabilization of this pool and consequent old age is probably predominantly the result of its biochemical composition."</p>	<p>(Watchman 1997: 7)</p> <p>(Falloon and Smith 2000: 389)</p> <p>(Six et al. 2002: 161)</p>
Organics can be inherited	<p>Fossils of tree roots occur as deep as 25 m in 'solid' rock through the natural weaknesses (joints) on hillslopes. Three samples were as old as 30,000 radiocarbon years, another 44,000 years and two other samples "have ages beyond 14C limits (>50,000 years)." Thus, old wood occurs in joints that, after erosion, makes up petroglyph panels.</p>	<p>(Danin et al. 1987: 95)</p>

diocarbon dating of petroglyphs does not work (Welsh and Dorn, 1997). It was clear to me that this test demonstrated very clearly that materials from the host rock effectively contaminated petroglyph ages. Every bit of prior archaeological knowledge indicated that the petroglyphs were Paleolithic (Clottes et al., 1995; Zilhão, 1995; Züchner, 1995). Yet, Watchman and I obtained the same mid-Holocene age because of the same mixture of ages. More

than four years after Watchman and I reported our findings independently, excavations showed that these Côa petroglyphs are truly older than 21,000 radiocarbon years (Herscher, 2000). Thus, in the only blind test ever conducted on petroglyph radiocarbon dating, both blind testers found similar materials, and we both obtained similarly incorrect ^{14}C ages that flew in the face of prior archaeological insight.

Since this blind test, a much more extensive investigation of the organics associated with the dating of organics in petroglyph contexts reveals serious systemic issues in the application of radiocarbon dating as a method in dating petroglyphs and geoglyphs (Table 2). Still, the use of radiocarbon dating of petroglyphs continued (e.g., Watchman, 2000), until the normal process of comment and reply (Whitley and Simon, 2002a; Whitley and Simon, 2002b) brought into focus the lack of independent controls in the continued use of this petroglyph dating method.

In the specific context of petroglyphs at Petrified Forest National Park, organic matter from the rectangular geometric design (PEFO-91-E-7) showed that some of the organics came from laminar calcrete joints in the host sandstone (Dorn et al., 2001). In particular, the SEM analyses revealed a similar mix of organic forms in the calcrete joints and in the petroglyph samples. Of course, the presence of ancient organics in rock fractures is not a new concept in radiocarbon dating (Table 2), even if those whose finances are tied to the use of radiocarbon dating continue to ignore these and other complications (Table 2) that could be resolved by detailed sample pretreatment done carefully by such organizations as Beta Analytic.

One conclusion from this experience is that the prior radiocarbon ages measured at Petrified Forest National Park are not reliable. It may be possible to discern what fraction of the organics mixed with the petroglyphs might yield reliable radiocarbon ages (Dorn, 2004b), but not with our present

knowledge. A second larger conclusion is to stress the importance of blind testing in chronometric studies (e.g., Loendorf 1991), for it is only through such blind testing that experimental methods can be dismissed (Welsh and Dorn, 1997) or relied upon (Marston, 2003).

THE NEXT STEP

The next step in petroglyph sustainability at Petrified Forest National Park is to identify those panels that are in the greatest danger of loss through erosion through using a Rock Art Stability Index (RASI). After a RASI identifies the endangered panels, the petroglyphs should then be sampled for scientific tests and sampled to preserve through imaging and recording strategies so we can preserve our knowledge about art most in danger from future loss.

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