POTTERY SOUTHWEST

Volume 30, Nos. 1-4 November, 2014
FALL/WINTER 2014 ISSN 0738-8020

MISSION STATEMENT

Pottery Southwest, a scholarly journal devoted to the prehistoric and historic pottery of the Greater Southwest (http://www.unm.edu/~psw/), provides a venue for students, professional, and avocational archaeologists in which to publish scholarly articles as well as providing an opportunity to share questions and answers. Published by the Albuquerque Archaeological Society since 1974, *Pottery Southwest* is available free of charge on its website which is hosted by the Maxwell Museum of the University of New Mexico.

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2014 Editorial Board

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ANASAZI ORGANIC BLACK-ON-WHITE POTTERY: A NEW PARADIGM

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ABSTRACT

The Anasazi production of black-on-white pottery using organic paint (paint from plant compounds, e.g., "bee weed" or *Cleom serrulata*) is a sophisticated ceramic technology lost to historic times. After years of failure attempting to replicate pottery of this kind archaeo-replicators found they could produce look-alike black-on-white pottery with organic paint if an Anasazi-style trench kiln was smothered with dirt after it reached peak temperature to quench the fire, seal the kiln from oxygen, and stop oxidation and destruction of the paint which had been the main problem. This firing regime then became promoted and accepted by many as the way the Anasazi achieved their black paint ("The Smothering Paradigm" or "SP"). This paper refutes this paradigm. Analysis from the principle of parsimony raises fundamental anomalies flagging it as a theory that can only be maintained by ignoring the physiographic, cultural-ecological, or contextual realities of the time (e.g., resource and tool availability). The extreme inefficiency of the regime including the amount of fuel it requires at a time when fuel was scarce, the large diameter fuel it calls for which along with the smothering dirt itself would have been hard to process without modern tools, highlights the untenability of the theory. Employing parsimony instead from the beginning in the context of "ecological realism" to ask the question: "How would the Anasazi have fired their kilns?" leads naturally it is shown to an alternative paradigm ("The Non-Smothering Paradigm" or "NSP"), which is demonstrated and corroborated experimentally, where dirt smothering is eliminated and all the anomalies associated with are eliminated too. A summary and analysis of Anasazi kiln excavations shows further the NSP

replicates the stratigraphy of these prehistoric kilns additionally falsifying or refuting the SP and corroborating the NSP.

1. INTRODUCTION AND BACKGROUND

The Anasazi prehistoric production of black-on-white pottery using organic paint (paint made from boiling down plant compounds, e.g., "bee weed" or *Cleom serrulata*) uses a remarkably sophisticated ceramic technology that was "lost" or not carried over into historic times. Historic Native Americans, such as the Hopi use bee weed in paint but typically in a relatively very small proportion (Mark Tahbo, personal communication) in combination with a mineral such as hematite or possibly manganese which is the main constituent. For this reason they are rightly considered "mineral" and not "organic" or "carbon" paints like the black-producing solely plant-based paint of the Anasazi. Firing pots as the Anasazi did to get black color fired into a pot using organic paint has proven to be a daunting challenge for archaeologists over the years who have attempted to figure out or "replicate" the technology ("archaeo-replicators") (Shepard, 1939; 1956; Fuller, 1984). The central problem is that at firing temperatures organic paint simply oxidizes (or "burns off") and the design on the pot is destroyed, leaving at best only a faint ghost of the image rather than black.

In the early 1990s archaeo-replicators found that if the fire in a trench kiln were smothered with dirt after the kiln reached peak temperature so as to quench (put out) the fire, seal the kiln, cut off the oxygen, and stop further oxidation of the pots that good black could be obtained and Anasazi look-alike black-on-white pots could be produced at least with some level of reliability (e.g, Swink, 1993). This firing regime with dirt smothering as the centerpiece was promoted with a big theoretical leap as the way the Anasazi fired their organically painted pots in order to achieve the black on their black-on-white pottery. Over time, this view became sufficiently entrenched so as to be fairly considered as the conventional assumption on the matter and it assumed all the properties of a paradigm (hereafter "The Smothering Paradigm" or "SP"). This paper takes issue with and refutes this paradigm. Closer examination reveals it is a theory that can only be maintained at the cost of ignoring the physiographic, cultural-ecological, or simply speaking, the contextual realities through which the process it wishes to explain evolved.

Evolutionary systems of this kind are autocatakinetic systems or flow structures, and, in the end, their structure, shape or morphology must be dependent upon the pathways available and the constraints that determine them for linking sources and sinks (e.g, see Swenson, 1991, 1997, 2000, 2010 for further reading). For the issue at hand, fundamental flow variables such as resource availability (especially fuel), and tool availability (a crucial path determinant) for example, are utterly fundamental towards the end of either build or evaluate a theory (viz., demarcation criteria, theory selection, and falsification). The SP proceeds decoupled from its environment, as though these determining variables did not exist or played no role. The result is a theory that, in its decoupling from its real-world physical context, becomes the theoretical analog of a model dependent on water running a mill wheel by flowing uphill.

Proceeding with the principle of parsimony as guide, this paper first reviews the SP and anomalies that readily follow from it and make it intractable. Then in the context of "ecological realism," parsimony is employed from the beginning (viz.,: "How with the parsimony principle as guide, would the Anasazi have fired their kilns?") pointing naturally to an alternative paradigm (“The Non-Smothering Paradigm” or “NSP”) where dirt smothering is eliminated and all the anomalies associated with it are found to be eliminated too. Experimental results demonstrating and corroborating the new paradigm or NSP are provided, and in a final section, an analysis and summary of the stratigraphy of Anasazi trench kiln excavations conducted over multiple decades provides further strong evidence against the SP, or dirt smothering. This section further confirms and corroborates the NSP where no dirt smothering is used or required.

2. **PARADIGMS, PARSIMONY, AND THEORY FALSIFICATION**

This section provides a brief discussion of some key terms, motivation and approach to the theoretical and experimental work presented here.

(a) Paradigms

In the study of the history and philosophy of science, although the terms “paradigm”, “paradigm shift”, and the recognition of the nonlinear and irrational component to the growth of scientific knowledge were popularized by Kuhn (1962), the general insight captured by the terms and the generic dynamics involved have been identified and elaborated by numerous others, although often under a different rubric, both before and after (e.g. see Popper, 1963; Lakatos, 1970). It is sufficient to say that at this general level there is widespread agreement on the principles and dynamics which will be described briefly here and for which I will use the Kuhnian terms.

The underlying point of the insight is the understanding that scientists organize their present research work, experiments and further theorizing not *de novo* but always under an in-place, pre-existing “paradigm”, a theoretical model or explanatory framework. A paradigm is typically built on a set of exemplars, claims, purported discoveries or observations that then become the starting place, the frame, the set of “background assumptions” that form the basis for future work or experiments. They are taken as given and at this point unquestioned while at the same time putting constraints on the kinds of questions asked or things considered in future work. As Kuhn elaborated and as Popper first pointed out, a paradigm typically becomes so entrenched by its supporters or those who have been trained under it that when refuting evidence arises they almost automatically concoct auxiliary ad hoc assumptions so as to rescue the paradigm from refutation or falsification and explain away anomalies. Popper called this a “conventionalist stratagem”. Lakatos later used the number of additional assumptions added to preserve a paradigm as a measure of whether it was a “progressive” or “regressive” research program. At some stage the number of anomalies reaches a tipping point at which time the paradigm is unstable and vulnerable to replacement. This leads to a “paradigm shift” which changes the fundamental underlying assumptions about the way “the world is seen” and future experiments are done or thought about.

(b) Parsimony

In the long and illustrious history of modern scientific methodology few principles, if any, have a longer and more genuine pedigree than the principle of parsimony. Found at the foundations of every part of modern science from physics to chemistry, biology and evolutionary theory, it can be traced back through, to almost arbitrarily name just a few the full list would be so long, Popper, Russell, Planck, Joule, Lavoisier, Newton, Leibniz, Aristotle and the Pre-Socratics before them. Simply put it says that between two competing theories (or in the case of Ockham, “ontologies”) or in the parlance at hand here “paradigms” the one *ceteris paribus* that explains a particular phenomenon or set of phenomena with the fewest number of postulates, assumptions, entities (“things” or “steps”), or explanatory devices is more likely to be the true one, or in any case, the truer of the two. In the discourse on the “truth” of scientific theories beginning with Popper’s “falsificationism”, Lakatos’ (1970) “sophisticated falsificationism” uses a well-focused formulation of the principle of parsimony as the ultimate basis for the falsification of one theory by another. Even with the most conservative use of the principle of parsimony, in scientific methodology it has proven to be a remarkably powerful heuristic tool unlike any other for guiding thinking in experimental and theoretical work.

The Principle of Parsimony Highlights the Anomalies of the SP. In the context of doing dozens of experimental trench kiln firings with organic black-on-white at our research facility in Arizona and with colleagues both at that facility and at multiple kiln conferences using the smothering paradigm (the SP) the principle of parsimony repeatedly kept bringing the intractable anomalies carried by the theory into view so as to eventually force the unavoidable conclusion that this could not have been the preponderant firing method (if used at all) used by the Anasazi to attain their organic black-on-white pottery. The next section of this paper reviews the SP, its “hard core” or “background assumptions”, what it looks like to fire with it, and the anomalies associated with it. This is followed by the experimental and additional research that forms the foundation for the replacing or “non-smothering” paradigm (the “NSP”) that rather than flying directly in the face of parsimony follows directly from it. Guided by parsimony (or a “first principles” cultural ecological “realist” perspective), the NSP changes the background assumptions in the approach to organic black-on-white firing, and in so doing, it will be shown experimentally, that it dissolves the anomalies or improbable assumptions associated with the SP. Following our example from Section 1, this provides a theory that rather than driving a “mill wheel” by requiring water to flow uphill, drives it, naturally by allowing the water to flow down.

3. THE SMOTHERING PARADIGM (THE “SP”)

Paradigms, as discussed above are distinguished by hard core or background assumptions and then distinctive features that define them. The background assumptions are just that, assumptions taken as axiomatic that sit in the background, assumed to be true, left unquestioned, and bracketed out of future experiments and research because they are transparently taken for granted[i]. The initial motivating background assumption of the SP is that:

> ***Background Assumption***: Firing carbon-painted (organic) black-on-white ceramics successfully is fundamentally difficult, arcane, or very tricky to achieve. There must be some “unique” or heretofore undiscovered firing secret or technique (some “explanatory device”) needed to explain it.

For example, as noted by Fuller (1984), pioneering ceramic technologist “Anna Shepard’s experiments (1939:239-261) indicate that organic paint has the tendency to burn out when it is fired too long, too hot, or with too much oxygen. She had difficulty achieving a successful firing of carbon designs regardless of what adjustments she made (1939: 265).”

> ***Conclusion***: Specifically, to solve the “mystery” or “puzzle” there has to be some special technique, “missing piece”, or explanatory device that had to be “discovered” or figured out to add to the firing sequence to halt the oxidation of the paint.

Solution: Smother the kiln with dirt after it reaches peak temperature to cut off the oxygen supply, quench the fire, and thus prevent any further oxidation of the pots (e.g, Toll, et. al, 1991).

This latter (smothering) then becomes the centerpiece of the paradigm couched in the following protocol:

Diagnostic Features of Model:

- **Discrete Four-Stage Firing Sequence** (Swink, 1996; 2004): (i) "The Primary Fire"; (ii) "The Setting" (on sandstone cobbles as "kiln furniture" to hold pots and cover sherds over the pots) set level with ground; (iii) "The Secondary Fire"; (iv) "The Smothering" (the fire is covered with dirt at peak temperature to quench it);

- **A Crib of Large Diameter Fuel**: "Leg-size spanners" and "arm-size" rafters (Swink, 1996; 2004)

4. WHAT IT LOKS LIKE TO FIRE WITH THE SP

Figure 1. After a primary fire has been built and burned down, sandstone cobbles are put over the coals, and pottery is set on the cobbles and covered with cover sherds. "Arm-size" rafters (shown here) are put over "leg-size" spanners (not shown) for the crib of the secondary fire. (Photo by the author: 2011 Leupp Kiln Conference, Pecos, NM)

Figure 2. Secondary fire burning. (Photo by the author: 2011 Leupp Kiln Conference, Pecos, NM)

Figure 3. After the secondary fire has reached peak temperature the burning coals are smothered with dirt to quench (put out) the fire, seal the kiln to cut off further influx of oxygen and stop oxidation and destruction of the paint. (Photo by the author: 2011 Leupp Kiln Conference, Pecos, NM)

Figure 4. After 18-24 hours for cool down, the kiln is excavated to remove the layer of dirt and copious quantities of charcoal left by the smothering. (Photo by author: 2011 Leupp Kiln Conference, Pecos, NM)

Figure 5. Canteen with most of the charcoal excavated from around it has typical thin white ash that, in a successful firing, is brushed off to reveal the black underneath. Good black can be produced by the SP but it is a highly inefficient process with a significant rate of failure. (Photo by the author: 2011 Leupp Kiln Conference, Pecos, NM)

5. ANOMALIES IN THE FUEL, THE DIRT, AND THE RECORD

From the principle of parsimony or a "cultural-ecological first principles point of view" anomalies become quickly red-flagged:

(a) The Fuel Size Specified by the SP is Anomalous and Unlikely

(i) Difficult to Process: If one were to attend one of the Leupp or Southwestern kiln conferences held in recent years, one would find archaeo-replicators firing under the SP using modern axes, and often chainsaws, to harvest and process the large diameter (leg-sized, and arm-sized) wood (piñon and more preferentially, juniper) called for by the SP. The Anasazi clearly did not have chainsaws or modern axes, and fuel of this size would have been extremely hard to process without them. Parsimony says the wood they would have used instead would have been of a diameter that could be gathered easily and processed (broken) by hand, under foot or between two rocks, roughly 1 inch to 2.5 inches at most.

(ii) Particularly Scarce: Especially by the time of Pueblo III when organic black-on-white pottery production was at its peak, deforestation had made wood a scarce and extremely valuable resource. Branches or small limbs of 1 inch to 2.5 inches in diameter grow faster and would have been way more plentiful than the comparatively particularly scarce trunk or large limb size (leg- and arm-size) fuel specified by the SP.

(iii) Larger Scale Means Greater Fuel Consumption: A crib built of larger wood inherently requires considerably more fuel to build than one built of smaller wood. Using large-scale fuel of this kind would not only have been (i) harder to process, and (ii) particularly scarce, but would have meant unnecessarily (as will be shown below) burning dramatically more fuel thus further compounding the anomaly. In addition to increasing fuel consumption, temperatures reached with large-scale fuel components of this kind are likely to be consistently well above those reached on average by prehistoric ceramicists and beyond those needed to sinter the clay in the sintering range of prehistoric black-on-white. Put simply, using fuel of this size does not pass a "test for reasonability". As Owen Severance, who has recorded the locations of more than 850 kilns in southeastern Utah, has remarked (personal communication), "if fuel had been burned at the rate it is burned under the current model, the deforestation that occurred going into and through Pueblo III would have occurred so fast there wouldn't have been enough wood to fire even a fraction of the thousands of kilns that were probably used in the Southeast Utah area (or in the Mesa Verde Region as a whole)."

(b) Smothering Itself is Anomalous and Unlikely

(i) Processing Dirt for Smothering is Extremely Labor Intensive and Time-Consuming: The majority of excavated Mesa Verde Region kilns were built away from densely populated areas and arable soil and were "dug into weathered bed-rock" (Erickson, 1996, p. 21) in particularly poor, hard, and rocky soil in areas "with virtually no topsoil" (Fuller (1984, p.7), making soil or dirt suitable for smothering itself a scarce and difficult to acquire commodity. Simply processing such soil to prepare it for smothering even with the shovels and other tools contemporary archaeo-replicators use is an arduous task. For landscapers the caliche-laced soil typical of the southwest often

means the jackhammer or the auger is the tool of choice for breaking it up. It is likely that the Anasazi, who had no shovels or any of these modern tools would have had only pointed sticks for the task and, after loosening the dirt it would have further had to be collected and sifted or sorted in order to eliminate rocks. At this point, there would still have to be a method to get it onto the coals in the kiln in an expeditious way. Done too slowly the pots in the uncovered or less covered areas would simply get smoked by the smoldering of partially suffocated coals. Contemporary archaeo-replicators use shovels to do this, but the Anasazi had no shovels. They could have used bowls or large sherds to scoop the dirt onto the coals, but this might have been too slow. Alternatively, they could have scooped the loosened, sifted dirt onto animal skins in advance and then dumped it on the coals that way. However it was done, if in the unlikely event that it was done at all, it would have been a very labor intensive and, as will be shown below, an unnecessary time-consuming process.

(ii) Copious Charcoal Production Means Wasting Scarce Resources and Additional Processing Time: When a fire is quenched at peak temperature, a large part of the fuel is only partially burned or converted to heat, gas, and ash, leaving a large amount of macroscopic charcoal behind (e.g., Figs. 4 and 5). This is a huge waste of fuel unless the charcoal is recovered for re-use possibly for the primary fire in a subsequent firing as archaeo-replicators, including ourselves, who have experimented with this method repeatedly often try and do. Yet to use the left-over charcoal (or part of it, since the quantity is so large) in this way it has to be carefully removed from the kiln and sorted from the dirt with which it becomes unavoidably laced. This itself is a time-consuming process wherein some significant amount of fuel and dirt are ultimately wasted. Experimental work quickly shows that using anywhere near the full amount of the charcoal produced this way is never closely approximated. As a consequence, archaeo-replicators typically find larger and larger piles of charcoal building up around their kiln sites.

(c) The Assumption or Implication that Smothering is Somehow Necessary is Anomalous: It is Falsified by Salado Polychromes

The SP rests on the idea that achieving successful black-on-white pottery with organic or carbon-based paint is inherently difficult and requires some special, “unique”, firing technique or explanatory device to account for how the necessary atmosphere in the kiln was achieved and that smothering is the answer that “solved the firing puzzle” (Swink, 1996, p. 317). But Salado Polychromes, the “most abundant decorated ware of the Classic Period (A.D. 1275-1450)” (Simon, 1996, p. 38) in the prehistoric Southwest, and of which over 95% from the platform mound communities were made with organic or carbon paint (Simon, 1996), falsifies this basic premise of the SP. Since Salado Polychromes have a strong black-on-white component where the black is organic or carbon paint, but also typically have large areas of oxidized red slip or paint on them, it is clear they could not have been made by smothering as the SP requires. The oxidized red on them falsifies the idea that achieving good organic black requires smothering with dirt. Rather than making smothering necessary, Salado Polychromes make it not only gratuitous but more importantly, not a possible explanation for the production of these ceramics.

6. CONFIRMING EXPERIMENTAL EVIDENCE AND CLUES

In the fall of 2012, in order to further press these observations and evidence, I built a small experimental gas kiln at our research facility in Arizona. While never intended as a way to fully analyze or fully test trench kiln technology, it was, nevertheless, seen as a way of conducting some fairly simple experiments to study certain component details of the process. Temperature could be controlled and checked easily with a pyrometer and the atmosphere could be changed from more or less oxidizing or reducing by controlling the amount of air mixed at the single Venturi burner itself, on the way into the kiln at the burner port, as well as by controlling the flue opening at the output. The Gila style bowl in Figure 6 shows the result obtained after several runs. It shows good black-on-white on the inside achieved with organic paint ("Bee Weed") while at the same time the slipped rim and exterior are all a highly-oxidized red.

Figure 6. A Gila style polychrome bowl fired in experimental gas kiln replicating the result achieved on Salado Polychromes in general; a pot with good organic black-on-white on one part and highly oxidized red on another. (Photo by the author: 2012, Apache Junction, AZ)

The result clearly experimentally demonstrated the production of organic black-on-white without smothering. However, it did something more. By replicating the results obtained in the production of Salado Polychromes, viz., organic black-on-white on one part and oxidized red on another, the results yielded further important clues regarding the requirements for obtaining organic black-on-white in general. In particular, they showed that as long as a pot is not oxidized on the way up (the climb up in temperature of the kiln) so the carbon paint is not oxidized, it can be subjected to increasing and substantial levels of oxygen on the way down. The reason this works is that the threshold for oxidizing black organic paint is a much higher temperature for a given amount of oxygen than it is for the iron in the slip/paint that produces the red. This showed clearly that firing organic black-on-white the pots successfully does not depend at all on the need to have the kiln completely cut off from oxygen intake as it is with dirt smothering. A kiln can be, and, in the case of Salado Polychrome production certainly was, subject to increasing levels of oxygen as it cools down and leave the black intact. In the experimental gas kiln this dynamic maintenance of the requisite redox state is accomplished quite easily when the kiln is subject to a reducing/neutral atmosphere on the way up. When the burner is shut off after the kiln reaches temperature, rather than sealing the kiln from further oxygen intake completely oxygen from the outside is allowed to slowly leak into the kiln in as it cools down. As the kiln loses about two thirds of its temperature (the amount depending on how high it is fired initially) it crosses over from reducing/neutral to an oxidizing atmosphere. Having a higher oxidation threshold, the black, at this point, remains unchanged while the iron in the slip, in the case of polychromes, with a lower threshold, is oxidized. With this experimental insight in hand, further parsimony analysis posed the next theoretical question: What simple kind of trench kiln firing could lead to the result similar to the experimental result in the gas kiln? What would a straightforward trench kiln firing technology be that could produce the dynamic firing environment achieved in the gas kiln experiment? The answer is remarkably simple and is provided in the next section by "The Non-Smothering Paradigm" or "NSP" identified above. The section after that shows the corroborating experimental results.

7. THE VOICE OF PARSIMONY AND A NEW PARADIGM: THE NON-SMOTHERING PARADIGM (THE "NSP")

The core assumptions of the NSP are quite different from those of the SP and are as follows:

a) ***Fuel Size of Roughly 1 inch to 2.5 inches in Diameter***

Fuel used for firing is not fuel that would have been hard to process and particularly scarce. It is fuel of a size that that would have been easily gathered and processed by being broken to length as needed without modern tools:

Hypothesis (Claim) and Implications: The major reason for the perceived difficulty found by modern archaeo-replicators in producing organic black-on-white pottery, in particular the problem of keeping the carbon-based paint from burning off or oxidizing on the way up or down, is the use of over-size fuel. The hypothesis asserts the use of smaller size fuel with a diameter of roughly 1 inch to 2.5 inches since this is the kind most easily gathered and processed in the environmental context of the prehistoric Anasazi potter. Thus it is the most likely to be used. Additionally, it automatically eliminates the problems usually associated with black-on-white firing as discussed in section b). The motivation for its use, however, by the prehistoric potter was straightforward; it was the simplest, most obvious, and most available fuel to use. Fuel consumption would be put at a reasonably practicable level rather than at the remarkably inefficient high rate of fuel consumption entailed by the SP or current conventional model which, as Severance (above) has opined is so profligate it would have made it impossible to have ever fired even a substantial fraction all the kilns now known to have existed in the region.

b) No Dirt Smothering

Hypothesis (Claim): Smothering a kiln with dirt was *not* the ordinary way (if used at all) prehistoric ceramicists fired organic black-on-white pottery. Instead, using smaller diameter wood and building the kiln in a prospective way, *the ash from the secondary fire is sufficient* to keep the black from oxidizing to a temperature threshold below which it no longer oxidizes. Thus, this kind of firing becomes a straightforward, efficient way of firing consistent with the cultural context in which this pottery was produced.

Discussion: The central problem for archaeo-replicators trying to get good black with organic paint has been that the paint is burned off or oxidized leaving at best only a light ghost of the design. The SP attempts to solve this problem by cutting off the oxygen at peak temperature with smothering. Although this often does produce good black-on-white pottery, the loss rate is still fairly high due to oxidation "on the way up" before the dirt goes on. This is a consequence of too much air getting into the kiln through large gaps created by the large diameter members of the crib. Using small diameter wood in accordance with the NSP eliminates oxidation on the way up due to a tighter crib created by the packing property of the smaller wood. As to oxidation on the way down, under the NSP the secondary fire puts a natural ash layer over the pots. This stops oxidation without dirt smothering. Finally, under the SP, oxidation can also occur if the smothering layer gets punctured from a settling coal underneath and opens up an air hole. This does not happen with the NSP as there is no layer to be punctured.

Although destruction of black through oxidation is the major problem with the SP, another common problem is that pots get smoked, i.e., the black is black but the white is either black or smoky gray. Most of the smoking comes from large smoldering partly combusted fuel either on the way up or on the way down under the crib where numbers of still smoking pieces of wood or coals remain. With the NSP, the use of smaller fuel in a well-stacked and set kiln results in complete combustion of the fuel which burns faster and cleaner. The fact that there is no smothering of partially burned wood eliminates almost all smoking completely.

c) Kilns Situated, Built and Fired So as to Attenuate Wind

Kilns were Situated and Built to Attenuate the Wind: Other than finding a place that is safe to fire relative to flammable things nearby, the location of the typical firing at a contemporary kiln conference such as the Leupp or Southwest Kiln Conferences is rarely discussed. However, Mesa Verde region kilns were all carefully located and built with regard to conducting efficient firings consistent with the NSP model. In particular, these were generally built on slopes of over ten degrees (Fuller, 1984) in or near drainages; they were quite clearly situated so as to attenuate wind and control airflow. In Helm's (1973, p.216) report on perhaps the first excavated and identified Mesa Verde style kiln, she notes Shepherd's (1956) discussion of trench kilns in general versus open firing as a way of controlling oxidation as required in the production of black-on-white. She then further notes that it is "significant that 2160 (the kiln under discussion) is located on the north side of a ridge" which, given that "(o)n the top of Cedar Mesa the prevailing wind is from the South" would have put it on the lee side of the Mesa, naturally attenuating the wind. All of this works, consistent with the NSP, to control or limit oxidation as Shepard has pointed out, and does it naturally by helping to keep the blanket of ash from the secondary firing on the pots while they cool down. In Fuller's (1984) extensive report on nine Anasazi Wood Mesa kilns, he underscores Helm's observations writing that in general all of these kilns were also "on north facing exposures." Twelve years later, following more excavations, Erickson (1996, p. 21) wrote "almost all late Pueblo III kilns are placed on north-facing slopes". Numerous kilns have been located since and while they are not all on north facing slopes, they are almost all uniformly on slopes in drainages where the same conditions and intent for wind attenuation can be identified.

Kilns Were Fired to Attenuate the Wind: After selection of the site and building the kiln so as to aid in optimal control of the oxidation state of the kiln, the next crucial concern is the setting of the pots and cover sherds within the kiln itself for firing. Cover sherds are used with the NSP as they are for the SP, but the SP has the top of the setting (the top of the cover sherds over the pots) at ground level (Swink, 1993; 2004). Set this high means that the ash blanket that protects the pots from oxidation in a natural (non-dirt-smothered) firing is above ground level when the fire burns down. This failure to take advantage of the trench itself will almost assuredly result in the ash blanket being blown off extremely quickly. For the NSP, in contrast, the top of the setting is roughly an inch and half *below* ground level. This way the edge of the kiln contributes sufficiently to keep enough ash on the pots to keep the atmosphere from being overly oxidized until the pots have sufficiently cooled down.

8. DOING AN ORGANIC BLACK ON WHITE FIRING USING THE NSP

Figure 7. Three simple test pots were made with Dakota formation paste found near Blanding, UT, and three from a red clay found near Pecos, NM. All were slipped with a montmorillonite clay from near Cortez, CO that holds organic paint well. Half were painted with Bee Weed (*Cleom serrulata*), and half with Brittlebush (*Encilia farinosa*) which our tests show can also work well as a black organic paint. (Photo by the author: 2014, Apache Junction, AZ)

Figure 8. After the primary fire has burned down to a bed of coals, sandstone cobble are put down and the pots, after having been pre-heated around the kiln during the burning of the primary fire are set on them. Cover sherds (not shown) are then placed over the pots to complete the setting the top of which is about an inch and half below ground level. (Photo by the author: 2014, Apache Junction, AZ)

Figure 9. A crib is built beginning with “spanners” going the long length of the kiln of about 2”-2 1/2” in diameter (not shown) and “rafters” 1”-2” in diameter (shown) are placed across the spanners. Smaller pieces (also shown) are used on top to start the fire. (Photo by the author: 2014, Apache Junction, AZ).

Figure 10. The secondary fire is shown here under way. Small diameter fuel means the crib is tight, and this keeps the “fire box” below from getting too much O2 “on the way up” and oxidizing (burning off) the paint. Combustion is not an issue with dry small diameter fuel which burns more easily for a given amount of O2 than large fuel due to standard surface/volume scaling (Photo by the author: 2014, Apache Junction, AZ).

Figure 11. As the crib collapses the ash forms a natural blanket that keeps the organic paint from oxidation. While some ash is inevitably blown away as the kiln cools, if the kiln has been built and situated properly it occurs so slowly that by the time the pots are exposed to substantial O2 they are cool enough so the black is stable. Here, cover sherds are starting to show through the ash. (Photo by the author: 2014, Apache Junction, AZ).

Figure 12. Shortly before being cool enough to open a good portion of the cover sherds have had the ash blown off them. At this point O2 at or near PAL (present atmospheric levels) is reaching the pots, but they are cool enough so the black is not altered. Whereas a dirt-covered firing takes 18-24 hours to cool down, a kiln fired with the NSP is ready to open the same day in 5 or 6 hours. (Photo by the author: 2014, Apache Junction, AZ)

Figure 13. This kiln, fired mid-day was ready to open by the end of the day and all pots show good strong black-on-white. Left behind in the kiln are cover sherds, and ash bed with some small charcoal inclusions. No excavation is required with an NSP as it is with the SP. The cover sherds are simply removed and the pots taken directly out. The layer of ash on the organic paint is then brushed off to reveal the black. (Photo by the author: 2014, Apache Junction, AZ).

Figure 14. In these additional shots of the pots inside one can see clearly with the Gila jar (center front) like the bowl (Figure 6) from the experimental gas kiln, oxidized red has been produced on the same pot with good black-on-white. This shows the natural dynamic, and roughly "automatic", control of the redox state of the kiln through the use of small fuel and the ash it produces. (Photo by the author: 2014, Apache Junction, AZ).



Figure 15. Closer photos of some of the pots showing strong black on white obtained from the firing. (Photos by the author: 2014, Apache Junction, AZ).

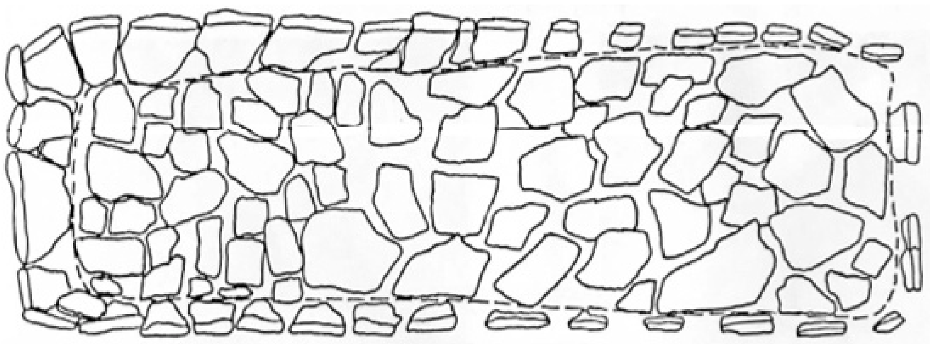
9. STRATIGRAPHY OF MESA VERDE REGION TRENCH KILNS

The theoretical deduction of the NSP and experimental work shown herein had its initial formulation with the principle of parsimony as its driving principle. As sketched above, after dozens of experimental runs with the SP, the principle of parsimony continually forced the conclusion that this *could not* have been *the* way (if ever used at all) that Anasazi potters produced their remarkable organic black-on-white ware. From the principle of parsimony, *ceteris paribus*, the facts are clear enough to warrant replacement of the SP with the NSP, or more strongly falsification of the SP by the NSP in Lakatos' (1970) terms. But the facts do not to this point give us a pure *ceteris paribus* situation; there are other data to consider. Beginning in the 1970s (Helm, 1973), dramatically increasing in the 1980s (e.g., Fuller, 1984; Hammack, 1984; Harden, 1988), and continuing into the 1990s (e.g., Hammack & Heacock, 1991; Heacock, 1995, Erickson, 1996; Brisbin, 1996; Lacey et al., 1997) a large number of Mesa Verde region kilns were discovered and excavated[ii].

After roughly a thousand years, these features are in variable states due to natural process of erosion from water and wind as well as other post-use anthropogenic disturbances. However, there are sufficiently strong invariances in their construction and stratigraphy to provide important clues to their use. A firing paradigm must not only produce (or "replicate") organic black-on-white pottery, it must also produce (or "replicate") a consistent stratigraphy and surrounds (e.g., Helm, 1973; Fuller, 1984; Blinman, 1992). This section reviews the key relevant points of this work.

a) Morphology, Physiographic Context, and Assemblages of Anasazi Kilns

In 1984 Fuller presented the most comprehensive detailed study of Anasazi kiln excavations done to that point. The nine Pueblo III Woods Mesa kilns near Yellowjacket Canyon that he described and analyzed (Fuller, 1984; Sullivan, 1988) serve as excellent exemplars of Anasazi kilns in general. They range in size from 1.9 m to 5.5 m in length, 0.9 m to 2.0 m in width, and 20 cm to 50 cm in depth. Although other outliers have been found subsequently, this is generally consistent with other Pueblo III Mesa Verde region excavated kilns; the width is typically fixed at roughly 1 m to 2 m, while the length may be more highly variable up to many meters. Typically, Anasazi kilns were situated carefully and built into non-negligible slopes of generally 10 degrees or more. They were oriented orthogonally to the slopes, in or near drainages and dug into poor rocky soil near or down to bedrock so as to be to the leeward of prevailing winds (Helm, 1978; Fuller, 1984; Hammack, 1984; Erickson, 1996). Consistent with the NSP, they were intentionally built and ideally situated to attenuate wind and facilitate a controlled oxygen-limited atmosphere during and after firing by retaining the natural ash blanket on the vessels for a sufficient period on the cool down. Figure 16 shows a plan view of a typical kiln with sandstone slabs or cobbles both lining the sides and placed on the floor where they were used in accordance with stratigraphic and general ethnographic evidence, to place or "set" the pots during firing (e.g, Fuller, 1984).



TYPICAL KILN PLAN VIEW SHOWING SANDSTONE COBBLES
(from Fuller, 1984, Kiln 1, 5MT7525 courtesy CASA, Cortez, CO)

Figure 16. The general shape of the typical Pueblo III Anasazi trench kiln, longer than wide, lined with sandstone slabs on the sides and variously sized angular sandstone cobbles on the floor for holding pots.

b) General Stratigraphy of Anasazi Kilns

The Fundamental Three-Level Stratigraphy: In her analysis of Kiln 1 of Feature 5MT6965 in Woods Canyon of the Yellowjacket System, Colorado, Hammack (1984) recorded the three-level stratigraphy that can be identified in almost every other subsequent kiln excavated in the region. The kiln, she wrote, "measured 2.6 m by 1.1 m and was approximately 50 cm deep. The floor was covered with a layer of angular cobbles and approximately 5 cm of heavy black charcoal. The upper fills consisted of (a layer) of a lighter, grey ash" with "colluvial inclusions and ceramic sherds" (Hammack, 1984, p. 27). This three-level stratigraphy with a (i) lower level of 5 cm or so of mostly heavy charcoal largely under sandstone cobbles; (ii) a level of light grey ash; and (iii) an upper-most level of colluvial or alluvial fill, was generalized by Fuller (1984) to all eight of the kilns excavated in the Yellowjacket district covered in his report :

> All features (kilns) have a.... layer of charcoal and ash on their floors. Within and sometimes immediately above is an amorphous layer of sandstone cobbles.... while (t)he upper fill of all eight excavated kilns consisted of an ashy layer, with inclusions of colluvial slope wash (Fuller 1984, pp. 52-54).

Fuller (1984, p. 54) noted dozens of other kilns in and around Woods Mesa, and what he estimated as hundreds of Pueblo III kilns "(i)n southeastern Utah...similar in form to the Woods Mesa kilns and situated in a similar topographic situation." When Harden (1988) excavated an additional kiln at site 5MT9700 in Montezuma County, a late Pueblo II kiln, he noted the same stratigraphy. "The feature," he wrote (Harden, 1988, p. 4) "appeared on the ground surface as a 1 x 2m concentration of burned rock and ash". Irregular sandstone blocks "covered the floor..."

and “the interstices between rocks were full of ash and tiny pieces of charcoal... (t)he pit was covered with 10 to 12cm of sandy colluvium” (Harden, 1988, p. 7). This generalized stratigraphy was further corroborated with Heacock’s 1995 report on the excavation of three additional Pueblo III Mesa Verde region kilns in southwest Colorado and southeast Utah, where she noted that all the kilns were “similar stratigraphically, to previously excavated...kilns”;

> Each had a basal layer of ash and charcoal on the floor with a layer of cobbles or slabs lying directly on or within this stratum. The upper fill of the pit (trench) kilns was generally composed of mixed deposits of ash and alluvial or wind-blown sediments.” (Heacock, 1995, p. 405).

In the legend for Feature 42SA10275, Heacock (1995, p. 397) summarized this typical three-level stratigraphy from the upper to lower layer as follows: “(1) post-use fill, (2) ash and occasional inclusions of charcoal, (3) a dark (heavy) layer of charcoal and ash” Heacock (1995, p. 397). This generalized stratigraphy for excavated Anasazi trench kilns is shown (from lower to upper layer) in Figure 17.

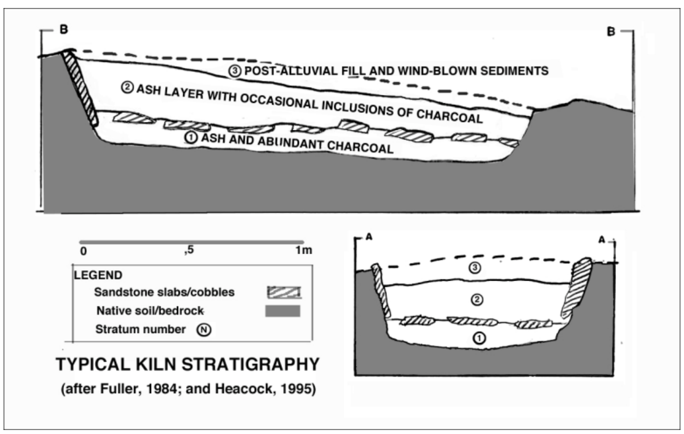


Figure 17. Typical three-level stratigraphy for Anasazi trench kilns: 1) Basal charcoal layer (ash with abundant charcoal) under and between sandstone cobbles; 2) Ash layer with occasional inclusions of small charcoal pieces and ceramics (cover sherds, and firing remnants); 3) Post-use layer of alluvial and wind-blown sediments.

c) Kiln Ceramic Assemblages Recovered from the Kilns and Implications for Firing

The ceramic contents recovered from the Woods Mesa kilns are consistent with the typological profile of other similarly excavated kilns (e.g, Hurst, 1996). All kilns were constructed and used primarily to fire Pueblo III white ware vessels, the majority of which were bowls[iii] (Fuller, 1984). All were Mesa Verde black-on-white or McElmo black-on-white painted with either organic (carbon) or mineral paint respectively; thus, all produced in an essentially oxygen restricted (reducing/neutral) atmosphere. Over the range of all the kilns the split between the two broad types is roughly even, with more carbon paint predominating closer to Mesa Verde National Park versus more mineral closer to Blanding, UT.

Oxidized Cover Sherds Further Corroborate the NSP and Falsify the SP. The recovery of a large number of partial bowl sherds, roughly 20% or less of a bowl, all highly oxidized versus the other recovered ceramics in the same kiln, forced the conclusion that these sherds were used as “cover sherds” during the firing. For example, in Kiln 2 at 5MT7525 there were a large number of oxidized bowl sherds found whereas, the majority of the non-oxidized fired ware were dippers. The firing was likely almost "all dippers" (Fuller, 1984, p. 38) with the oxidized sherds used as cover sherds to help protect the dippers and keep them within a more isolated, less oxidative micro-environment during the firing. This corroborates the NSP and clearly falsifies the SP since, if the fire had been quenched with dirt, the cover sherds would not have been oxidized. Fuller describes other kilns such as Kiln 5, also of 5MT7525, that demonstrate the same thing whereby oxidized cover sherds made with corrugated pots, each consisting of about 25% of a vessel, were used to cover white ware vessels.

d) What the Stratigraphy of Anasazi Trench Kilns Says About the Firing

The three-level stratigraphy of the Anasazi trench kiln corroborates the three-stage firing process of the NSP and falsifies the SP:

The Primary Fire, Cobbles and Basal Layer of Charcoal: "Layer 1", the basal charcoal layer, a layer of abundant charcoal with ash, under and sometimes between a rock layer of irregular sandstone cobbles, is evidence of stage one of the firing process under both the NSP and SP, the primary fire, as well as the beginning of stage two, the setting of the pottery. The stratigraphic and the general ethnographic evidence make this quite clear. A primary fire was built in the kiln and allowed to burn down to a bed of coals at which time sandstone cobbles were put in over the coals providing a place on which to set the vessels, keeping them even and at the same time buffering them from the direct thermal shock of the hot coals of the primary fire below. The dense charcoal lens of the basal layer in almost all excavated Anasazi kilns resulted from the fact that the cobbles necessarily smothered the coals underneath them enough so that they were never completely combusted thus, leaving charcoal in this basal level at the end of the firing process. This level of stratigraphy of excavated kilns is easily replicated when this process is used.

The Secondary Fire, Layer of Ash and Ceramics: After the conclusion of the second-stage of the firing process, the setting of the vessels on the sandstone cobbles and placement of cover sherds over the top of the pots[iv], a crib of fuel (spanners and rafters) is built over the setting. At this point, the SP and the NSP diverge dramatically. As discussed above, the SP uses large-diameter fuel to build the crib over the setting with the setting built to ground level, while the NSP uses small-diameter fuel to build a crib over the setting that sits an inch to an inch and a half *below* ground level. With the SP when the secondary fire gets to peak temperature the coals are smothered with dirt which quenches the fire while with the NSP the fire is *not smothered* but let to burn down from coals to ash naturally. Figure 18 shows a detail from a NSP firing after the fire has burned down. What remains in the kiln is ash with occasional inclusions of small pieces of charcoal and ceramics. An oxidized cover sherd is also visible in Figure 18. The stratigraphy from the NSP firing precisely replicates what a firing would need to look like to replicate the typical generalized stratigraphy of excavated Anasazi kilns (Figure 17).

Figure 18. Ash with occasional small inclusions of charcoal and an oxidized cover sherd that result from of a firing using the NSP precisely replicates the stratigraphy of excavated Anasazi kilns. See also Figs. 11, 12, and 13. (Photo by the author: 2014, Apache Junction, AZ).

The Stratigraphy and Archeology Refutes the SP: While Anasazi stratigraphy corroborates the NSP, it strongly refutes the SP. Figure 19 (see also Figs. 4 and 5) shows a kiln and its surrounds after firing with the SP and the fired pots are about ready to take from the kiln. The dirt and much of the copious charcoal produced by the this method have been excavated from around the pots showing the large amount of charcoal still in the kiln and piled around it from this single firing. If the SP, were the method of firing, the stratigraphy of excavated kilns would be dramatically different from what it is. It would consist of a dense layer of large pieces of charcoal with a relatively small amount of ash instead of the second layer being comprised of ash with occasional inclusions of small pieces of charcoal, In addition to the heavy deposit of charcoal *within the kiln* there would be large deposits of charcoal *around it*, and this, as the excavation reports show, is simply not the finding.[v],[vi]

Figure 19. A kiln fired with the SP after firing showing the large quantities of charcoal that result from a single firing both in the kiln and in piled around it. See also Figs. 4, and 5. (Photo by author: 2011 Leupp Kiln Conference, Pecos, NM)

Ash Piles Rather Than Charcoal Piles: Where piles of kiln residue are found, rather than charcoal, as would be required to corroborate the SP, ash piles, are found instead, further corroborating the NSP. Examples are shown in Figures 20 and 21.

Figure 20 shows a plan view of Site 42SA10275 as documented by Heacock (1995). Feature 5 is a kiln with accumulations of ash not charcoal around the outside of the kiln and Feature 4 is a large ash pile nearby measuring roughly 1 m by 2 m.

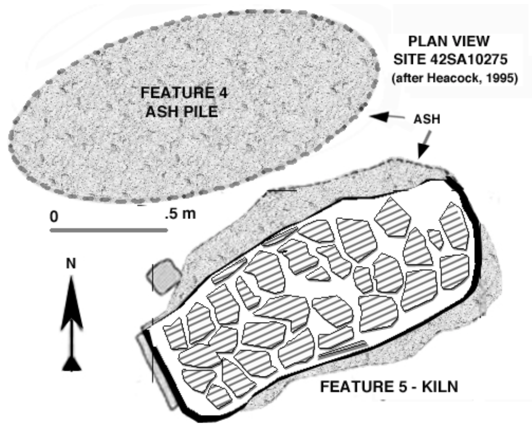


Figure 20. Site 42SA10275 kiln (Feature 5) from Heacock's report (1995) showing ash accumulation around the outside and large "clean out" pile of ash nearby (Feature 4).

Figure 21 shows Site 5MT9431 excavated by Hammack (1991) with similar features, one of which is an even larger ash pile, measuring roughly 2.5 m wide by 4 m long. Bearing in mind that the total amount of ash produced in a natural NSP firing is small relative to the amount of fuel consumed (vs. the amount of charcoal produced with the SP) and that a good portion of this ash, especially the lighter, whiter part, is readily transported away by wind (vs. any charcoal on site) the accumulation of the quantities of ash reported in these examples indicate numerous, repeated firings of the same kilns where clearly dirt smothering was not used.

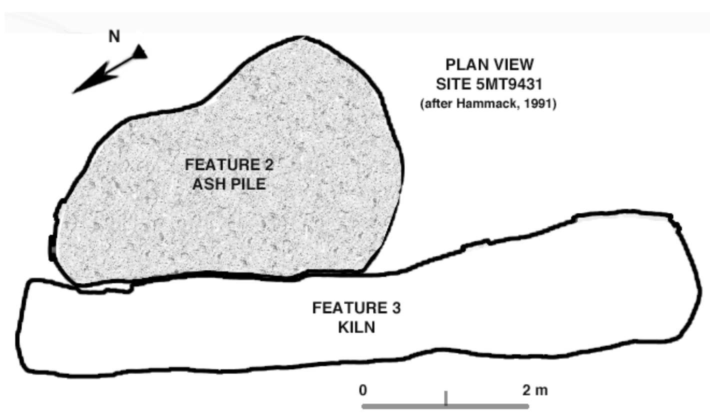


Figure 21. Site 5MT9431 kiln (Feature 3) from Hammack's (1991) excavation with large adjacent ash pile (Feature 2) over 4m long.

e) Is There Any Real Substantial Archeological Evidence at All That Corroborates the SP?

The Short Answer is "No". Subsequent to the other excavation reports discussed above Brisbin (1996) reported on nine additional kilns excavated in seven archeological sites on the western side of Chapin Mesa in Mesa Verde National Park. Construction work around the Mesa Verde Waterline Replacement Project had damaged some of these sites and excavation was part of the effort to mitigate this impact. The kilns, in contrast to the other kilns discussed herein, with the exception of Harden (1988), were Pueblo II rather than Pueblo III. In addition to this difference, and that they were, on average likely more damaged or impacted by recent anthropogenic activity than most of the other excavated kilns, the excavations were significant according to Brisbin (1996, p. 281) because the "uppermost layer of soil....(was identified) as prehistoric cultural rather than post abandonment fill...and interpreted as a smothering layer applied by the prehistoric potters to effectively halt the limited oxidation process of the pottery firing". "Once this smothering stage was recognized" he wrote, replicators were able to "obtain consistent results in the production of black-on-white pottery." Figure 22 shows the general stratigraphy summarized by Brisbin in his report where the new level he added distinguishing his report from all the previous kiln excavation reports by all the other experts until then is Stratum 3.

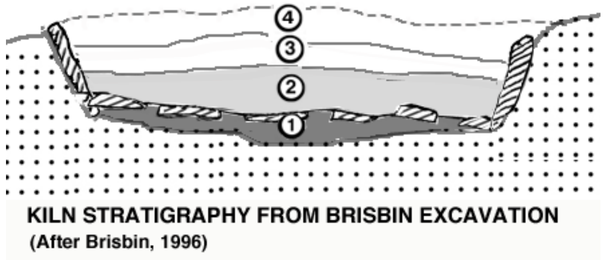


Figure 22. Stratum 3, according to Brisbin (1996, p. 298) is "redeposited sterile soil...probably used to smother the fire". Other strata generally conform to strata identified in all other previous kiln excavations.

He described this layer as a layer of "redeposited sterile soil which had *probably* been used to smother the firing" (Brisbin, p. 298) (italics added). The general characterization was the same although his description of the layer varied slightly from feature (kiln) to feature, e.g., "a layer of redeposited sterile soil" (Feature 1, Site 5MV3972), "fairly clean redeposited sterile soil (that) contained small angular fragments of decomposed bedrock" (Feature 1, Site 5MV3945), and "primarily redeposited sterile soil...with small inclusions of charcoal and... sandstone" (Feature 1, 5MV3899).

This "intact" smothering layer (Swink, 1996, p. 318-319) "was the key to solving the puzzle." Swink wrote an accompanying report included with Brisbin's on a series of firings using dirt smothering, outlining the procedure of the SP (e.g., "leg-size spanners" and "arm-size rafters" etc.) where he was able to tweak the process sufficiently to produce black-on-white pottery. Swink (1996) further claimed that this dirt smothering regime, or the SP, then "replicated" not only Anasazi ceramics but the stratigraphy of excavated kilns as well. However, the latter, as reviewed below does not hold up. It must be strongly underscored that not a single report of other Anasazi kiln excavations prior to Brisbin identified such an extra layer of added "sterile soil" between the Ash Layer (Stratum 2, Figure 17 above) and the Post-Use Alluvium Layer (Stratum 3, Figure 17 above).suggestion of a smothering layer at all. This can only mean one of several things: (a) Brisbin's kilns were different, and therefore not generalizable to Anasazi firing technology as a whole; (b) *all* the other experts erred by not recognizing such a layer in their analysis although the layer existed in their kilns too; or (c) Brisbin himself misidentified this layer in his analysis. I rule out (b) because it is hard to accept that every other leading expert stratigrapher in the field, in every other excavation would have failed to identify such a layer if it existed in their kilns. On the other hand, since it is not my intention here to question Brisbin's identification of an additional layer of *some kind* in *his* kilns I proceed by stipulating the elimination of (c) as well. However, even if in the limited form of (a) the Brisbin's observation is accepted or stipulated, it still does not corroborate the SP. The stratigraphy only further invalidates the SP. What follows is a brief review of that point.

In Swink's (1996) discussion of the proposed firing regime, in order to preserve Brisbin's stratigraphic interpretation as a discrete identifiable smothering layer he is forced to make some unrealistic assumptions (what, following Popper and Kuhn [see above "Paradigms"], are exemplars of "*ad hoc* assumptions" invoked to save or rescue a paradigm from falsification). In particular, he asserts that since under this interpretation "all the kilns...have their smothering layer intact" this "indicates the kilns were not excavated for pottery removal" (Swink, 1996, p. 319-320). Needing to underscore that the layer Brisbin said he found was applied in smothering *during the firing and not post-use* (either by natural or human processes) he then, ironically, invokes a rough form of parsimony by asserting "It seems unlikely that all kilns would have been back filled (in other words had the dirt put on or in them after use) due to the universal human propensity for avoiding completely unnecessary tasks" (Swink, 1996, p. 320). Let us look at the assertion that the pots were not excavated out of the kiln after firing. This is an unconvincing claim, and one Swink can be seen to reject or at least back-pedal from some years later (see below).

Figures 4, 5, and 19 show pots being excavated from a SP fired kiln. We are asked to believe that to save the "intact" layer of dirt in the kiln and, thus, the smothering interpretation of the stratigraphy, the pots were recovered without excavating or removing the dirt, the cover sherds, and a good part of the charcoal as shown in these pictures. Instead one plunged ones hands blindly through the dirt, into what would likely be a very hot kiln[vii], first hitting the cover sherds, and then feeling around trying to find pots without first removing the layer of dirt and cover sherds. If the dirt were removed as it typically is, then this would place it (along with a lot of charcoal) outside the kiln and *not in it* as Brisbin's interpretation says it is, and the dirt would have had to have been put there post-use or back-filled contrary to Swink's claim regarding back filling.

On the other hand, even if we accepted the untenable claim that the pots were not excavated, the stratigraphy Brisbin has asserted is not replicated by the SP. It does not take much to imagine what would happen to a kiln filled with pots with continuous cover sherds placed over the top when those cover sherds were somehow pushed aside so the pots could accessed and loosened enough to be pulled out. The simplest physics would means that both charcoal and dirt would cave in to fill the holes all the way down to the sandstone slabs or cobbles on which the pots rest; large quantities of charcoal would be brought to the top as well. In short, there would be no intact layer of soil in place at all and the contents of the kiln would be almost entirely mixed. Either way, with or without the *ad hoc* or auxiliary assumptions, there is no logical way to claim Brisbin's layer as a smothering layer. The fired pots and cover sherds would have to have been found still in the kiln, otherwise they would have had to have passed through the layer by some act of magical dematerialization. If we stipulate that Brisbin did correctly identify a "sterile layer of redeposited soil" in the kilns he excavated, then this layer *would have had to have been put there (back filled) post-use or after the kiln had been fired and unloaded, and not used for smothering*. For whatever reason it was put there or when might be an interesting archeological question, but it could not have been used for smothering.

Finally, to conclude this section, it needs mentioning that while continuing to present the SP as *the* way that Anasazi potters produced black-on-white, Swink later back-pedaled from "plunge-and-pull" vs. excavation as a best hypothesis for kiln unloading which he calls "the most important aspect of the firing for potters" (Swink, 2004, p.). "Experience has shown" he now says, that "plunging the hands into the kiln, fishing around and pulling out the vessels... is a waste of time. The jumbling effect this method has..." wastes both soil and charcoal "which could be reused if the kiln were opened systematically" or excavated. This completely unhinges the central justification for the assertion that the layer Brisbin is assumed to have found was a smothering layer at all and not instead a back-filled post-use layer as the evidence suggests. In either case the archeology, in general, and the stratigraphy in particular, even as given by Brisbin, do not provide a principled basis for any corroboration or evidence supporting the SP[viii].

Further Failures to Corroborate the SP. Following the recognition that reasonably good look alike black-on-white pottery could be produced by smothering a kiln with dirt Lacey et al. (1997), in their excavations of two additional Mesa Verde style Pueblo III kilns in Southeastern Utah, intentionally looked for evidence of a smothering layer. They reported finding no "intact" or discrete layer of "redeposited sterile soil" in either of the kilns they excavated. Since organic black-on-white had been now produced experimentally it is understandable that they made a thorough and rigorous effort to find corroborating evidence of smothering in their excavations. Rather, these excavations further falsified the SP.

For the first kiln at site 42SA1279, as noted, there was no evidence of a layer of redeposited sterile soil such as that which Brisbin reported. Excavators found an initial layer of "charcoal deposits below sooted rocks" (Lacey et. al, 1997, p. 8) consistent with Layer 1 in Figure 17. Additionally, and they found "large lenses of gray ash" (Lacey et. al., 1997, p. 10) above it consistent with Layer 2 in Figure 17. Above this they found a "sandy alluvial material" mixed with stratum 2 below it; rather than smothering material it was determined as post-use natural fill (consistent with Layer 3 in Figure 17) and it was "more likely that the material came from the slope above the kiln and washed lengthwise through the feature after prehistoric use...." (Lacey et al., 1997, p. 28). For the second kiln at site 42SA22558 the report is roughly the same. No evidence of a layer as described by Brisbin was found. The only possible smothering dirt might have been some "mottled soil and charcoal with unsooted sandstone slabs and rock pieces 10-11cm thick" (Lacey, et. al. 1997, p. 30) that were found in the kiln. Clearly, sandstone slabs and rock pieces of this thickness could not have been part of a smothering layer as they would certainly have crushed the pots. It was determined that after the active use of the kiln this was the result of the walls of the kiln falling into the kiln. These results add to the overwhelming evidence in the stratigraphy across all kiln excavations supporting the 3-level stratigraphy as expected with the NSP and falsifying the SP.

10. CONCLUSION

The history and philosophy of science have shown that paradigms, to the detriment of future scientific research and potential discoveries, become entrenched over time and go on unquestioned and taken for granted as true. This is the case of "The Smothering Paradigm" or "SP", which was the paradigm assumed to provide an explanation for the way prehistoric potters (Anasazi) achieved black color on white pots using organic or carbon paint (e.g., "Bee Weed," or *Cleom serrulata*). The core assumption or central explanatory device of the SP is that prehistoric potters using organic paint smothered their kilns with dirt after they reached peak temperature to quench the fire, seal off the kiln, and prevent the oxidation and destruction ("burn off") of the paint. The theoretical framework and experimental results presented in this paper refute this paradigm, and corroborate a replacement or "new" paradigm, the "Non-Smothering Paradigm" or "NSP" whereby dirt smothering is eliminated as well as the many anomalies associated with the SP. In addition to experimentally corroborating the NSP and in Lakatosian terms falsifying the SP, this paper has provided a summary of the analysis of Anasazi kiln excavations over several decades and across the large population of kilns excavated while paying special attention to the stratigraphy and kiln surrounds the evidence unambiguously corroborates the NSP while undermining any principled basis to justify a smothering hypothesis and thereby further falsifying the SP.

Discussion and Recommendations for Future Research. Given the results presented in this paper, is the SP worth pursuing at all? I would argue that for the scientist or archaeo-replicator interested in learning and discovering more about the way prehistoric potters fired organic or carbon paints or, for that matter, mineral paint in an oxygen restricted environment to achieve black the answer is "No". Firing the SP following what has been presented here is essentially an extremely inefficient jury-rigged process designed to get around certain technical problems in a "whatever it takes" strategy. Because it is jury-rigged, in other words it "solves" or more appropriately "bridges" technical problems in a makeshift manner far from ideal, it prevents the practitioner from acquiring the authentic skills and actual knowledge of the ancient expert potters that might otherwise be understood. With the amount of fuel it uses, the amount of time it takes, the amount of charcoal, and other anomalies as covered in this paper, even for those who do not care about whether the particular practice is authentic or not, it is an extremely inefficient path to follow.

In the title of this paper, and throughout, the NSP is referred to as a "new" paradigm, however, the real assertion is that the NSP is not actually a "new" paradigm but in fact *the* "old" or original paradigm. For those who have fired the SP and then learn the simple rudiments of the NSP firing it is likely to feel like a remarkably liberating experience; like casting off a great weight. There is a lot more work to be done to further gain a deeper understanding of this remarkable ancient technology. For example**:**

i) Is a crib with "spanners" and "rafters" really a necessary component to a successful firing regime at all? The min/max width of Anasazi kilns is relatively constant over almost all excavated kilns. If we ask, what the affordance[ix] structure of such a constraint might be we certainly understand wind attenuation and retention of ash as clear and understood, but affordance structures are multidimensional and evolutionary systems that evolve along multiple dimensions. In addition to ash retention, the constrained width dimension, viz., 1-2 m, also affords simply laying small diameter fuel across the kiln without spanners. So were cribs *per se* really used at all? We have not determined this, but parsimony suggests perhaps not. Further experiments are needed;

ii) How many layers of pots were fired in (or can be successfully fired) in a typical firing? Proponents of the SP have claimed only one layer, but again, on parsimony, this would make almost as little sense as smothering. Although beyond the discussion of this paper, our experiments have shown that two layers are obtainable without a problem. In fact, a likely hypothesis is that cover sherds originally started this way with the "covers" originally being inverted bowls. Stacking itself helps to maintain, as cover sherds do, the miro-atmospheric environment conducive to black-on-white firing. More experiments need to be done;

Other carefully constructed experiments over the full range of organic black-on-white dealing with questions about paint application, paint viscosity during application, and other issues need further work. Careful examination of many prehistoric pots suggests the paint was applied in only one coat, but modern archaeo-replicators often meticulously apply up to three coats to get strong results. Again, there are tentative results, but there are still unresolved issues at this time. viz., how many coats, and what is the best viscosity of the paint going on? It seems likely that if we could get the firing regime more finely tuned then the additional layers of paint would be unnecessary. These and other questions need answering, and should provide a lot of interesting work in this area for the future. In closing, it is hoped, that this paper, which has focused principally on the firing regime of organic black-on-white pottery and its discussion of the NAP has provided a better context, for researchers, archaeo-replicators and others, to carry on future work on all of these and other remarkably fascinating questions.

ACKNOWLEDGEMENTS

The work presented here could not have been done without the support, contributions, and facilitation of a whole community of people over the past several years to whom I am indebted. Without the space to acknowledge my full appreciation to the following people, special thanks to: Jo Ann Weldon, Bob Casias, Bill Lucius, Winston Hurst, Mark Tahbo, and Roger Dorr. In addition, I have further benefitted from discussions with a host of other people including Wayne Keene, Owen Severance, and Joel Brisbin to whom I am grateful. Special thanks to the following for their supportive efforts locating hard to access materials important to the research presented here: Nancy Hammack, Bill Hammack, and Mary Erickson of Complete Archeological Service Associates (CASA),Cortez, CO; Crow Canyon Archeological Center, Cortez, CO; Roger Moore from Chaco Canyon National Park, Nageezi, NM; Arleyn Simon, ASU, Tempe, AZ; Tracy Murphy from the Anasazi Heritage Center, Dolores, CO; and Deborah Westfall of the Edge of the Cedars State Park Museum, Blanding, UT. And to the editor of this journal, Patricia Lee, my very special thanks and indebtedness for being the very best editor one could ever hope for, going way beyond the call of duty in her support and facilitation of this article, part of which was also to help me locate hard-to-find material. Finally, I must conclude with my immeasurable appreciation for the support of my beautiful wife, Miriam, who accompanied and indispensably partnered with me, a lot of the time in a small travel trailer, through often very hot and very cold days during the pursuit of all that is here and turning each day, regardless of the immediate challenges, into an absolute joy. I conclude with the usual caveat when giving thanks: All errors or misjudgments in this paper are mine, and none should be attributed to any of the people above.

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[i] See also Lucius (n.d) and Lucius and Di Naso (2014) for well-pointed discussion of unjustified assumptions and axioms in the case of elemental chemical characterization and sourcing ceramic production.

[ii] With a few exceptions (e.g, Heacock, 1995) the majority of this work is found in the "gray literature" rather than ordinary academic publications. More specifically, "gray literature" here refers to articles, reports, papers outside the realm of academic or commercial publishing such as technical reports for government agencies, companies, or unpublished papers presented at conferences.

[iii] Of the 95 vessels recovered from the nine Woods Mesa kilns, 86 percent were bowls, 8 percent jars, 2 percent mugs, and 3 percent dippers.

[iv] It is likely that the use of cover sherds began and was often accomplished simply by firing two levels of inverted bowls, or one layer of one kind of vessels and a second of bowls. Advocates of the SP (e.g., Swink, 2004) maintain only one level of pots were fired at a time, but I believe, again on an argument from parsimony this is very unlikely. More likely a minimum of two levels were fired. This particular detail is beyond the focus of the present article.

[v] The extremely large quantity of charcoal produced with the SP relative to the amount of ash, the essential residue of the NSP (with the exception of very occasional small inclusions of charcoal) is hard to overemphasize. When wood burns completely to ash, it is reduced, depending on the wood, to roughly 1% of its visible mass, the remainder being converted to heat and gas ((Misra et al. 1993)). But the visible mass remaining, roughly 15%-20% of the original mass of the fuel under the SP as charcoal is dramatic compared to the ash remaining with minimal charcoal with the NSP (an increase of 1,500%-2,000%). Further, because ash, especially fine white ash, is easily transported by wind, by the time the secondary fire burns all the way down a good part of the ash has been blown away making the total amount of macroscopic mass smaller still. Charcoal, on the other hand, above 1 cm, is not readily transported by wind at all (e.g., Hart et al. 2008) so the large quantity produced by the SP will remain in the kiln and around it, and charcoal that was there 1,000 years ago when these kilns were in use should be almost entirely all there."Charcoal is composed of inorganic carbon and therefore does not decompose in soil" *(*Pasquale, D. G. et al., 2008, p.19). Charcoal put in the soil to aerate it by prehistoric farmers more than 1,500 years ago in the Amazon basin is still there, and macroscopic charcoal is so stable it is used to date palaeoevents over the entire Holocene (Cordiero et al. 2014) and even to the end of the Pleistocene (Horn et al. 2000) thus going back at least 12,000 years.

[vi] It may hardly be worth mentioning, but a hypothesis occasionally advanced is that the charcoal is missing because it was reused in a subsequent firings, but even if it were possible to use all the charcoal in a subsequent firing (which for multiple reasons it

could not be) the reader will likely have already seen the immediate error in this idea; using it for a future firing that has not taken place of course still begs the question of where it is or went in the meantime. In the real world, you are always stuck with (at the end of) some last firing and the copious quantity of charcoal produced by just one firing is just what is shown in Figure 19.

[vii] Even after 18-20 hours kilns with dirt on them have been found to be at internal temperatures of over 500F and without removing some of the dirt are way too hot to put hands into without being burned. It is hard to imagine Anasazi potters simply standing around waiting for the kiln to cool down for hours on end.

[viii] The defensive framework built around a paradigm often include canards or anecdotal accounts or stories that become entrenched as part of the "myth of corroboration" that a paradigm in trouble increasing builds around it. One such myth was raised, with good intentions one only assumes, by an archaeologist at an oral presentation of this paper in Tijeras, N.M. this past August. As previous supporter of the SP he was willing to concede at this point that it may have not been *the* way but certainly *a* way because of the case in the excavation of kilns in the Mesa Verde region the discovery of the kilns was due to the fact that a bulldozer scraping the initial layer of soil off the surface for some other purpose encounter rectangles, one after the other of charcoal, which turned out to be kilns. Not having encounter such a thing in the review of all the major Mesa Verde excavations he was queried about it. The case it turns out he was referring to, but simply repeating an inaccurate account of, that had become part of the defensive lore of the SP, was the Hammack (1984) excavations which were included as part of our review in this paper. It turns out, in fact, to be quite false. There was *one* kiln that opened up the discovery for the group of kilns by the fact that the ground was scraped and a dark rectangle was found revealing a kiln. But it was *not*, in fact, charcoal at all but ashy soil consistent with the 3-level stratigraphy discussed in this paper. Here are Hammack's (1984, p. 12, 15) own words: "During monitoring activities....clearing produced a well-defined rectangular outline of black ashy soil.. Fill consisted of dense *ashy soil with occasional small charcoal fragments.*" (italics added). There was no kiln filled with charcoal (or charcoal around as there would also be in the case of dirt smothering) but exactly the stratigraphy, as given, again in the 3-level virtually universal description, that corroborates the NSP.

[ix] The term "affordance" in this context is due to "ecological realist" or "perceptual realist" J. J. Gibson. See Swenson & Turvey (1991) for further discussion and development of theoretical framework. See also Matsuno and Swenson (1999).

RESOURCES
(Announcements, Exhibitions, and Publications)

Crow Canyon Archaeological Center recently compiled a number of timelines of the ancient southwest (http://www.crowcanyon.org/index.php/explore-pueblo-history/timelines). These timelines mark significant, but selected, developments and events in Pueblo Indian history as documented in the archaeological and historical records. In addition to these interactive timelines, a number of photo galleries of archaeological artifacts, landscapes, and sites were developed. The pottery artifact gallery is likely of greatest interest to readers of Pottery Southwest (http://www.crowcanyon.org/index.php/galleries/artifacts-gallery). This part of the artifact gallery was paid for by a National Science Foundation Grant awarded to the Village Ecodynamics Project. The collection of pottery included was selected from the collections at the Bureau of Land Management's Anasazi Heritage Center in Dolores, Colorado. Pottery from the entire Pueblo pottery sequence in the Mesa Verde region included, from Basketmaker III Chapin Gray to Pueblo III Mesa Verde Black-on-white. Major vessel forms, including jars, bowls, kiva jars, and mugs are represented by a number of different examples, showing variation in form.

LIFE, DEATH, AND TRANSFORMATION IN THE AMERICAS
Brooklyn Museum

http://www.brooklynmuseum.org/exhibitions/life_death_transformation/

(M. Patricia Lee photograph, Brooklyn Museum, Brooklyn, NY: 11/5/2014)

Life, Death, and Transformation in the Americas organized by Dr. Nancy Rosoff, Andrew W. Mellon Curator, Arts of the Americas, Brooklyn Museum; and Susan Kennedy Zeller, Associate Curator, Native American Art, Brooklyn Museum. This "long term" exhibition presents over one hundred masterpieces from our permanent Arts of the Americas collection, exemplifying the concept of transformation as part of the spiritual beliefs and practice of the region's indigenous peoples, past and present. Themes of life, death, fertility, and regeneration are explored through pre-Columbian and historical artworks, including many pieces that are rarely on display.

ANCIENT CULTURES OF THE SOUTHWEST

Logan Museum of Anthropology
Beloit College, Beloit, Wisconsin
https://www.beloit.edu/logan_online/exhibitions/virtual_exhibitions/north_america/southwest/index.php

The Logan Museum of Anthropology at Beloit College in Beloit, Wisconsin, possesses a superb collection of artifacts from the ancient Southwest. The vast majority were collected during excavations undertaken by the Museum in the 1930s in the Mimbres Valley of New Mexico and at Mogollon sites in the Reserve area of New Mexico. The wealth of treasures recovered from these sites enabled the Logan Museum to exchange some artifacts with other institutions. Through these exchanges, the Museum was able to obtain representative samples from the majority of Southwestern peoples. Donations from private patrons and close friends added substantially to the Museum's Southwestern holdings.

The Logan website provides a complete and up-to-date resource for the identification of ancient Southwestern ceramic types on the Internet. The website is a source of information on pottery types and other artifacts which can be referenced by both scholar and layperson alike. Additionally, it is a showcase of these invaluable remnants of the artistic ingenuity of the ancient peoples of the Southwest.

THE POTTERY PROJECT EXHIBIT
Arizona State Museum
http://www.statemuseum.arizona.edu/exhibits/pvia/

With over 20,000 whole vessels, Arizona State Museum's collection of Southwest Indian pottery is the world's largest and most comprehensively documented. The website affords the viewer an opportunity to explore more than 150 choice examples of their collection. The Arnold and Doris Roland Wall of Pots as well as video interviews with archaeologists and Native potters and the "Virtual Vault" are available for further research.

EVOLVING TRADITIONS: 2000 Years of Native Pottery
California Academy of Sciences
http://www.calacademy.org/explore-science/2000-years-of-native-pottery

The second installment of "Evolving Traditions: Southwest Native Pottery and Silver" at the California Academy of Sciences located in Golden Gate Park, San Francisco, CA presents examples of pottery from many different tribal groups, allowing for the comparison of the vessel forms, designs, and colors from one group to another. All of the pots are made from clay, but no two clay deposits are the same and the traditions of one tribe or pueblo also differ markedly from each other.

Southwest Archaeology Today
http://www.archaeologysouthwest.org/what-we-do/information/sat/

Southwest Archaeology Today (SAT) is a free e-mail news digest providing subscribers with information about current news and events in Southwest archaeology. Published weekly, *SAT* is maintained as a community networking tool for professional and avocational archaeologists in the American Southwest and Mexican Northwest. SAT is published by Archaeology Southwest, a non-profit preservation and research organization located in Tucson, Arizona. The home page includes information on upcoming talks and events as well as a blog with updates on recent research. http://www.archaeologysouthwest.org/.

A Combined Approach: Using NAA and Petrography to Examine Ceramic Production and Exchange in the American Southwest

By: Mary F. Ownby, Deborah L. Huntley, and Matthew A. Peeples

Journal of Archaeological Science (52):152-162, December 2014

http://www.sciencedirect.com/science/article/pii/S0305440314003057

Neutron Activation Analysis (NAA) has a long and distinguished history of use for analyzing Southwest ceramics. Petrography has also been utilized; however, it is less common for the two methods to be used in combination. The current article presents such an approach in which statistical methods have been employed to combine NAA and petrographic data on a set of Maverick Mountain Series and Roosevelt Red Ware samples from southwestern New Mexico and southeastern Arizona. The results indicate the likely production of both wares along the Upper Gila at several locations with exchange also taking place.

California Ceramic Traditions I, II, and III.

ed. Brian Dervin Dillon and Matthew A. Boxt

(47) 1 and 2, (47) 3 and 4, (48) 1 and 2

Pacific Coast Archaeological Society Quarterly

Costa Mesa, California

The Pacific Coast Archaeological Society Quarterly devoted three issues to a summary of the status of ceramic studies in California and adjacent areas that may be of interest. Volume 47 (1&2); Volume 47 (3&4); and Volume 48 (1&2) were published in May 2003.

Prehistoric Southwestern Pottery Types and Wares Descriptions and Color Illustrations CD

by Norman "Ted" Oppelt

When *Pottery Southwest's* editor was asked where to find Ted Oppelt's *Prehistoric Southwestern Pottery Types and Wares: Descriptions and Color Illustrations*, Ted's widow, Pat Oppelt generously offered us her only remaining copy of Norm's 2010 expanded edition. At our suggestion, she agreed that AAS could digitize the volume to make it available on a CD. This volume responded to Norm's concern that "written descriptions were inadequate to understand what a pottery type looked like (Oppelt 2010:i)." Thus, he scanned sherds and whole vessels to produce a volume with illustrations and descriptions of 27 wares and 228 types. The Order Form for this CD is on the last page of this volume. (See Order Form on Page 40)

Albuquerque Archaeological Society
Publications: 1968 – 2003 in PDF Format
Available as a 2 CD Pack for $15.00
(See Order Form on Page 40)

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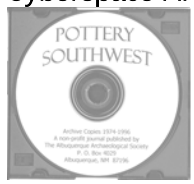

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