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PREHISTORIC USE OF COAL BY INDIANS OF NORTHERN ARIZONA

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DURING the course of excavations made by the Peabody Museum Awatovi Expedition in the Jeddito Valley, much additional information about the prehistoric use of coal has been brought to light. The fact that prehistoric inhabitants of this part of northern Arizona used coal was recognized by Fewkes, Hough, and Hodge, and Colton has published a short paper describing actual mining operations. The great extent to which coal was used was, however, not suspected until the excavation of the pueblo of Awatovi, a large ruin covering approximately twenty-five acres.

The fill in the buildings of the pre-Spanish sections and in the prehistoric refuse mounds contained a high percentage of coal ash. Because of the noxious gases produced in combustion, Hodge believed that coal was used only for firing pottery and in outdoor fires and that it was not employed within the houses themselves. The Peabody Museum Expedition has discovered evidence of extensive use indoors. Many firepits and primitive stone stoves containing coal ash have been found in the houses, and, in most of the kivas built between 1300 and 1600, two firepits have been found, one containing wood ash exclusively and the other containing coal ash.

The assumption that the principle of the chimney was totally unknown to the Indians before the arrival of the Spaniards does not seem to be borne out. In 1891 Mindeleff made the following statement: "Although the pueblo chimney owes its existence to foreign suggestion, it has evidently reached its present form through a series of timid experiments." Such experiments have been found in the rooms of Awatovi going back into the Jeddito Black-on-orange period at approximately the beginning of the fourteenth century. In connection with these experiments, the fireplace is found in the corner of the room as in historic times.

It is still impossible to give the date at which the prehistoric inhabitants of the Hopi region began to burn coal. The 1939 season of the Awatovi Expedition will be spent largely in the excavation of small early sites, and it is hoped that this information will be forthcoming. At present it is possible merely to say that coal was in use by the middle of the thirteenth century. Coal ash was found in the firepit of a small kiva in a Pueblo III site antedating the introduction of Black-on-orange pottery. A study of the pottery firing heaps along the coal outcrops of the Jeddito Valley has not as yet produced such an early date for the use of coal for firing pottery. At present we have no proof that pottery was fired by coal before the age of the production of the Jeddito Yellow wares, though this must as yet be viewed entirely in the light of negative evidence.

The regular household use of coal by the Indians of northern Arizona in the thirteenth century is particularly interesting when compared with the situation in our own Northern

European culture. The history of the knowledge of the properties of coal is very vague. There is reason to believe that it has been known to European civilizations for a long time. It is generally accepted that the first historical reference is that of Theophrastus, 300 B. C., who mentions the use of coal by blacksmiths in Greece. Coal cinders have been found in the refuse dumps of Roman sites in Great Britain, and, earliest of all, evidence as yet unpublished has been found by Sir Cyril Fox of use of coal in the Bronze Age in Wales. The first known historic reference to coal in England was in 852 A. D. in the Saxon Chronicle of the Abbey of Peterborough. There was a grant of a coal pit at Preston, Haddington, to the Monks of Newbattle between 1210 and 1219, and it is said that Henry III granted a license to someone to dig coal in 1234. Apparently it was not until about the end of the thirteenth century that it began to be used much in London and at first this use was only in manufacturing. With the introduction of coal into the city came complaints that it was injurious to human health, and, in 1306, the British Parliament petitioned the king to forbid the use of coal, and a proclamation was issued against it. Because of the high price of wood, however, this ban did not last for long, and coal soon came into general use in the city.

Thus, from the evidence of our excavations, it seems that the prehistoric inhabitants of part of northern Arizona were burning coal regularly before it came into general use in Europe.

Strangely enough, with the coming of the Europeans, the use of coal seems to have been largely abandoned. Relatively little coal ash was found in the seventeenth-century sections of the town. A number of contributory causes for this may be suggested. The odor and gaseous nature of the coal must have been offensive to the Spaniards. Furthermore, burros and horses and possibly crude wagons were now available for hauling wood.

The Awatovi excavations show that the other important new domestic animal, sheep, was present in large numbers in the seventeenth century, but we have not obtained conclusive evidence as yet to establish the time at which the use of sheep dung for pottery firing began. All of these reasons probably contributed, for, whatever the cause or causes, we know that, after extensive use for a number of centuries preceding the coming of the Spaniards, the mining and consumption of coal dropped off rapidly during the seventeenth century.

The modern and ancient Hopi villages are located on the southern edge of Black Mesa. This mesa, which is in reality a greatly dissected group of smaller mesas and plateaus, is underlain by the Mesaverde formation, composed of interbedded sandstone, shale, and coal. The Jeddito Valley ruins, where the work of the Peabody Museum has been carried on, are, like the modern villages of the Hopi Country, located on the southern edge of Black Mesa so that coal-bearing rocks crop out on the mesa edge below the ruins. Here the coal occurs principally in one large seam which varies from a foot and a half to six feet in thickness. This coal is of subbitu-

minous grade and, though it burns well, leaves a high percentage of white ash. Below the ruin of Awatovi another seam was found about forty feet above this large seam. It is six inches to a foot thick, and burns to a red ash. Both of these seams were used by the inhabitants of Awatovi, and

Fig. 7. A large ash heap near Jeddito Trading Post. The coal outcrop can be seen in the background on the hill slope.

the larger one was used by the inhabitants of the other large ruins of the valley. The coal seams are located on a wide sloping bench about halfway down the mesa edge, and are easily accessible.

That the coal of the Jeddito Valley was abundantly used can be proved by the coal ashes found in the ruins. All the coal was not burned in the towns, however. A small proportion of the coal mined was used for firing pottery, and was burned in the open near the coal seams. The residues of the pottery firings may now be seen on the benches below the ruin of Awatovi and below all the other large Pueblo IV ruins of the Jeddito Valley. They consist of heaps of coal ash. Below Awatovi they are red near the upper coal seam and white where near the lower coal seam, showing that the coal for firing pottery was not carried far but was burned close to the place where it was mined.

The typical ash heap is about three feet high, and about ten feet in diameter at the base, being roughly conical in shape. It has a mottled appearance, being composed of red or white ashes, with flecks of red and white burned shale. The fine ash has usually been washed off the surface, leaving a resistant cover of coarse ashes or clinkers, burned shale and potsherds. The burned shale is derived from the black shale which is frequently an impurity in the coal. The potsherds are the remains of fired pottery which was improperly fired or broken, and discarded.

One of the largest ash heaps was trenched. The trench disclosed that the ashes were stratified. Several small layers of wood charcoal and burned corncobs were found, which probably represent trash and wood used as kindling. About twenty large slabs of burned sandstone were uncovered which may

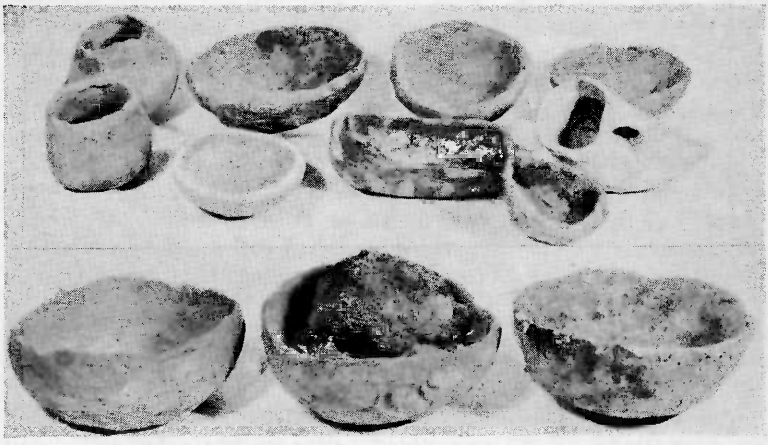

Fig. 8. Group of pots found in ash heap near Jeddito Trading Post. About one-half size.

have been used to shield the pottery from the coal embers, or to control the draught of the fire. Potsherds were taken out in great numbers (over 275 were counted); most of these were reddened as though improperly fired, or overfired. The most remarkable find, however, was a group of twelve miniature pots, nestled together near the top of the ash heap, and surrounded and filled with coal ashes. Packed above them were several slabs of burned shale. The pots were unpainted but had been fired and left in place. It may be that they were made by a child, were forgotten, and never removed from the firing heap. Whatever their origin, they clearly prove that the ash heaps are the residues of pottery firing places.

The numerous remains of kindling fires, the stratification of the ash heap, and the abundance of the sandstone slabs, show that the ash heap is the result of many firings, and was probably built up over a long period of time.

Over eighty-five ash heaps were mapped below Awatovi. They are all on the bench of the cliff near the coal seams. The inhabitants of Awatovi carried their pottery down to the coal mines and fired it there. A fire was kindled with wood and trash. The pottery was apparently placed in a crude structure, for protection, or to control the draught, and apparently ashes were packed around it. Firing was done from time to time at the same place so that gradually large mounds of ashes were built up.

The coal mines are not as easily recognized as the firing places. In the two or three hundred years that have elapsed since the mines were abandoned, erosion has destroyed many of the evidences of mining, and in some places the ancient mines can be recognized only by excavating. But where the mining activity was great, high piles of mining waste, some-

times as much as twenty feet high, can still be seen. In the Jeddito Valley the method of mining most commonly used was a method known in modern mining as "stripping" or "strip mining."

The coal crops out on the bench halfway up the cliff or valley wall. Mining begins by simply quarrying the coal. The waste material, consisting mostly of impurities in the coal, is discarded and forms small piles of debris at the foot of the original outcrop of the coal. As quarrying continues, the point is soon reached where because of the slope of the valley wall the coal seam becomes covered by the next overlying bed of rock which in mining practice is referred to as the overburden. In the Jeddito Valley this usually is sandstone, which, if more coal is to be mined, must be removed and discarded. The overburden, being of hard sandstone, is broken up and piled behind the miner, together with the discarded fragments of the impurities in the coal. Thus the miner really works in a sort of open trench, parallel to the hill slope, with piles of mining waste behind him and the rock face in front of him. As mining continues and this trench advances the overburden becomes increasingly thicker, and the piles of waste become higher and higher. Likewise mining becomes more and more laborious. Finally a point is reached where the mine must be abandoned.

After mining is discontinued, the open trench in which the miner worked is gradually filled in by rainwash with sand and clay, and the piles of mining waste behind the trench are leveled off by erosion, and eventually may take on the general form of the valley wall. The presence of the ancient strip mine is then recognized by excavations, or by an occasional cut produced by a gully which discloses a flat area of shale

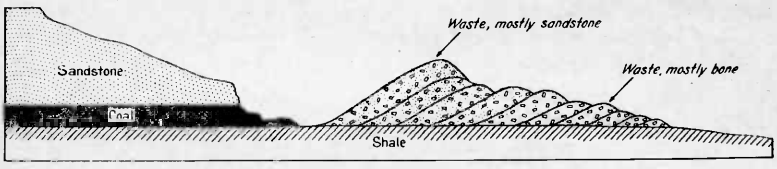

Fig. 9. Ideal section of a typical Hopi strip mine. The word "bone" refers to impurities removed from the coal and discarded.

(the rock underlying the coal, and forming the floor of the strip mines), with mining waste lying above it, in the position at which the coal seam would normally be expected. If this mining waste is excavated by trenching toward the hillslope, the once open working trench will eventually be reached. This is now filled in by slope wash. Beyond this the coal face with a cover of overlying rock will be encountered.

Below Awatovi, an enormous amount of overburden must have been removed; for piles of mining waste over twenty feet high may now be seen. The pottery firing heaps are often found on top of these piles of waste, showing that firing was done within the mining area.

When the overburden above the coal becomes too thick to be removed, the miners had a choice of either starting a

mine somewhere else, or undermining the sandstone overburden, and using a method of underground mining. An underground mine was located near Awatovi and a portion of it was re-excavated. In this mine, the miners had simply undermined the overburden, and, when danger of collapse occurred, they had supported it with waste material, and with sandstone blocks piled up like bricks. The coal face was found fourteen feet in from the place where undermining had begun. Right at the coal face an original open working space was found, filled in with waterlaid clay and sand, and between this and the point of beginning of undermining was a large area where the coal had been removed, and replaced by sandstone blocks and waste. In one place a large sandstone slab had been propped up on edge to help support the roof of this undermined area.

Some evidence of the type of mining tools used has been found. A large, heavy, quartzite hammerstone was found in an ancient strip mine near Jeddito. Also numerous pottery fragments were found which showed evidence of having been used as scraping tools. Mining was probably done mostly by picking and hammering. But hammering could not be easily done in an underground mine, since the working space was very small and cramped; hence picking was probably used. The removal of coal was made easier by the weight of the overburden, which probably caused it to spill off. But, however actually mined, the process must have been slow and laborious, and it seems likely that it was probably sporadic.

The strip mines below the ruin of Awatovi could be located and their boundaries approximately mapped. It was possible to show that over 27,000 tons of coal were mined in a distance of one-half mile along the cliff below this ruin. In three hundred years time, this would be a daily output of about 450 pounds, a figure which, considering the primitive methods of mining used implies considerable activity. A brief survey of other mining areas in the Jeddito Valley led to the estimate that over 100,000 tons of coal were mined in the whole Jeddito Valley region.

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