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ARCHAEOLOGY'S NEAREST TOOL - CARBON 14 DATING

A Brief Explanation

Benjamin L. Smith and George P. Bates

Archaeologists have always been alert to adopt any developments of science which promise to be of assistance. They have also added techniques peculiar to their specialized needs.

The meticulous care with which archaeologists excavate sites, and the detail with which they record their observations, is well known. Sloppy work, careless interpretations of data quickly lead to erroneous conclusions. The careful archaeologist uses every known method to check his results. In dating a site he makes every effort to arrive at the closest possible approximation of its age by correlation of the various strata revealed. Relative chronology may be easily established in simple sites by careful recording of the contents of successive layers as they are uncovered, though problems are encountered if the original users of the site did some excavating of their own, with consequent back piling and reversed stratigraphy.

Scientists working in the Mississippi valley have used the Mississippi River Commission's map of the extensive meanders or changes in the river bed to set up a system of chronology. The oldest sites are of course found on the oldest meanders, and by careful excavation of these sites a relative sequence has been determined. Accurate dating, however, is lacking here as in other areas.

The many effects of repeated glaciation in France and other parts of the world have been studied with great care, and a whole series of interglacial cultures extending backward a half million years has been established in some areas and relatively correlated, but accurate dating has so far proved impossible.

Other methods for checking relative chronology include examination of refuse dumps where occupants of a site have built up successive layers of material. These layers may be checked with excavation of the site itself. Fossil pollen found in the several layers of a site, when identified as to the type of vegetation from which it came, can give the paleobotanist clues to climatic changes as the site developed. Identification of the series of charcoal fragments from hearths can likewise be used.

The geologist is frequently called in to interpret the manner in which deposits such as sands, gravel, and loam were laid down under, in, or above a site. Important clues to the relative age of a site are obtained by the site's relation to such geological features as glaciers, river terraces, terminal moraines, eskers, drumlins, kettle holes, slope washes, and water levels. The geologist's dating is generally on so broad a time scale, however, that it does not satisfactorily meet the archaeologist's requirements.

Paleontology—the study of fossil animal and plant life, can be of assistance in establishing relative ages of the microscopic forms found in clays and peats at a site by comparing them with established chronologies for type stations in the vicinity. Skeletal material from modern and extinct animals can be identified and relative ages thus established. The identification of the bones accompanying the first points at Folsom, New Mexico, in 1926 as those of an extinct bison touched off the investigation which established Folsom Man as a truly ancient race.

Dr. A. E. Douglas furnished archaeology its first precise dating method with his demonstration of dendrochronology, or tree ring dating, but this method is restricted to a period of less than 2000 years, and its effectiveness is largely limited to dry climates like that of the American southwest.

Recently, nuclear research has given the archaeologist an important new tool of great promise. This is "carbon 14" dating. With present techniques there is an element of error which expands rapidly when the method is applied to materials of greater and greater age. The method is still in process of development, however, and improved techniques should soon reduce the factor of error to provide archaeologists with their first reliable dating method of extensive application.

The method derives from the fact that some of the neutrons coming into the earth's atmosphere from outer space strike atoms of nitrogen, which constitute about 78% of our atmosphere. As a result of the collision the cosmic neutron enters the nucleus of the nitrogen atom, raising its atomic weight from 14 to 15. The usual form of nitrogen has the formula \( ^{14}N \), the 14 standing for the atomic weight of the atom and the 7 for the number of positively charged protons in the nucleus. The collision produces the nitrogen isotope \( ^{14}N \).

\( ^{14}N \rightarrow ^{14}N + \tilde{N} \)
Under cosmic ray bombardment these nitrogen isotopes have a proton knocked from their nuclei, thus changing nitrogen 15 to radioactive carbon 14 ($^{14}\text{C}^\text{14}$) while the free proton upon picking up a free electron becomes an atom of hydrogen ($^1\text{H}^2$). [See Appendix I for a table of carbon and nitrogen isotopes and their characteristics.]

Carbon dioxide, another gas present in the earth’s atmosphere, has a molecule composed of one atom of carbon and two atoms of oxygen. Its normal carbon atom has the formula $^1\text{C}^1$. Radioactive isotopes, such as $^1\text{C}^4$ (carbon 14), also enter into combination with other elements yet retain their radioactive properties. Carbon 14 has thus become an important “tracer” in current research in many fields.

In nature the carbon 14, formed as described above, combines with atmospheric oxygen to form carbon dioxide which is absorbed and utilized by plants just as is the normal and more plentiful carbon dioxide containing non-radioactive carbon 12.

The amount of carbon 14 on the earth is practically constant, a result of a uniform rate of disintegration of this radioactive isotope which has reached an equilibrium with its apparently constant rate of formation.

Most living things absorb carbon in one form or another as food. All plants absorb carbon dioxide from the air, store the carbon, and release the oxygen. Since the process is continuous it is obvious that they absorb the carbon 14, which is present in atmospheric carbon dioxide, until that concentration is reached at which the carbon 14 is disintegrating at the same rate that it is being absorbed, and an equilibrium point is attained. Animal life also absorbs carbon 14 through the carbohydrates it eats, and again the carbon 14 retained reaches an equilibrium. Thus the percentage of carbon 14 to ordinary carbon 12 is the same in all living organisms, and remains the same as long as the organisms are alive. The quantity of carbon 14 and carbon 12 depends, of course, upon the size of the plant or animal. [See Appendix II for the carbon dioxide cycle.]

When an organism dies it ceases to replenish its supply of carbon, including the carbon 14. Through radioactive disintegration the concentration of carbon 14 then begins to diminish. This reduction provides the basis for dating once the rate of loss of radioactivity is known. Various substances lose radio activity at different rates; their “half-lives” (the time it takes each to lose one-half its activity) vary from seconds to thousands of years. The half-life of carbon 14 has been determined to be 5,720 years, plus or minus an error in measurement of 47 years. It therefore follows that in 5,720 years the radioactivity of carbon 14 is reduced to one-half its original intensity.

Now if one determines the carbon 14 radiation in a piece of living wood (considered as fully radioactive) and then compares it with the radiation from a very old piece of dead wood, a mathematical calculation will give the age of the dead wood (from the time of its death), plus or minus the error of measurement.

Scientists from the University of Chicago have measured the radioactivity of living organic material from many parts of the world, and have found that the world-wide weighted average to be 12.5 ± 0.2 counts per minute per gram of carbon, (cpm/gm), on a “flow counter.” [See Appendix III for a diagram and explanation.] The figure of 12.5 ± 0.2 is the standard radioactivity of carbon 14 for all except marine organisms, which have an average count of 14.1 ± 0.3.

As materials disintegrate, the decrease in radioactivity is not constant, but decreases over what is known as an exponential curve. [See Appendix IV.] The rate of decrease is more rapid at first and tapers off as the disintegration progresses. Since the rate of error becomes very large as the radioactivity approaches zero, the usefulness of the method is limited to that part of the curve which indicates a reasonable degree of activity. Today about 12,000 years is as far as it is safe to go, but it is hoped that with improvements in technique it will be possible to go back more than 20,000 years. If the full activity of carbon 14 is taken as 12.5 cpm/gm, the half-life would be 6.25 cpm/gm at 5,720 years. Three-quarter life would be 3.125 cpm/gm; and seven-eighth life would be 1.5625 cpm/gm.

An example may illustrate the practical application of the method to the dating problems of the archaeologist. If pottery is found at a certain level in an excavation, a sample of organic material is taken from the same spot and its radioactivity is measured by means of a counter. Assume that the counter registered 2.21 cpm/gm of carbon. An approximate age may be found by referring to the curve in Appendix IV. On the curve’s vertical axis find 2.21, then follow across to the curve and drop down to the time axis and the age is shown as approximately 14,000 years. This graphic method is satisfactory for a rough approximation of age, but for more exact results the following equation should be used.

$$t = \frac{5720}{0.69315 \log_e \frac{12.5}{N}}$$

In this case t=14,300 years. [See Appendix V for the derivation of the above equation.] Thus we find the age of the organic material and, by association, the age of the pottery and the culture. This method has been checked with material of known age found in ancient Egyptian tombs.

As yet there is a certain amount of error connected with this process. For instance, the half-life of
carbon 14 could be 47 years more or less than the norm of 5,720 years, also, the counting of the radiation emitted is not completely accurate. Furthermore, an examination of the graph will show that there is more chance for error when the amount of radiation is low. For example, between 11 and 12 cpm is a period of about 700 years, whereas between 1 and 2 cpm there is a span of 5,500 years. Thus the assay of material over 20,000 years old is at present so inaccurate as to be practically valueless.

These errors are not necessarily insurmountable, for there are ways to diminish them. First, the counter can be more perfectly sealed against outside radiation which distorts the readings. Second, further study of the disintegration and enrichment of carbon 14 will undoubtedly lead to a more exact determination of its half-life. Finally, carbon 14 makes up a very small percentage of the total amount of carbon in any organic material, and to overcome this deficiency larger thermal diffusion columns can be used. By this process the different isotopes can be partially separated because they have slightly different boiling points. It is not possible to obtain pure carbon 14 by this method, but a greater concentration is produced, thus making the counting process more accurate.

It is known that living animals, including man, contain carbon 14. Thus far most attention has been focused on trees and other plants. Hence further developments in this field can be expected as more research is done. Also it is known that living matter contains radioactive isotopes other than carbon 14; and here is another field to be explored. In this connection some work has been done with radioactive fluorine, but as yet the results have not been published. The archaeologist can look forward to greater accuracy, wider applications, and a more complete knowledge of this subject and process in the near future, since it is being studied by many scientists on university and government projects. A process which has been the dream of archaeologists for years is now being developed to the point where many unsolved problems concerning dating may be answered.

The writers do not wish to imply that this method is simple or foolproof. As yet it is strictly a laboratory process for the experts, but the reasoning is sound and results so far have been encouraging. Therefore it is reasonable to expect that new methods and more perfect techniques will ultimately establish this process of dating as one of the archaeologists’ most valued tools.

Concord, Mass.
August 1950
APPENDIX I

A Diagram of the Isotopes of Carbon and Nitrogen

<table>
<thead>
<tr>
<th>Number of Protons</th>
<th>Element</th>
<th>No. of Protons and Neutrons</th>
<th>Abundance</th>
<th>Half-Life</th>
<th>Type of Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Carbon</td>
<td>10</td>
<td>--</td>
<td>8.8 sec.</td>
<td>B⁺</td>
</tr>
<tr>
<td>6</td>
<td>Carbon</td>
<td>11</td>
<td>--</td>
<td>20.5 min.</td>
<td>B⁺</td>
</tr>
<tr>
<td>6</td>
<td>Carbon</td>
<td>12</td>
<td>98.9%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>Carbon</td>
<td>13</td>
<td>1.1%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>Carbon</td>
<td>14</td>
<td>--</td>
<td>5720±47 yr.</td>
<td>B⁻</td>
</tr>
<tr>
<td>7</td>
<td>Nitrogen</td>
<td>13</td>
<td>--</td>
<td>9.93 min.</td>
<td>B, ⁺⁺r</td>
</tr>
<tr>
<td>7</td>
<td>Nitrogen</td>
<td>14</td>
<td>99.62%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>Nitrogen</td>
<td>15</td>
<td>0.38%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>Nitrogen</td>
<td>16</td>
<td>--</td>
<td>8 sec.</td>
<td>B⁻</td>
</tr>
</tbody>
</table>
APPENDIX II

The Carbon Dioxide Cycle

Sea Shells used by organisms to form Carbonic Acid which dissolves limestone to form Limestone

Limestone Carbonic Acid

plus water forms

CARBON DIOXIDE of the AIR

Coal and Fuels burn and form Carbon Dioxide of the AIR

Food Respiration Fermentation

Starch and Sugar Cellulose
There are several different varieties of counters which can be used for the assay of carbon 14 in biological samples; however, the theory is basically the same. Above is a diagram of the windowless flow counter which is one of the best and least expensive.

This counter is continually supplied with gas under a slight positive pressure which is continually flowing through it. A good gas for this purpose is a mixture of helium and absolute ethyl alcohol vapor. The cylindrical cathode and the central wire are maintained at a critical electrical potential. The sample is placed on a tray at the bottom of the counter. Electrons emitted from the carbon 14 ionize the gas, which lowers the resistance for a brief moment between the two terminals. Each time the resistance is lowered electricity flows for an instant and a count of these impulses can be picked up with the aid of an amplifier system. Any outside radiation would alter the number of counts, so in use the counter is surrounded by thick lead walls, and anti-coincidence shielding. It is also obvious that the sample itself must be completely protected from contamination after excavation, as its rate of emission could be radically distorted. This is one of the most serious problems so far encountered.
APPENDIX IV

The Exponential Disintegration Curve of Carbon 14

N or radioactivity axis in cpm/gm of carbon

half-life

3/4 life

7/8 life

I or time axis in 1000's of years
APPENDIX V

Investigations have shown that the relative rate of change of radioactive materials, in general, is a negative constant.

Thus
\[ \frac{dN}{dt} = -k \frac{N}{\text{if} \quad dN = -k dt} \]

\[ \log_e N = -kt + \log_e C \]

\[ \frac{N}{C} = e^{-kt} \]

\[ N = C e^{-kt} \]

where \( C = N_0 \), the original amount of radiation, for \( N = C \) when \( t = 0 \). \( N_0 \), in the case of radioactive carbon 14 in organic material other than marine growth, is 12.5 cpm/gm of carbon.

Thus
\[ N = 12.5 e^{-kt} \]

To determine \( k \) let \( N_1 \) be the count at time \( T_{\frac{1}{2}} \) which is the half-life, and \( N_2 \) the count at a later time equivalent to the half-life.

Then
\[ N_1 = N_0 e^{-kT_{\frac{1}{2}}} \]

\[ N_2 = N_0 e^{-2kT_{\frac{1}{2}}} \]

Division gives
\[ \frac{N_1}{N_2} = \frac{N_0 e^{-kT_{\frac{1}{2}}}}{N_0 e^{-2kT_{\frac{1}{2}}}} \]

and
\[ \frac{N_1}{N_2} = e^{kT_{\frac{1}{2}}} \]

Since \( N_2 \) is half of \( N_1 \), \( 2 = e^{kT_{\frac{1}{2}}} \);

thus
\[ \log_e 2 = kT_{\frac{1}{2}} \]

and
\[ kT_{\frac{1}{2}} = 0.69315 \]

However, it is known that \( T_{\frac{1}{2}} \) equals 5720.

Hence
\[ k = \frac{0.69315}{5720} \]

Substitution results in the following relationships:

\[ N = 12.5 e^{-0.69315 \frac{5720}{t}} \]

or
\[ N = \frac{12.5}{e^{0.69315 \frac{5720}{t}}} \]

\[ \log_e \frac{12.5}{N} = 0.69315 \frac{5720}{t} \]

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REFERENCES


8. Monsanto Magazine - Nuclonics Issue, XXIV, 6, 1945, St. Louis.
AN EARLY OCCUPATION SITE, EASTPORT, MAINE

Isaac W. Kingsbury and Wendell S. Hadlock

Although the shell heaps of Maine have been known for many years to archaeologists working in the eastern area of the Woodland Indians, excepting Matthew's report on the excavation at Bocabec New Brunswick in 1883, little work other than spotty recording of sites had been undertaken north and east of the general region of Mount Desert Island. During the summer of 1947, we discovered an old site which did not conform to the pattern of other sites known to us in the region of Cobscook and Passamaquoddy Bays. During the next two summers, an occupation area of two thousand one hundred square feet was excavated, disclosing seven fire pits, five fire hearths and one hundred forty-five stone artifacts. The pin gravel and near-by beach yielded fifteen more stone artifacts. Shell, bone, pottery, and any evidence of European contact were entirely lacking.

Three quarters of a mile beyond the Toll Bridge, on the Cobscook Bay side of Moose Island, facing west of south between two rhyolite out-crops five hundred feet apart, lies a crescentic cove. To the east of its center a recently eroded embankment one hundred thirty feet long is the top of a clay bench; the south end of this bank is over three feet high and has considerable pin gravel at its base. This erosion embankment is the front edge of a narrow bench which, at one time, was inhabited by Indians. The northward drift of the pin gravel at the top of the beach has raised its level to become flush with the surface at the north end of the bench. The back of the bench, near its center, is limited by a turfed-over rhyolite talus slope which outcrops near by to the northeast. At the talus slope the bench is thirty feet wide, broadening out to the north, and narrowing to the south, where it merges into a till-covered slope and loses its identity as a bench.

The clay bench contained a few boulders dropped from glacial ice. The top of the clay sloped gently upward as it approached the talus slope. Near the talus slope, where the marine clay showed no appreciable weathering, its upper part contained smaller angular talus rocks, rotting sandstone pebbles, coarse rather sharp sand, and small somewhat water-worn pebbles. These findings would seem to indicate a bench of not long duration, marking a relatively short halt in post glacial emergence. (See Fig. 9).

EASTPORT SITE

W-E VERTICAL CROSS SECTION AT DATUM LINE SCALE: 1 = 10 FEET

BEACH BENCH TALUS SLOPE OUT CROP

MARINE CLAY

RHYOLITE LEDGE

SYMBOLS

- PIT

- HEARTH

- TALUS ROCKS

- TALUS ANGLE

- DATUM STAKE

- PIN GRAVEL

FIGURE 9

22
Recent rapid erosion of this bench exposed artifacts on the beach, the finding of which led to the excavation of the site.

In the past twenty years this bench has been eroded back over twenty feet. Fifty years ago, between the bench and the bay, there was a flat sea-wall of beach gravel some thirty feet wide. "This sea-wall was about one and one-half feet above high water." (1). This extremely rapid erosion has been caused by the removal of beach debris, gravel and rocks by thick anchor-ice which forms and floats away during the winter and spring, and also by the tidal stream and eddy. The strong tidal stream and eddy currents are caused by the great tidal range of 18.2 feet which is increased during a storm with a strong southeasterly component in its winds, and especially so at a perigee spring tide.

While the erosion and deposition components were in balance, the sea-wall was a protection against further erosion. This balance was upset by the removal of a considerable portion of the sea-wall for road building, (3), thus permitting the erosion elements to take charge.

With such rapid change taking place during the last fifty years it is probable that this region has undergone other changes since post glacial emergence. (2). Beginning at the lower part of the talus slope, thinning out as one went up, where it came quite close to the surface, was a layer of nearly white fine friable loamy material. In thickness it varied from six inches in lenses to less than an inch. This white horizon was below the occupation layer. Downward it graded into the darker colored sandy loam, which is between the talus rocks. We eventually took this to be the result of podsolization, occurring before occupation. (3). We were supported in this conclusion upon receiving reports of the analyses of various samples from the University of Maine Soil Laboratories. (6).

### The Occupation Layer

On the bench: The single horizon of occupation lay directly upon the Marine Clay. (4a). Except at, and about, the hearths it was only an inch or so thick. Its dirt blackened the hands. (Fire-dirt is an appropriate term). Scattered through it were rhyolite rocks of varying size and shape, many of which were whitened by prolonged fire exposure. (Fire-rocks). The chips and artifacts were always found at, or within an inch above the Marine Clay.

Overlying this layer was post-occupation growth debris loam, varying in thickness from a turf at the north end, to ten inches at the center and south end. Dense alders covered the south and central parts of the bench.

1. Personal communications from Mr. Allen H. Ray, life long owner of the site and from his son-in-law, Mr. Howard Johnson, who "had to move the shore cow-fence back over ten feet twice in the past twenty odd years." At present it is falling onto the beach. We express our warm thanks for their interest and generous permission to excavate.

2. From our studies of the geological reports and old maps of this region, we have concluded that the following changes took place. Following the stabilization of the land mass, after the erosion of the very shallow bay, there is a strong probability of a bar having formed at the mouth of the cove. The usual lagoon would have formed back of the bar or barrier beach. (2b). The lagoon would have had its opening to the northwest, and the barrier beach would have migrated toward the head of the cove. The end result of such erosion and building forces would be the formation of a low beach gravel sea-wall of considerable width, with a swale and cranberry bog as the remains of the lagoon, such as was the case in 1900. (3). This lagoon and the shallowness of the bay may well have been factors in the selection of this location for an occupation site, which at present appears to possess no natural advantages. In order to understand the great changes which have taken place in erosion and elevation of the land mass of eastern Maine, see the following references:


3. Ray and Johnson (as in Note 1).

4. This observation was also recorded at Bocabe sixteen miles north of Eastport. Matthew, G. F., "Discoveries at a Village of the Stone Age at Bocabe, New Brunswick," Bull. Nat. Hist. Soc. of New Brunswick. 1884. Reprinted Bull. 1887. The lower of the two horizons of this shell heap had "pottery of a different pattern and the weapons were larger and cruder than those of the upper layer."

Diligent search failed to locate Matthew's Specimens.
At the angle at the base of the talus: The layer above the occupation horizon was thicker because of the slope slippage and some sandy loam was seen between the smaller talus rocks.

On the talus slope: The very thin dark occupation layer with its occasional chip and artifact was easily traced from pit to pit, but was lost a few feet above the pits.

Fire pits averaging about twenty inches in diameter, at the top, and about fourteen inches deep were more numerous at the talus edge near the center. All of the centrally located pits were dug into the rising talus slope. Some contained a flat stone which had been placed at the base of the pit. All of the pits were filled with ash, fire-dirt, fire rocks, and surface material which had slipped down the talus slope; but rarely was a chip or artifact found in them. Two horizons of ash and fire-dirt separated by a larger band of slippage indicated that one of the pits had been used intermittently.

The fire hearths were located on the bench. They were wider than the fire pits. Some had a carelessly laid foundation of irregularly shaped talus rocks and glacial boulders up to eight or ten pounds in weight. Some hearths were laid directly on the Marine Clay. Fire-dirt and ash accumulation was up to five inches. Not enough pure charcoal was seen to consider a Carbon 14 determination. It was notable that the underlying clay showed little or no apparent fire effect. This was true also of the largest and deepest talus pit which had been dug down into the underlying clay.

The Artifacts

The greatest percentage of the one hundred sixty artifacts taken from the site consisted of projectile points (19.4%), knives (44.4%), and scrapers (16.25%), all chipped implements.

None of the projectile points were small. (Plate I, a). The average length was 2.33". The points were similar in pattern and workmanship to the large blades found in the lower horizons of Taft's Point, (4d), the Union River site, (unpublished), and the so-called "Red Paint" graves of Maine. (7). Of the thirty-one points, all except six were straight stemmed. Only two could be termed side notched.

Implements classified as knives were similar to the chipped blades in material and technique of manufacture. One semilunar knife and a few others were of material not seen in other artifacts. This was also true of some of the largest points and scrapers. All displayed bold flaking and indicated that the makers were thoroughly familiar with the materials used and the methods employed. Four of the chipped implements were considered to be knives, and the remainder to be scrapers or chipped implements.

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Artifacts from the Moose Island site: a) projectile points—(1) is a core; b) knives—(2) is a drill, (3) an adze; c) scrapers. (Scale the same in all figures.)
Artifacts from the Moose Island site: a) hammerstones; b) abrading stones; c) artifacts from the site collected by the Knapton brothers. (Scale the same in all figures.)
blades were notched on one side only and may have been used as hafted knives. Other chipped blades which may have been hafted and used as knives are shown in Plate I, b. In the same Plate is shown a drill. (Plate I, b2).

Nineteen of the twenty-six scrapers excavated were large, measuring an average of 2.6 inches long by 1.8 inches wide by .8 inches thick. A great proportion of these scrapers were similar in shape to the large plano-convex chipped stemmed scrapers reported by Dr. Strong in his report on Northeastern Labrador sites. (4c). Scrapers of this type have been reported from Maine shell heaps, and in most instances were confined to the lower horizons. The remaining scrapers were of the small thumb nail type commonly reported throughout the Northeast. (See Plate I, c).

Although chips and flakes of stone indicating considerable manufacture of flaked implements were found throughout the entire area of occupation, most of such chips were from the less finely finished implements. Some may have been from a felsite outcrop at the west end of Hinkley Point, Dennysville, Maine. (2f). No chips of the most carefully made larger points and knives were found. Some of the latter implements were of materials commonly found on Indian sites of the upper St. John River and known by us to be stone locally to the Plaster Rock region of New Brunswick.

Twelve hammer stones manifesting little to considerable use were evenly distributed throughout the occupation area. (See Plate II, a). They were in most instances egg-shaped beach rocks. There were also found many stones, similar in material and size to hammer stones, of crystalline or metamorphosed rock which showed no evidence of use or of having been worked. Few were striated but all appeared water worn, and stones of like material were found in close proximity to each other. Without evidence of glacial deposition and not of local material, and limited to the fire-dirt, they must have been introduced by the inhabitants of the site and presumably intended for use as hammer stones.

The presence of eight sharpening stones of fine grained sandstone and slate implies the use of polished implements. However, excepting for the broken highly polished beveled adze shown in Plate I, b3, we have no evidence that other polished implements were manufactured or used on the site. The broken adze is of a fine grained rather light colored homogeneous rock often found among the so-called "Red Paint" implements. It fits the definition of argillite.

The rather high acidity of our soil test tempts one to use this finding to explain the lack of bone. However, Professor Terman, Agronomist at the University of Maine, wrote us “The pH values are those commonly obtained on unlimed soils.” The evidence of podsolization was always in a horizon below the occupation layer and was present only on the slope, whereas bone was lacking everywhere. There is no good reason to suppose that the seepage water through the thin soil overlying the occupation layer was more acid than at any other site lacking shell.

If there had been any considerable amount of shell one would expect to find it, unless the age of the site is greater than that of the usual site. Shell, when present, in or over an occupation site tends to deposit a protective coating of lime on bone or stone artifacts. Thus, in the lower horizon at Bocabec, fish bones were reported. With no reason to believe that weathering conditions at our site were abnormally severe, it would seem that normal weathering and great age are the best explanations for the lack of bone.

If pottery had been present we believe that sherds would have been found. Their absence does not prove preceramic time. The significance of the absence of bone shell and pottery is emphasized by the fact that pottery is common in Cobscook waters and that a mile away from us there is a site with the usual shell heap findings.

The site discussed in this paper is of great importance in supporting a chronology in cultural development of the Indians of Maine. Archaeologists familiar with the archaeology of Maine have believed that the Indians of this region did not arrive with a fully developed culture, similar to that recorded by the early explorers, but to argue that there was cultural growth it was necessary to find sites which demonstrated such a growth within one area, or sites which fitted into the over-all picture of the development which took place.

The Eastport site, its material objects, and the position of the artifacts in relation to the underlying marine clay, present one of the earlier aspects in the cultural growth of the Eastern Woodland Indians. We concluded that the large projectile points were used as heads of throwing or thrusting spears. The rather specialized artifacts and their limited frequency of occurrence, considering the area of occupation, and the absence of clam shells, in an area abounding with shell fish, leads us to postulate that the
inhabitants of this site were predominantly hunters of sea mammals and fish. They were nomadic, ranging over a considerable area of New Brunswick and Maine. (8).

In this one-horizon site were found most of the stone artifacts essential to the later development of the Indian culture present in Maine during the early colonial period. Similar artifacts have been reported from other sites in Maine and adjacent areas, and have a high frequency of occurrence in the lower horizons of stratified sites.

A study of the literature on the archaeology of the northeastern area leaves no doubt that this site is representative of a very early stage in the cultural development of the Eastern Woodland Indians, and equates with the lower horizons of Taft’s Point Shell Heap and the sites reported by Strong in Labrador. (4c).

**ADDENDUM**

Plate II, c shows the 21 specimens dug at the water’s edge or found on the site beach by John and Doug Knapton of Edmunds, Maine, who generously added them to ours. They are not included in the main body of this report simply because we personally did not find them. They fit perfectly into our report.

The object shown in Plate II, c 4, was excavated by us from the fire-dirt layer. It may be a lap anvil. It was not included in our report because it belonged in the group termed “utilized but not classifiable.” Its large crude flaking is similar to worked stone found in a small bulldozed area three hundred yards northwest of our excavation. On the exposed ledge there, we located 3 fireplaces, one of which had chips near by. We obtained, on the surface, one broken straight stemmed point, a wide portion of a large ground adze or gouge, and a large crudely-made chipped adze or chopper.

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8. We call attention to the unusual extensive area of shallow water off the site. (Chart 801). Such waters would be ideal for an Eskimo method of sealing described by Dr. Rink. It consisted of harpooning from a kayak at a distance up to twenty-five feet with the aid of a “thrower of wood.” The barbed head had a line attached with a blown up bladder at the other end of the line, by which the wounded seal could be located and eventually retrieved. (Dr. Rink in Danish Greenland. 1877, pp 113-114). Quoted in History of North American Pinnipeds. Allen, J. A. Miscellaneous Publication No. 12, U.S. Geol. and Geog. Survey. Gov’t. Printing Office. Washington, D.C. p 523.