Central States
Archaeological Journal

VOLUME 50 SUMMER, 2003 NUMBER 3

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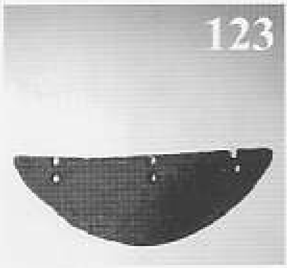

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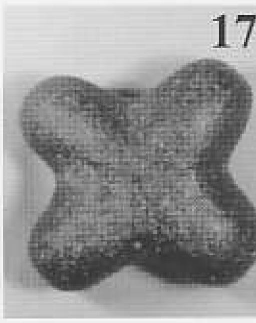

On our cover

Intrusive Mound Culture pipe, made from highly polished steatite found by Jasper M. Martin, near the town of Fitzgerald in south-central Georgia. This pipe was chosen by the officers of the Peach State Archeaological Society of Georgia to represent Georgia on the cover of the *Central States Archaeological Journal*. It is shown actual size. From the family collection of John Booth. See article on page 124.

Central States Archaeological Journal

A COMBINED PUBLICATION OF THE

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GREATER ST. LOUIS ARCHAEOLOGICAL SOCIETY OF MISSOURI
INDIANA ARCHAEOLOGICAL SOCIETY
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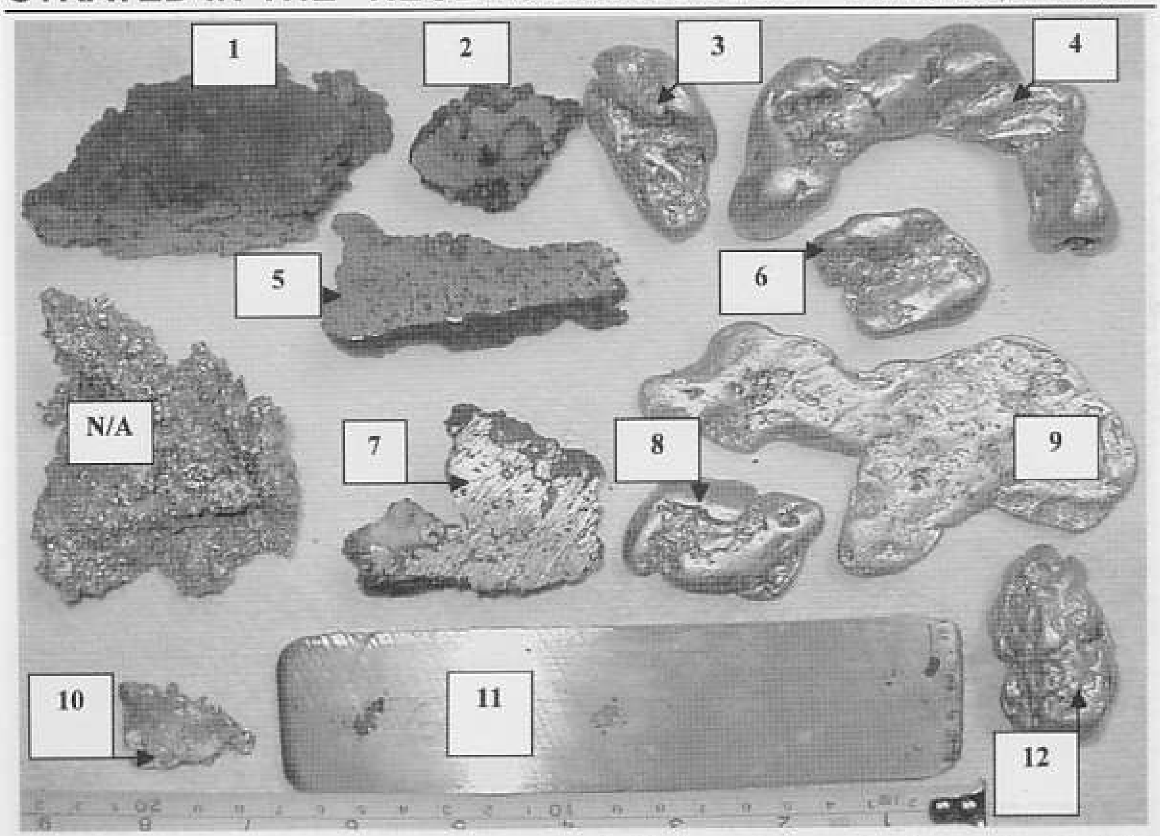
NATIVE COPPER CHARACTERISTICS DEMONSTRATED IN THE "NEUBAUER PROCESS"

David H. Peterson
Two Harbors, Minnesota



Twelve selected raw native copper specimens used in the Neubauer Process. See the graph on the facing page for more detailed information on each specimen.

This experiment, through application of the Neubauer Process, reports on the selection of twelve native copper specimens from the Lake Superior basin and follows each specimen's manufacture into ancient tool and ornament forms by annealing and pounding.

Native copper, naturally occurring 99.75-99.98% pure copper, is a unique metal found throughout the Lake Superior basin, including Ontario, Michigan, Minnesota and Wisconsin. Native copper does occur in the Appalachian Piedmont area of Georgia, Tennessee, Virginia and North and South Carolina and at several other locations around the world; however, the Lake Superior basin native copper is unique because of the random trace elements such as silver, arsenic, nickel and iron. These trace elements provide unique mineral combinations to the lake basin copper deposits such as half-breed (silver and copper) and Mohawkite (Cu_3A_5 or Cu_6A_5) nuggets and float. These combinations exhibit vastly different malleability characteristics when annealed and pounded as compared to relatively pure native copper.

Copper tools whose wood hafting remains have been preserved due to anti-bacterial protection by copper oxides have been radiocarbon dated to 6800 BP at South Fowl Lake, Minnesota, site 21CK1. This date for a completed copper tool and inferred technology indicates that the people who inhabited the Lake Superior basin from 7000 to perhaps as early as 8000 years BP were utilizing amygdaloidal native copper or native copper float deposited by the glacial retreat 10000-12000 BP. They mined the amygdaloidal native copper, as evidenced by thousands of man made pits found in Minnesota, Wisconsin, Ontario, Isle Royale and the Upper Peninsula of Michigan.

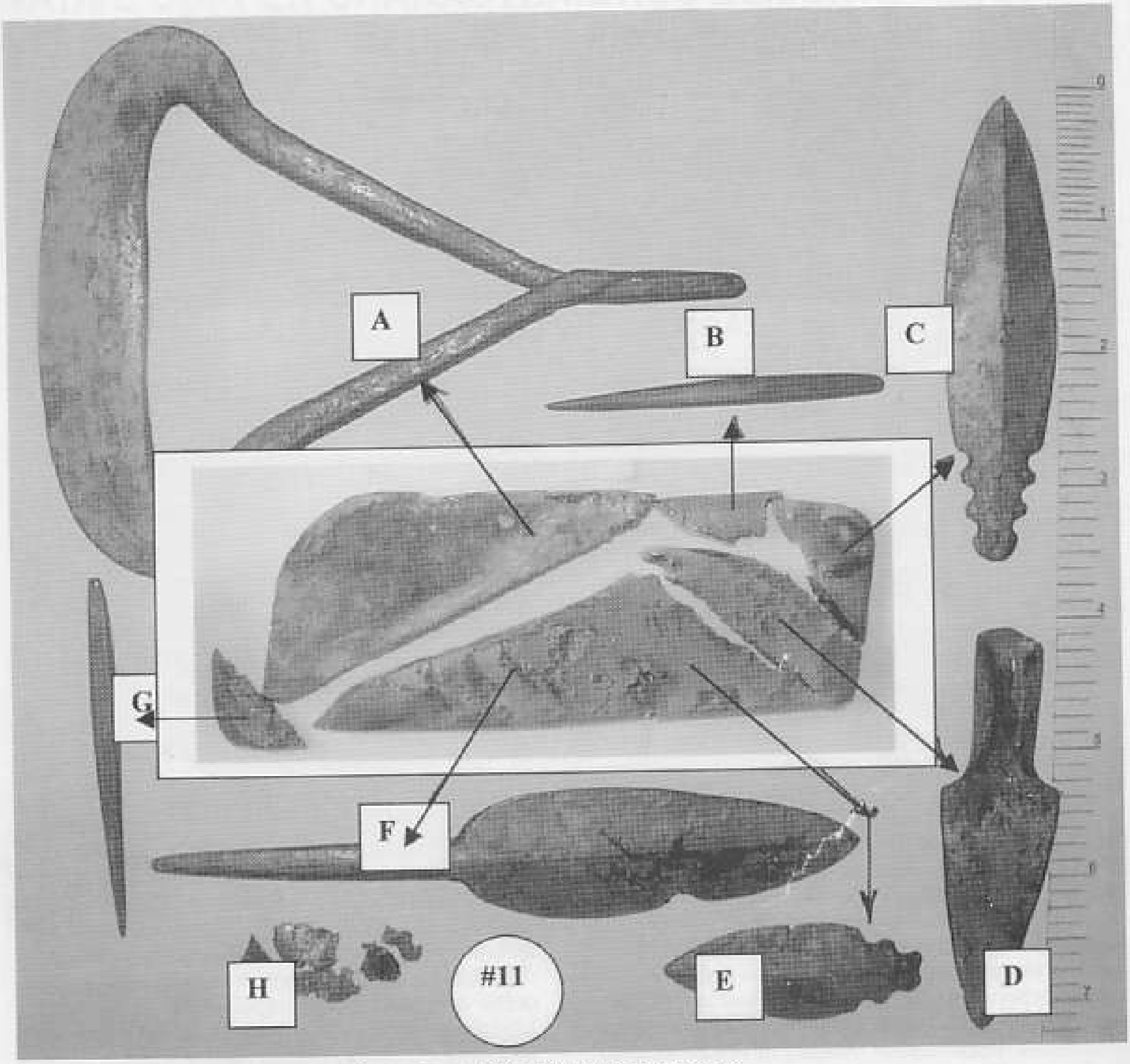
A skillful, energetic and prolific experimental archaeologist, Joseph Neubauer Sr., has been an active professional metal and coppersmith for over sixty-five years and has manufactured hundreds of native copper specimens into hundreds of tool and ornamental forms identical to the artifacts left behind by ancient copper workers. The manufacturing steps termed the Neubauer Process, published in *Central States Archaeological Journal*, Vol. 50, No. 2 Spring, 2003, documents the fundamentals that Joe has learned and applied to native copper. These manufacturing fundamentals definitely mirror the debitage and final forms created by the ancients. Native copper can be transformed by hand from its natural condition into shapes by a patient, meticulous and precise application of heat

Specimen Number	wt gr begin	wt gr final	description	color	prep	forms finished	comment
1	234.82	234.82	amygdule mohawkite	goldish copper	cut	n/a	control
2	34.86	29.08	amygdule copper	orange copper	cut	0	discarded flaws
3	110.05	94.86	float copper	orange copper	tumble	0	discarded flaws
4	305.10	269.83	float copper	orange copper	tumble	0	discarded flaws
5	94.08	63.23	amygdule mohawkite	goldish	cut	0	2 anneals crumbled
6	65.09	55.38	float copper	orange copper	tumble	2	2 ingots
7	85.85	55.43	amygdule mohawkite	goldish	cut	0	2 anneals crumbled
8	73.05	62.72	float copper	orange copper	tumble	2	2 ingots
9	165.16	125.40	float copper	orange copper	tumble	0	discarded flaws
10	12.25	12.12	amygdule halfbread	silver	none	0	discarded flaws
11	234.18	203.14	float copper	orange copper	cut	7	7 ingots excellent
12	72.09	65.04	float copper	orange copper	tumble	3	3

(to soften) and pounding to shape and harden. Repeating the anneal-pound cycle for up to thirty cycles will manufacture tool forms such as shouldered obverse and reverse ridged spear points and long arm-twisted ulu crescent knives. Smelting or melting has not been required.

The experiment being reported was to follow the characteristics found in twelve native copper specimens from Upper Michigan's Keweenaw Peninsula. The specimens were selected for the purpose to anneal and pound them into a completed tool form identical to at least one known ancient artifact. Hidden or minute mineralization of elements or molecules differ from pure copper and develop into flaws and appear at any cycle and often rendered pounded ingots useless for the intended form. In the first year of this four-year study, Joe learned that the nugget determines the cubic ingot size and the pureness of copper mineralization determines a potential final tool form. A standard or repeatable form is possible, but standardization of actual size, mass, length and width could never be accomplished or predetermined. The nugget determines the ingot sequence, which determines the final tool form and size. The coppersmith must follow the characteristics provided by the copper and other mineralization found within that specific ingot and cannot with certainty carry a nugget from a preconceived tool form to completion. Surface bubbles appear on dozens of copper ingots and final tool forms, which may be mineralization such as feldspars or calcite being vaporized and expanding within the native copper mass. These bubbles form anytime from the first to the last anneal and appear without any predictability. The bubbles do not interfere with ingot malleability or the tool's final function, e.g., strength.

In 2001, twelve nuggets were culled from hundreds of native copper specimens at Houghton, Michigan's Keweenaw Gem and Gift. This mineral supply company, owned and operated by Cindy and Ken Flood, provided native copper specimens and expert geological consultation. All nuggets had been cut or tumbled clean. This allowed Joe, Ken and the author to analyze, in detail, every surface feature and apparent mass solidness of hundreds of specimens prior to selection of the final twelve study specimens. The final twelve nuggets were selected to demonstrate a range of natural conditions such as graininess, density, mineralization of compounds different from copper, amygdule-fissure, float, color and size. Size is very important because copper is a very tough, hard-to-chisel-cut substance even when annealed into a softened state. Much time and energy is applied to large nuggets in order to reduce the mass to smaller ingots. A large specimen becomes far too difficult for the efficiency of time and task vs. creating a functional tool. This may explain the lack of large-sized artifacts and the lack of standardization from the tens of thousands of copper artifacts found throughout North America. Even in America's fertile eastern Wisconsin "fields" of copper artifacts, there does not appear to be a stan-



Specimen # 11 Final Tool Forms

description	Weight 1/100gr	#anneal pound cycles	length	width	depth
native copper cut slab	234.18	n/a	6 1/2 "	1 1/2"	3/16"
A ulu knife-twisted arms	77.43	22	5 1/8"	4 1/16"	1/18"
B awl	6.66	7	2 3/16"	1/8"	1/8"
C turkey tail spear	28.15	15	3 1/2"	7/8"	3/16"
D socket spear	27.86	20	3 1/8"	7/8"	1/8"
E turkey tail spear	13.82	15	2"	3/4"	1/8"
F rat tail spear	39.65	20	5 3/8"	1"	3/16"
G awl	6.72	7	2 1/2"	3/16"	3/16"
H debatage	2.85	n/a	n/a	n/a	n/a
Total	203.14	n/a	n/a	n/a	na

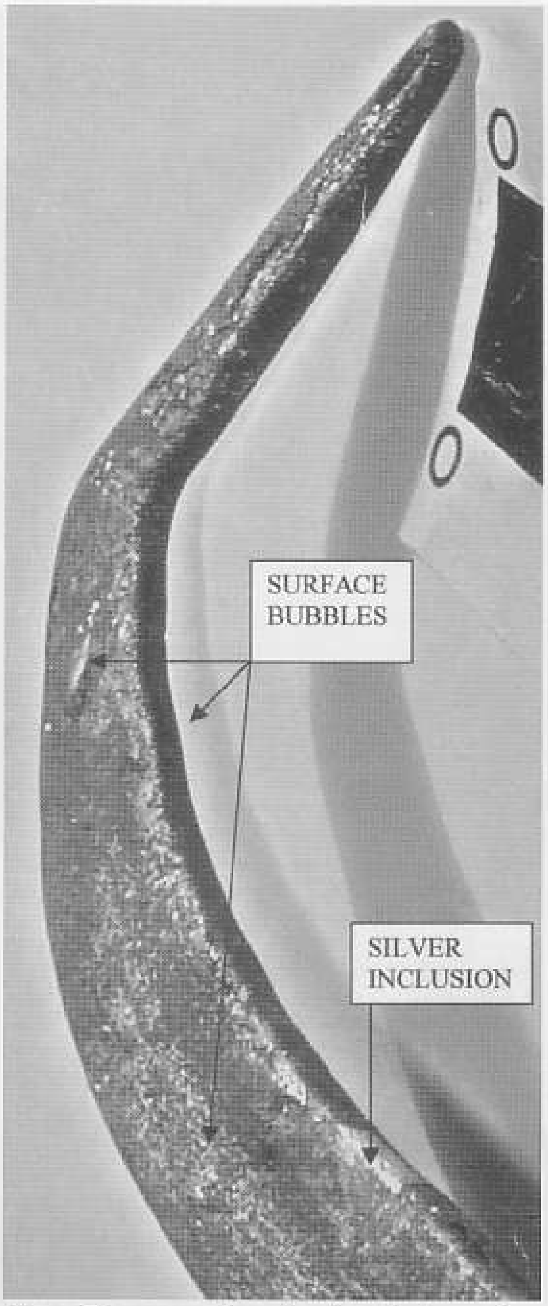
dard size found with any particular artifact tool or ornament form.

The twelve raw native copper nuggets were weighed, visually studied and photographed. All nuggets were analyzed and photographed immediately after the first anneal (heated to red hot in a white oak ember bed) prior to the first pounding, which initiates the beginning of cubic ingot formation. Additional documentation with photography of all specimens occurred when the ingots began their conversion to smaller masses due to flaws which demanded chiseling (cutting) or pounding off flawed flakes, wings, scales or small masses. Chiseling was impacted upon the natural lines of flaws found through the anneal-pound cycles in order to cut the original mass into usable smaller ingots that could go forward in the manufacturing process to create some type of a smaller tool or ornament form.

As the chart and photographs demonstrate, one Mohawkite specimen was saved without any application as a control sample, two Mohawkite specimens were useless because they crumbled into unusable small pieces early in the anneal-pound cycling, four of the solid float specimens produced at least one final tool form, three apparently solid float nuggets were so filled with mineralization that they were discarded early in the anneal-pound cycles and one half-breed amydaloidal specimen was a high percent native silver and resisted malleability and was discarded due to crumbling after the third anneal. Many of the discarded specimens did not exhibit serious mineralization and the resultant flaws until numerous anneal-pound cycles had impacted the specimen. The cracks, gaps and holes that develop, as minerals other than copper are annealed and pounded out of the original mass, are defined as flaws. The mineralization of elements and compounds other than copper was often deep within the mass and were not released until the cubic rectangular ingot was being formed.

Native copper nugget number eleven was a "mother lode" for production. Ken Flood has cut specimens, such as number eleven, into thin slices from native copper float or amygdules with diamond saws for display and mineral sale. These slabs are manufactured with modern technology but provide an unusual ability for an experimental archaeologist to apply keen visual inspection for mineralization and flaws. A density test with a Jolly balance can also be used to define specific gravity and hence the probable purity of a copper mass. This experiment did not use the Jolly balance test for density. Slab specimens are excellent samples for the anneal-pound cycle, Neubauer Process, as they are genuine float or amygdaloidal copper but expose a greater surface area, which provides a quick comprehensive visual analysis. The experimenter is less likely to waste time and energy creating an ingot that cannot physically endure the numerous anneal-pound cycles required for a final tool form production.

The ability to cut and create slab forms of native copper with diamond saws was not an option the ancient copper masters could use. However, the ancients could and clearly did obtain near perfect masses of copper by annealing and pounding off flakes or smaller masses of pure copper from the many large copper float erratic boulders found throughout the copper ranges. The famous Ontonagon boulder from the Ontonagon River demonstrates around its entire surface the worrying off of smaller copper masses by the ancients. The smaller pieces of copper mass obtained in this manner would have provided the ancients with a flawless mass from which they could pound flawless ingots. This is because the mass, without internal flaws, could clearly be moved back into itself to form the required cubic rectangular ingot that is a critical step in the Neubauer Process.



Above: Copper specimen showing showing suface bubbles and a silver inclusion. Below: An ingot heated on white oak embers showing the mysterious bubble effect.

Nugget eleven was an excellent example of the variety and quality of tools that can be pounded from a relatively small specimen. The processing of the specimen from a raw slab of float into seven final tool forms provides an excellent example of the Neubauer Process.

Native float nugget number eleven produced seven excellent, strong, unflawed final tool forms, from the difficult twisted stem ulus (requiring 22 anneal-pound cycles) to simple awls (requiring 7 anneal-pound cycles). This demonstrates the wide range of tools that can be chiseled off smaller ingots along natural flaws, pockets and lines that occur in the original mass.

The flaws, pockets and cracks reveal themselves in the anneal-pound process. Sorting dozens of slabbed specimens with obvious mineralizations helped avoid poor quality specimens in the process. The nugget selected indeed yielded a very low percentage of debitage, discarded chips, red dust and grainy marl waste by-products. Comparing the original nugget weight to the weight of all completed tools and scraps proved the solid mass. A Jolly balance test for density was not used; hence, it demonstrates that ancient copper workers could have selected native masses that would have been cost-effective to manufacture tools from. It also demonstrates that some raw nuggets are totally hopeless and crumble with the anneal-pounding after the first cycle. This might indicate that trading cubic rectangular ingots or finished tool forms would have been the most cost-effective commodities from the copper ranges of upper Michigan thousands of years ago. Joe pounds and throws approximately four times as much mass unto his junk debitage pile as the total mass found in his completed tools.

The nugget yielded seven final tools by only applying heat from oak embers, pounding, chiseling to cut, bending and limited abrasion by sandstone. Modern steel hammers and anvils were used throughout the experiment to increase the speed of production. Rock hammers and anvils of hardened copper, rock or wood produce the same results as modern tools but require more time on task. In all instances swedging was required as the applied physical force vectors applied to the obverse surface of a cubic rectangular ingot transfers through the ingot's mass unto the reverse side (180 degrees opposite), which is contiguous to the anvil's surface. This is the inevitable and only application of force to the molecular structure of native copper mass, and it is why the cubic rectangular form is a critical step in the Neubauer Process. The cubic rectangular form is very common debitage found at ancient worksites and campsites.

No bubbles were realized on any of specimen number eleven's final tool forms and none were observed on the ingot's surfaces during the manufacturing cycles of this nugget. It is speculated that the 3/16-inch even thickness of this slab may have allowed for any mineralization to vaporize during annealing.

The twisted arm ulu exhibits flow lines or pressure ridges where the copper mass bunches up into ridges as the long form of an arm is drawn out and bent from the cubic rectangular ingot. This pressure ridge or flow line characteristic is observed on many anneal-pounded tools, especially those exhibiting length and bending.

Several tools show a layered characteristic, which appears to indicate a folding of a thinner sheet into the final tool's form. In all instances, this folded appearance is derived from pounding the ingot's flawed internal mass and not from folding a thin sheet into a thicker mass.

The final seven tool forms were determined after the third and through the seventh anneal-pound cycle and only after a solid cubic rectangular shape could be produced. The shape and size of the completed cubic ingot then, and only then, was the critical factor which led into final tool production. No melting or smelting was required or necessary for any of these tool forms or several hundreds of other Neubauer Process completed tool and ornament forms.

The debitage, dust, cracked and flawed ingots, photographs and finished tool forms for the entire set of twelve original copper specimens have been saved and are available for further study. Included with this saved set of data are examples of ingots and tools with surface bubbles, ingots and finished tools with silver inclusions and bubbles on the same tool, anneal-pounded tools with a folded appearance, tools with pressure ridges and/or flow lines and deep-shouldered socketed spear points. All experimentation has been accomplished through the unique approach provided by the Neubauer Process.