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Table of Contents

The Neubauer Process: 1999-2003 Observations

David H. Peterson, Two Harbors, Minnesota

Joseph Neubauer Sr., a master native coppersmith and experimental archaeologist, has been annealing and pounding native copper specimens from Upper Michigan for the last four years and has manufactured hundreds of ancient tool and ornamentation forms which replicate the process followed by the Ancients over the millennia. The sequential steps applied to native copper as required by the characteristics of native copper were termed the "Neubauer Process" in the *Central States Archaeological Journal*, Vol. 50, No. 2, Spring 2003. This author has had the opportunity to observe, document, study and interact with Joe and his project colleges since the inception of this investigation. During this intense four-year period of investigation, experimentation and reporting, many observations relative to the anneal pound technique have been made which may be useful for future experimental archaeologists. It has always been Joe's hope that this work, the Neubauer Process, will stimulate and encourage youth to continue the research on native copper manufacturing, use and distribution by the Ancients. This report reviews the major findings, techniques and safety concerns of the Neubauer Process.

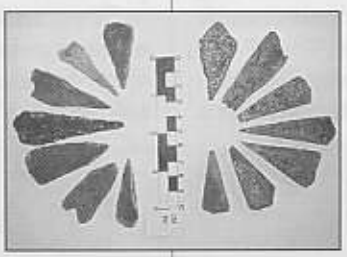
Native copper, which the Anishinaabeg called Miswabik, has for millenniums, since the glacial retreat from the Lake Superior basin 10,000 years ago, invoked a curiosity and applied utility from man. Post-glacial, prehistoric Old Copper Culture, historic Indian bands of Anishinaabeg through today's lake inhabitations all have revered native copper. It is tough and unbreakable but malleable, becomes brittle with pounding, yet returns to a softened state with heat over 500 degrees F, obtains a razor sharp edge when pounded, occurs as seventeen ton masses (or more as fissure mineral such as found in the Minnesota Mine-Rockland, Upper Michigan) to mere minute flakes, can be bright and shiny or black, brown, silver tinted, red, green, pinkish, gold tinted, or orange. People today enjoy native copper for home decoration, home construction, electrical transmission, and personal jewelry, trade it as money and even wear it as a medical treatment for arthritis. Anishinaabeg continue to speak of the mystery of lake copper, especially as related to Manitou's Mishi Ginabig and Mishi Bizi.(Mishebeshu). Lake Superior basin native copper continues to influence a spiritual, medical, trade (money) and economic influence today.

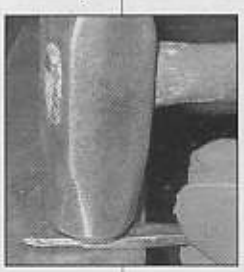
As inquisitive students of Lake Superior geology or archaeology read the Neubauer Process, it is Joe and the author's intent that the research plus the duplicative procedure format (which can be followed with the correct sequential application of annealing, pounding, time and energy) will stimulate interested readers to study native copper, ancient copper manufacturing techniques and related cultures. The following tips and tidbits of coppersmith instruction and safety advice should be helpful in this pursuit.

Lake Superior basin native copper can be found naturally occurring throughout Ontario, Canada; Michigan; Minnesota and

Wisconsin. The vast majority of specimens are found in the Houghton, Keweenaw and Ontonagan Counties of Upper Michigan.

The fastest and most economical way to obtain native copper specimens (without fatal flaws, which are embedded trace elements and minerals such as feldspars, arsenic, calcite and silver) is to purchase them from mineral dealers such as Keweenaw Gem and Gift of Houghton, Michigan. Ken and Cindy Flood, geologists and owners, provide digital photographs of specimens on their website (www.copperconnection.com) or may be emailed at copper@up.net. Native copper "float" or slab cut "float" copper is readily available in all sizes. Ken Flood has been the geologist working directly on this research and has encouraged the Neubauer Process through professional analysis of specimens prior to application of the anneal-pound cycles. Many other reputable mineral dealers from Upper Michigan are available and can be reached through web research or telephone directories of the Keweenaw Peninsula of Michigan. Rock collectors regularly find float native copper throughout the peninsula, but days may pass without finding suitable solid copper specimens. Specimens must be a very dense mass of copper without other minerals being present, which cause cracks, gaps and flaws that are fatal to tool production. Many hundreds of Joe's ingots have been discarded. Fatal flaws can, unfortunately, occur at any stage of manufacturing, including after twenty anneal-pound cycles. To obtain the purest of native copper specimens, a Jolly balance density or specific gravity test should be applied. This experimentation relied on visual and hand-felt density, which are the probable selection tests applied by the ancients.





Annealing (heating native copper to at least 500 degrees F or higher to a red-hot glow) will have to be accomplished. White oak ember beds with a draft on many occasions have reached the melting temperature of 1761 degrees F, as proven by silver inclusions melting out of some half-breed copper nuggets or ingots. As the experimental archaeologist increases in skill, deep-shouldered socket spear points and twisted arm ulu crescents will require up to thirty anneal pound cycles. Advance preparation of several heating furnaces or fires concurrent with ingots at various stages of anneal will greatly increase efficient use of energy time on task. The critical component will be the experimenter's arm and wrist strength. Many people will find the task of pushing ingots into cubic rectangles and final forms too physically exhausting and difficult. Constant solid impacts of a full-force arm swing instantly stopping on a copper mass can cause tendonitis very quickly in an unconditioned wrist and arm.

Annealing can be accomplished from any available heat source above 500 degrees F. The heat source will determine the time required to reach actual anneal temperatures. When pounding renders the ingot too brittle to continue. White oak ember beds have been used in 95% of the experiments during the past four years, with three major ember beds being fired at one time to increase time on task when several ingots were under simultaneous manufacture.

Ingot Shaping into Rectangular Cube

Patience and strength is required. This manufacturing process with or without rock and primitive tools will take dozens to hundreds of hours to create one final tool form, depending on the copper specimen's original size and mass. Much arm and wrist strength will be needed to drive a copper mass into itself to obtain a cubic rectangular shape. Once the cubic ingot is formed, then it is pushed through force and accurate pounding into various final tool or ornament forms.

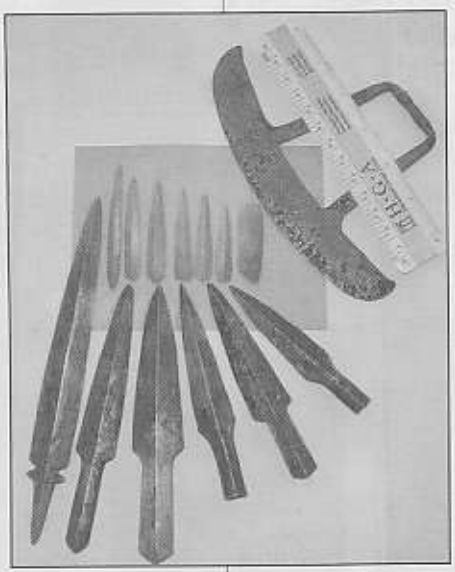
Native copper, even when annealed to a soft state, is a very tough substance to cut, bend or shape. Much time and physical strength is expended to shape and form each cubic ingot as it metamorphoses into its final form.

Ingot Manufacturing Techniques

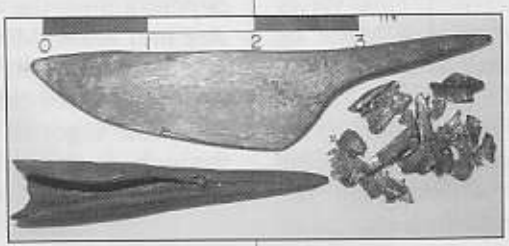
Hot ingots need to be cooled, as most experimenters do not have time to use wooden branch tongs, nor do they have access to black

smith tools required to hold hot ingots and pound. However, pounding hot ingots is very time efficient as the internal mass heat continues to anneal the ingot while being pounded so a higher number of impacts can be delivered between anneals.

Hot ingots can be pushed out of a fire with green sticks, and picked up while hot with a scoop, tube, lever or two copper spikes used like chop-sticks. Also, if the ingot is too hot to safely handle, it can simply be allowed time to cool naturally as the fire bed burns off, or it can be plunged into cold water. The method or speed of cooling has no apparent effect on the ingot's malleability. The number of anneals between pounding does not affect the malleability, e.g., produce a softer mass. In addition, annealed ingots can be stored away and pounded in the softened state years later.



The Ancients probably used leather, split stick tongs, copper mandrels (a mandrel artifact stuck in conical spear point is owned by avocational archaeologist Gordon Morris) or rock anvils with depressions for holding/forming ingots and rocks, antlers, tusks and hardened copper tools as hammers. A private artifact collection owned by mining engineer Dan Koss and found in Upper Michigan has two apparent hardened copper hammers with hardened copper anvils demonstrating much pounding use. Today, a number of modern tools exist which can be used to hold and pound copper. Either an ancient or modern tool may be used, for it has no effect on the ingot's physical characteristics. The characteristics of atomic alignment in a mass of native copper determine the forms that can be manufactured from the mass. Joe always says, "Copper is copper and copper will only allow you to do what copper can do." Joe should know; at age 82, he has been a professional copper and metal smith since age 17. Joe has been pounding copper over sixty-five years and native copper specimens full time as an avocation, since 1999. Dan Koss, Ken Flood, Tony Romano, Al Bergstrom, George Weimer, Tom Amble, Glenn Krapu, Gordon Morris and the author have been consultants on the Neubauer Process project.



Beginning copper experimenters are encouraged to anneal and pound very small, even thickness or slab-cut copper until the technique of pushing the existing copper mass into a cubic rectangle is learned. All final forms are created from a cubic ingot, and until that critical step is made (up to fifteen or more anneal-pound cycles may be required on large ingots), the pounding out (pushing) of the ingot into tool forms is futile. Small native copper nuggets are many times more difficult to shape than commercially rolled thin copper, which many experimenters have used for research. This appears to be true because it requires geometrically more energy to push larger copper masses with irregular surfaces into the initial cubic ingot form. The pure refined commercial grade copper used by some experimenters may also be more malleable than native copper with trace elements.

Safety Considerations

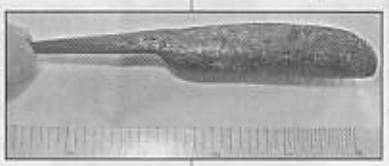
Safety first! Annealing copper to over 500 degrees F or, with white oak embers, up to silver-melting temperatures reaching 1761 degrees F and pounding imperfect ingots with all available arm strength is dangerous and safety precautions are necessary.

Nuggets at 500 degrees are black and do not look hot but obviously will cause serious flesh burns. Extreme care must be used to protect exposed skin until the nugget returns to room temperature; and if the ingot is pounded hot, then strong tools, eye shields and leather gloves are absolutely necessary. Strong, rapid pounding on a cold ingot produces a natural heat which can burn exposed skin.

- Pounding on ingots creates razor sharp scales, which can fly loose or bend upwards off the ingot surface like tiny razor blades any time during the pound

process. Hands without gloves, exposed skin and eyes can be cut as these scales fly through the air.

- Anneal-pound cycles create dust and gas. Gas is being released during the anneal, as witnessed by dozens of ingot surface bubbles formed at any stage or even upon the final tool's surface. Surface bubbles appear to be vaporizing internal minerals other than copper. Large amounts of red dust suspected to be cupric oxide and lighter crumbling masses of unknown substance continue to be extracted from ingots while being pounded. These represent mineralization other than copper, which become the cracks and gaps termed flaws in the ingot's remaining mass during the anneal-pound cycles. Native copper does on occasion have arsenic present in the mass (Mohawkite: Domeykite Cu6As and Algodonite Cu3As) and also float specimens often have heavy green patina in the molecular form of carbonates $CuCO3Cu(OH2)$; and acetate, $Cu(H3C\text{-}COO)2$, produces verdigris, a poison if ingested. Cupric acetate is a bluish-green product of acetic acid and copper and has been known for centuries as a poison.



- Native copper also has intrusions of silver, and attached to the silver may be atoms of mercury. Careful annealing of specimens with native silver is encouraged, as atoms of mercury may be released into the atmosphere.
- Pounding on ingots, which rest on rock, hardened native copper, hard wood or steel anvils, creates thousands of sharp loud impacts. The sharpness of the impact's sound increases as the ingot becomes brittle through repeated pounding.
- Minimum safety measures should include leather gloves, an apron, safety glasses, hearing protection, a dust mask if the specimen exhibits dust, work area ventilation, or up wind if outdoors, vacuuming and cleaning interior work areas, washing work clothes and hands and face after pounding prior to ingestion of food or drink.

Conclusion

The 10,000s of ancient manufactured tools and ornaments discovered throughout the Lake Superior basin are proof that the Ancients knew how to protect themselves and pass on from generation to generation safety techniques to work with native copper mining and manufacturing. It would be interesting to observe a worksite with the Masters at work 5000 years ago somewhere on a Lake Superior basin trap or beach. Did one Master have an entire band of apprentices working on various stages of mining and manufacturing? What reward did the Master and the workers receive to undertake such a difficult and physically demanding manufacturing process? Copper mining and manufacturing would have required tremendous energy expenditure at great physical risk and discomfort.

Joe has demonstrated that to manufacture the original nugget or float into a useable tool or ornament form requires a long, concentrated period of practice and experience with the characteristics of native copper nuggets, amygdule and float. Thousands of years ago, the average person certainly would not have the food, clothing, tools, fuel, time, ambition, knowledge, physical arm and wrist strength to accomplish success with copper. How would the ancient coppersmith masters have been selected and compensated to study, practice, accomplish and endure the manufacturing of tools and ornaments? The Neubauer Process demonstrates that with great skill and effort, the process of anneal-pound applied in precise cycles can replicate the Ancient's beautiful work; however, it does not provide the reason why the Ancients were motivated to expend such tremendous effort. ❖