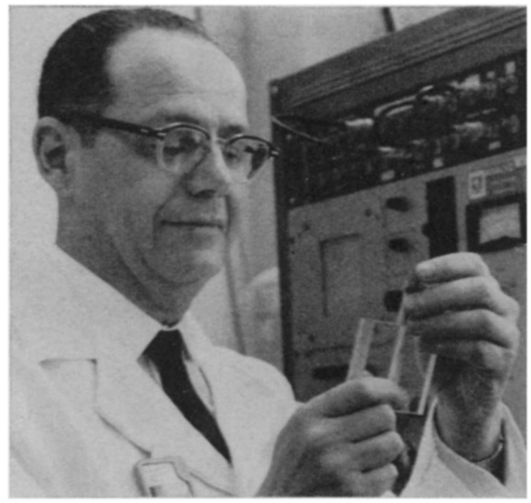
Chemistry probing the past



Ancient copper is irradiated . . .

An arsenal of atomic-age instruments, applied to the study of ancient cultures, offers new understanding

by Patricia McBroom

Some 2,000 years before Christ, Americans were mining copper in northern Michigan. They dug pits in the ground and built bonfires to heat rocks. Then they poured on cold water to split the rocks and beat out the copper with stone hammers.

Archaeologists have found about 10,000 of these pits. By some estimates they could have produced a billion pounds of metal. The Michigan deposits are exceedingly rich in copper in its pure form, so this earliest-known metallurgy in the New World would have required no great sophistication.

The Old Copper Culture disappeared around 1000 B.C., and copper artifacts have not been uncovered in sufficient abundance to account for all the metal which apparently was taken out of the ground.

No one knows where the people went, nor what happened to their copper. They could have traded to the south, transporting copper down the Mississippi to South America. The people themselves might have migrated north to influence the Copper Eskimos whose culture flourished later in Canada.

One way to establish the validity of either or both possibilities is to trace copper artifacts to their geological origins through chemical analysis of impurities in the metal. Michigan copper, for instance, contains traces of silver.

But before a chemist could analyze a South American pot and decide it was made of Michigan copper he would have to know the chemical characteristics of copper deposits elsewhere in the world. Such knowledge requires extensive chemical fingerprinting.

At the Argonne National Laboratory in Illinois, Dr. Paul Fields, a chemist, is analyzing hundreds of copper samples from various parts of the New and Old Worlds, hoping eventually to build a library of the distinguishing characteristics of ore sites and artifacts.

The Argonne effort reflects stirrings of a new and highly promising front in archaeology. The technology, much of it developed originally for the Atomic Energy Commission, includes such sophisticated methods as neutron activation analysis, thermoluminescence, X-ray fluorescence, infrared spectrometry, mass spectrometry and a newly instrumented technique used by Dr. Fields, spark-source mass spectrometry. Many chemists, not to mention archaeologists, have yet to grasp the full potential of these techniques.

Typically they are used only as laboratory aides in archaeology. An archaeologist brings in a piece of pottery, for example, and asks the chemist to date it or compare it to known ceramics.

But the instruments can be used in quite another way—as basic research tools in mapping the world's deposits of amber, obsidian, copper and clay, among other materials, and then correlating them with artifacts found anywhere on the globe. With such fingerprinting, chemists could reveal a wealth of new information on trade routes and migrations of ancient peoples.

Dr. Curt W. Beck of Vassar College has made a start. This summer, mapping European amber, he discovered that Greeks of the Mycenaean period, around 1500 B.C., were using Baltic amber which probably came from deposits in Denmark. His discovery lends support to ancient stories of Phoenician trade between pre-classical Greece and northern Europe.

Dr. Beck used an infrared spectrometer to distinguish between Baltic amber, never found south of Germany and the Carpathian mountains, and amber deposits in southern Europe.

Such mapping takes years and thousands of samples, says Dr. Beck. "But I think it is the most important thing chemistry can do for archaeology in the long run."

Pottery presents special problems to the chemist since clay contains at least 30 different elements. "We don't know which elements in clay are the important ones," says Jacqueline Olin, a research chemist at the Smithsonian Institution. "Consequently, we do not know which variations will be useful in distinguishing between clay deposits."

She says archaeologists are always surprised when they are told that chemists do not know what clay is, but then no one has studied it chemically before.

Now, with neutron activation analysis, it may be possible to answer some of these questions.

The object to be tested is irradiated in a nuclear reactor or some other source of neutrons. The neutrons penetrate the object, forming radioactive isotopes which emit gamma rays at energy levels peculiar to each of the elements. By measuring the gamma ray emissions, chemists can identify the elements present.

Given time and fortitude, chemists should eventually be able to correlate masses of data on various clays and find the essential elements.

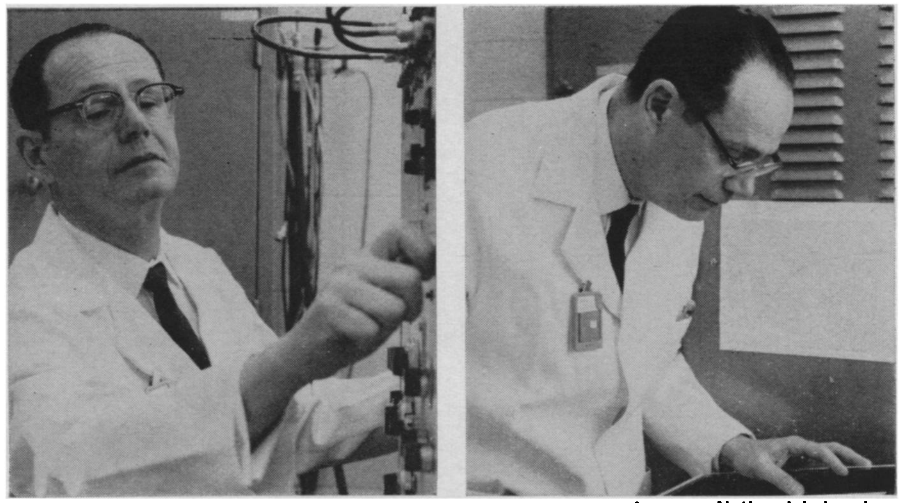
At the moment, chemists are perhaps most excited about a dating technique called thermoluminescence. It offers a means of dating clay artifacts directly. Only two or three years old, thermoluminescence has already picked out several forgeries which had been passing as valuable Etruscan statues. One other is now before the courts.

Chemists at the University of Pennsylvania Museum first used thermoluminescence in 1966 on one of their own treasures, the Etruscan Lady, and found her to be a fake. She was no more than 100 years old instead of the 2,000-plus years claimed. Testing a second figure, Diana the Huntress, owned by the St. Louis City Art Museum, the Philadelphia group discovered that she also was of modern origin. The suggestion was that both statues had been made by the same 19th century Italian forger.

In the ensuing publicity given these discoveries, Pennsylvania's Dr. Ellen L. Kohler wrote, "to all the terracotta-forgers still loosing their spurious wares on the world, thermoluminescence issues an ultimatum."

It also issues a word of caution to art dealers. Trustees at the St. Louis Museum are suing the art dealer who

. . . *for neutron activation analysis.*



Argonne National Laboratory

Dr. Fields then analyzes gamma radiation to identify trace elements.

Dr. Curt W. Beck

Mapping of European amber enables chemists to track ancient trade routes.

sold them the statue 16 years ago. Claiming that Diana the Huntress is not an authentic work of Etruscan art, the museum wants its money back.

Thermoluminescence dating depends on uranium and thorium content in clays. The older the artifact, the more these radioactive elements have decayed, leaving trapped electrons in the sample. When heated, the artifact will release these electrons in the form of light. Works of ancient origin give off considerable light, while Diana the Huntress gave off very little.

But there is a hitch to this method. Artifacts with high uranium and thorium content will release quite a glow regardless of age. Unless chemists also measure concentrations of inherently radioactive material, their dates are unreliable. This was a problem with Etruscan Lady, who glowed under heat; she was made of clay with much uranium.

The heating can be done on a small sample without damaging the artifact. But determining uranium content takes three grams of material and curators are reluctant to take that much from a possibly authentic art work. If and when different clays are fingerprinted and their uranium content mapped, this problem could be greatly reduced.

Whether the infant field of archaeological chemistry is carried to its full potential depends on the persistence of chemists and the cooperation of archaeologists, many of whom have yet to appreciate the value of chemistry. It has not been uncommon in the past for archaeologists to confuse amber with bone, silver with tin and copper with bronze. But they have the artifacts needed by the chemists. "Unless we can get archaeologists interested," says Dr. Fields, "we won't have much to work with."

Pennsylvania University Museum

Diana the Huntress; focus of a suit.