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Neutron Activation Analysis Traces Copper Artifacts to Geographical Point of Origin

The problem:

To trace copper artifacts back to their point of origin. Previous investigators assumed that ore impurities would alloy in the artifacts in significant quantities. This is not necessarily true, since ore impurities can locate themselves in the slag as well as in the metallic copper. Therefore, it must be determined which impurities remain in the metallic copper when artifacts are made.

The solution:

Identify the impurities which are likely to carry through from the ores to the metallic copper and quantify these impurities by spectrographic and neutron activation analysis. Determine the relative probabilities that a given copper artifact was derived from a certain type of ore. The ability to determine the type of ore used to produce copper artifacts is a major step in placing the geographic location of the ore, and hence, the point of origin of the artifact.

How it's done:

The method of solving the problem is based on the assumption that the type of ore used is dependent on the level of technical competence of the makers of the artifact. These types of ore are as follows: type I, naturally occurring metallic copper, used by primitive peoples; type II, oxidized ore, used later to produce the metal by heating the ore with charcoal; and type III, reduced ore, used still later to produce the metal by converting it to oxides by roasting and then heating with charcoal.

Samples of each ore type are used to experimentally produce metallic copper by the most primitive method known for that type. Optical spectroscopy and neutron activation analysis are used to determine and quantify the impurities which remain in the copper metal and the impurities which are lost in the slag. The impurities most likely to carry through into the artifact are silver, arsenic, bismuth, iron, antimony, and lead.

These impurities are then catagorized into nine levels of concentration. From these data a frequency distribution is tabulated, relating impurity and level of concentration to ore type. The frequency distribution tables for the impurities must be converted to tables of relative probabilities.

The artifacts are analyzed to determine the concentration level of each impurity. The corresponding probability of occurrence for each of the three ore types can then be determined by using the tables of relative probabilities for each impurity.

Another table containing the probability of occurrence data for the impurities listed according to ore type must be made up. Since the relative probability that all impurity concentrations will occur in a given ore type is related to the product of the individual probabilities for each impurity of that ore type, the product of probabilities of the impurities in each ore type must then be computed.

Since it has been assumed that a given artifact must have come from one of three types of ore, the products of the individual probabillties can be normalized to 100 percent. Thus, the probabilities that a given artifact was derived from the three types of ore can be determined.

Notes:

1. Complete details of this investigation are contained in: *Science*, Vol. 152, June 10, 1966, pp. 1504–1506.

(continued overleaf)

2. Inquiries concerning this innovation may be directed to:

Office of Industrial Cooperation
Argonne National Laboratory
9700 South Cass Avenue
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Reference: B67-10036

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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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