If instead of changing $V_L$, the leakage *conductance* is changed to zero, the theoretical resting potential changes from zero nearly to $V_K$, as in Fig. 1*B*. Low signal levels in the analog computer, however, prevented accurate computation of this alternative modification.

We conclude that a change in one parameter ($V_L$) of the Hodgkin-Huxley equations is sufficient to describe experimental potential curves of lobster and crayfish giant axons (*8*, *9*).

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## Prehistoric Copper Objects from Western Mexico

*Abstract.* A series of Pre-Columbian copper artifacts from Nayarit, Mexico, is analyzed. Evidence of deliberate alloys is negative, but the specimens are important as early examples of metal working in Mesoamerica.

Recent excavations in the state of Nayarit on the Pacific coast of Mexico have yielded a large number of objects made of copper. The objects, over 100 in all, come from three different prehistoric sites in the vicinity of Santiago Ixcuintla, near the settlements of Amapa, Coamiles, and Peñitas. All the artifacts, which include awls, eyed needles, bells, small sheets or "slugs" of metal, and a finger ring, were recovered in controlled excavations made under the auspices of the University of California, Los Angeles, under permit from the Instituto Nacional de Antropologia e Historia, Mexico.

Table 1. Pre-Columbian copper artifacts from Nayarit, Mexico. Chemical analysis of samples 739, 342, 455, and 601 was carried out by Dave Ross (U.C.L.A.). The specimens were examined spectroscopically before analysis; Cu was determined electrolytically, Ni by precipitation with dimethylglyoxime, and As through distillation as the trichloride followed by titration with iodide. These pieces were cleaned of surface corrosion products before analysis. Sample 1256 was examined by x-ray fluorescence through the courtesy of Larry Knight (U.C.L.A.). Nothing but Cu was recorded. Samples 1246, 3120, and 3310 were analyzed by high mass spectrometer through the courtesy of the California Research Corporation. These samples were badly corroded, and surface encrustation was not removed; hence a high reading for corrosion products was obtained. +, Trace; −, absent.

| No. | Site | Object | Size (cm) | Percentage of component by weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Cu | Fe | Ni | As | W | Ag | Dirt and corrosion products* |
| | | | *Chemical analysis* | | | | | | | |
| 739 | Peñitas | Celt | 14.2 × 4.5 × 1.6 | 98.35 | + | + | 1.50 | − | − | |
| 342 | Peñitas | Tip of awl | 0.19 (diam.) | 99.42 | − | − | − | + | − | |
| 455 | Peñitas | Sheet copper | 1 × 1 | + | † | † | † | † | | All |
| 601 | Coamiles | Needle with eye | 11 × 0.2 | 99.63 | − | + | − | + | − | |
| | | | *X-ray fluorescence* | | | | | | | |
| 1256 | Amapa | Oval slug | 6.4 × 3.6 × 0.3 | 98+ | | | | | | |
| | | | *Mass spectrometry* | | | | | | | |
| 1246 | Amapa | Sheet copper | 4.0 × 3.5 × 0.1 | 70.33 | 0.34 | − | − | − | 0.10 | 29.23 |
| 3120 | Amapa | Bell | 1.5 (diam.) | 33.94 | 0.96 | − | − | − | + | 65.10 |
| 3310 | Amapa | Bell | 1.0 (diam.) | 72.20 | 0.57 | − | − | − | 0.17 | 27.06 |

*Si, O, Na, Mg, Al. † Could not be analyzed.

Copper artifacts have also been reported from Sinaloa (*1*), and as far north as Arizona and New Mexico (*2*), where well over 100 objects have been found in scattered archeological sites. The Arizona–New Mexico finds, formerly believed to have been manufactured locally, are now generally considered to be trade pieces from Mexico since they are identical in form and manufacture to Mexican specimens. The location of the prehistoric copper mines is not known, although they were no doubt somewhere in the Sierra Madre Occidental, possibly in the state of Durango.

The Nayarit specimens are of interest because many of them were found in mounds of domestic refuse, showing that copper artifacts were in common use. The dating also appears to indicate that the use of copper is more ancient on the west coast than in central Mexico, suggesting that knowledge of metallurgy may have originated in the west coast area.

The chronology is uncertain, but copper artifacts from Nayarit are found associated with pottery that is presumably Late Classic and Early Post-Classic in date—something to be equated with the Mazapan horizon in central Mexico. According to the dating system based on the Spinden correlation, the bulk of the copper objects were made between A.D. 700 and A.D. 1100. Copper objects seem to have reached southern Arizona by A.D. 900 and northern New Mexico by A.D. 1000 or 1100; it would not be surprising if they originated in western Mexico at a somewhat earlier time. This system yields a consistent if highly speculative chronology, since we do not have firm dates for the first appearance of copper in any of the regions mentioned.

A couple of broken copper artifacts from Nayarit showed a yellowish color, suggesting the possibility of alloys with other metals. Deliberate alloys are not generally found in Mesoamerica, and the most important technological alloy, bronze, although known in the Andean area, has not so far been found in Mexico. Accordingly, several examples were analyzed; the results (obtained at different times by different methods) are given in Table 1. All of the objects analyzed proved to be essentially pure copper. The only exceptional piece is a copper celt (No. 739) which contains 1.5 percent arsenic. This is probably too small an amount to permit the sample to be considered a deliberate alloy, although it may be significant that this is the only specimen containing arsenic and is also the only "heavy duty" tool among the objects examined.

In addition to the copper objects mentioned, both gold and silver artifacts (the latter exceedingly rare in Mexico) have been found in Nayarit. Traces of gold leaf were found in the excavations at Amapa, but no specimens have been analyzed.

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