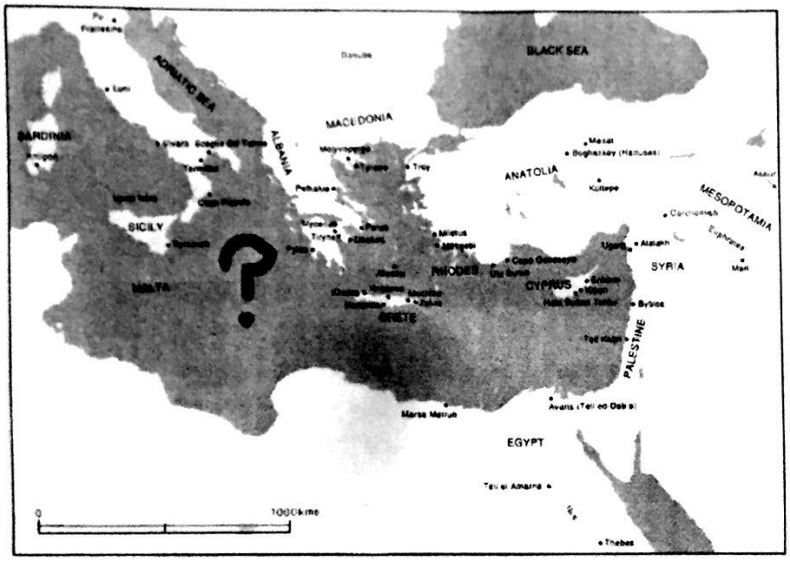
ANTH 415
Archaeological Science

Lab Four
Provenience (Pb isotopes)

People have long speculated about, and searched for, the lost city of Atlantis yet none have located its remains. Some suggested it was simply an allegorical tale spun by Plato. But with some clever research and cunning survey strategy, you and your nautical survey team have conclusively identified the remains of this fabled city in the depths of the Mediterranean Sea, not in the Atlantic. And after several years of painstaking underwater excavation, you and your team have shown that the city was founded in the Early Bronze Age (ca. 3,100-2,000 BC) and flourished during the succeeding Middle Bronze Age until its catastrophic plunge into the Sea about 1,600 BC following a major volcanic eruption. You do not want to attract unscrupulous visitors, so you are not publishing a map of its location. But for those select few outside your loyal excavation crew, you are willing to say that it is somewhere between Sicily and Crete....



Your primary archaeological interests have been in the economic life of the city, as the Early and Middle Bronze Ages elsewhere in the Mediterranean were periods of dramatic economic and political change. The Early Bronze Age was characterized by small polities whose elites seem to have underpinned their authority primarily through ideological means, rather than by ostentatious displays of wealth. So, they supported construction of monumental public architecture presumably used in events where they could show their largesse by feeding everyone in celebration of a particular ritual (i.e., they threw good parties!). But later elites in the Middle Bronze Age used displays of extreme wealth to reinforce their authority, primarily through control of trade routes to acquire exotic raw materials that were then crafted in closely supervised workshops. Whereas craftspeople previously had enjoyed relative autonomy in their trade networks to obtain raw materials, now they could only obtain goods through bureaucratic channels managed by the elites.

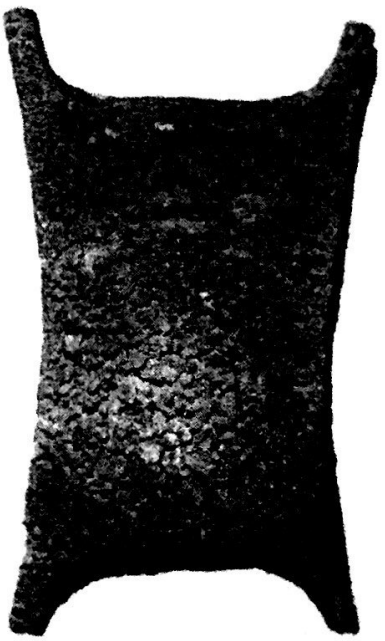
Your excavation work so far has been able to document the overall plan of the city, in which you identified <u>three</u> metal workshops (designated A1, B2, and C4 from your site map) that crafted bronze objects. The metal artifacts from these workshops appear to have been locally-produced based on their stylistic attributes; that is, there is little indication the objects *themselves* were manufactured elsewhere and later imported. You would like to examine whether Atlantis followed a similar political trajectory to other city-states in the region, so you are interested in the trade networks of metals for this maritime city. You turn to analysis of

lead isotopes in the metal artifacts to see if you can identify the sources of the ores obtained by these craftspeople nearly four millennia ago.

Background

There are four stable isotopes of lead (^{208}Pb, ^{207}Pb, ^{206}Pb, and ^{204}Pb). The three heaviest are produced by the radioactive decay of isotopes of uranium or thorium, whereas 204-Pb is 'primordial,' or its terrestrial abundance has not changed in the geological past. Because of the geochemistry of their parent elements, the abundances of daughter 208-Pb, 207-Pb, and 206-Pb in a particular geological formation vary based on its compositional history and age. Geologists use this to their advantage to date rocks. Archaeologists use it to their advantage to distinguish metal-bearing veins, particularly of copper, exploited by people in the past.

A corollary to their radiogenic production is that the ratios of 208-Pb, 207-Pb, and 206-Pb vary much more *relative* to each other than they do relative to 204-Pb. That is, you might consider 204-Pb as a sort of *constant* against which variation in the others might be best visualized. You have at your disposal the lead isotope ratios of three possible source areas for Atlantis trade in copper ore: Cyprus, Greece, and Sardinia. All these places were significant production centers of ore in prehistory, and you hypothesize they were the most likely candidates for raw material procurement. For reasons related to the history of analysis, archaeologists sometimes report ratios of radiogenic isotopes rather than a radiogenic versus 204-Pb, as you may notice in the provided data. But recall that you can multiply two ratios together to get another with your preferred numerator or denominator. For example, multiplying values for (208/206) x (206/204) will give the ratio (208/204).



For this study, you sampled a series of artifacts—like the 'oxhide ingot' at right—from each of workshop across <u>two</u> different periods of the city that you think, based on changes in public architecture and the construction of palaces, straddle a political change in the life of the city.

- <u>Period 1:</u> Represents the earliest occupation of the settlement in the Early Bronze Age (EBA) and shows large-scale monumental architecture, but very little differentiation in residences either in size or artifact assemblages.
- <u>Period 2:</u> In contrast to earlier Period 1, monumental architecture not only becomes larger, but is cordoned off to restrict access, and there are least three structures you identified as elite 'palaces' were constructed in this occupation period.

You selected approximately 10 artifacts from each workshop and period and were able to get good data for all of them. (Wow!) So, you now have data for 60 artifacts spanning Periods 1 & 2. By examining this data, you would like to see if you can *confirm or refute the hypothesis of elite control over trade routes*. As you work with the data, consider what it might mean—from the point of view of obtaining raw materials—for a particular workshop to be 'independent' or 'managed' by an elite. Will there be diversity in source areas for a specific shop, or will they obtain from a single source? It is wise to think about possible configurations of social, economic networks that would bring raw materials to a shop. Or, perhaps the geography of sources for raw materials may shift entirely with changing political economy.

Report

To start your analysis, follow the instructions below. Include answers to the questions in a report explaining your analysis of the data and summarizing your conclusions. Be sure to detail your logic, discuss any uncertainties or difficulties you faced, and include relevant graphs or figures. If you use outside sources, you should cite them appropriately in the text and in a bibliography and the end.

Instructions

1) Obtain the dataset (in Excel format) from *myCourses*. There are two sheets: one listing Pb isotope ratios (and associated analytical error) for the Atlantean artifacts; and one with data from ores obtained in three possible source areas. It does not matter which graphing software you use. Also, data reduction techniques are not necessary here, but you may decide to use 3-dimenionsal plots, if you choose.

2) Your first step should be to look at the ore data. You want to see how well different ratios may differentiate ore source areas. One possibility has been provided. Experiment with plotting other bivariate combinations of Pb isotope ratios against each other. Do any pairs of ratios separate the source areas better than others? Choose a pair that looks best to you, then either take note of the spaces in the plot that 'define' each source areas or find a way to 'fade' them so you use these as reference comparison for the artifacts (i.e., by plotting artifact data on 'top'). Consider your rationale for choosing the particular plot in depicting the data.

3) Using the same axes as you chose for the ore data, plot the artifact data. Be attentive to categories that might help you discern patterns and address your hypothesis about elite control of workshops. You might want to use different data markers for each workshop, or by each period, or by artifact type. Combinations are possible, but attempt to make any patterns you see in the data clear for someone else to see with color, shape, or the like.

Questions

A) Which pair or set of Pb-isotope ratios separated the ore sources the 'best' for you? Explain the rationale for your choice with reference to the 'provenience postulate'[1] What difficulties did you encounter in making this decision? Include your 'best' plot of ore data.

B) What differences exist *between* workshops? Time periods? Artifact types? What changes, if any, do you observe in the way the workshops individually and collectively obtained their raw materials in Period 1 and 2?

C) Consider that trade networks reflect *social networks*. How do the patterns you observe support or refute the hypothesis that elites managed the flow of ore raw materials into Atlantis in Period 2? You want to clearly articulate your logic to support your case by citing examples in the plots you've created.

D) What problems did you encounter in creating your interpretation? Can you suggest other data, artifacts, or information you could collect to further test the hypothesis (e.g., other chemical data, other artifacts, artifacts from other types of contexts within the site)?

[1] Groups defined by quantitative data from artifacts should be characterized by greater variation *between* groups than *within* groups.