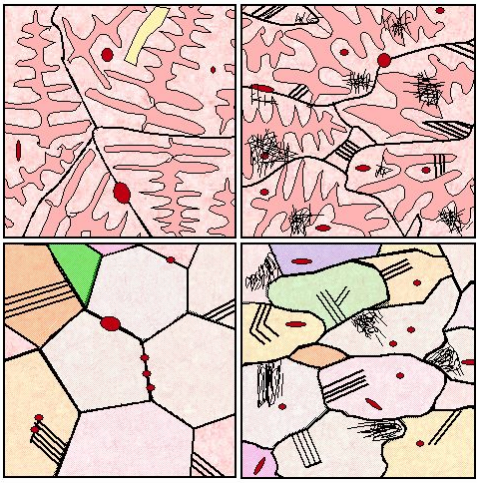
Copper Microstructure Tells It All

Illustration

- Was that copper artifact made from native copper or from smelted copper? Was it hammered into shape or cast? How can I tell?
  - Look at the microstructure - after you got an idea about the basic composition. Polish it, use a proper defect etch, and look at it under a microscope. What you will see is:

    - A nice dendritic structure for *cast copper* that cooled down "naturally". A few precipitates (e.g. Cu_2O) may be visible if your copper isn't 100 % pure.
    - A distorted dendritic structure with lots of twins and "dark" areas full of dislocations if your cast copper was *cold-hammered*.

As cast	As cast and cold hammered
	
Annealed / Recrystallized	**Annelead and cold hammered**

Copper structures schematic

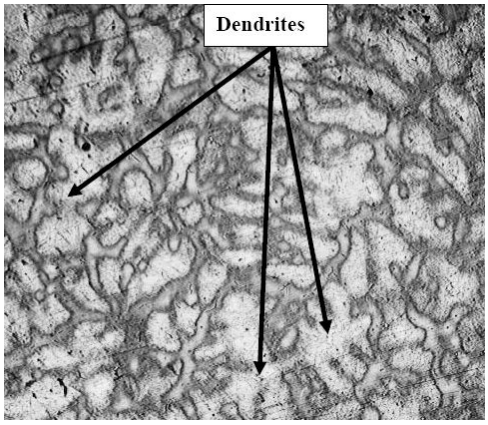
Source: general knowledge and the paper: Tobias L. Kienlin: "Aspects of the Development of Casting and Forging Techniques from the Copper Age to the Early Bronze Age of Eastern Central Europe and the Carpathian Basin" Montanhistorische Zeitschrift Der ANSCHNITT. Beiheft 24; Veröffentlichungen aus dem Deutschen Bergbau-Museum Bochum, Nr. 180

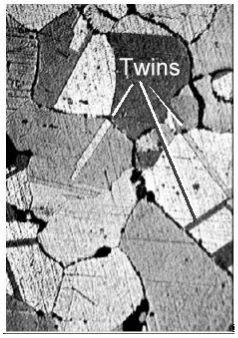
    - Nice big grains with relatively straight boundaries, a few twins and precipitates on boundaries for fully *annealed and thus recrystallized* copper.
    - Wobbly grains with many twins and "dark" areas full of dislocations for *annealed and then cold-deformed* copper.

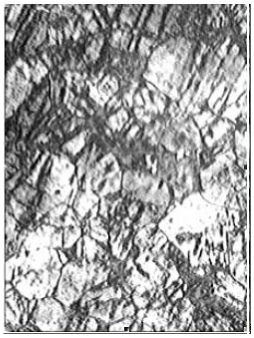
  Refer to David **Scott's** book for details about what to expect and how to recognize what you see. Or just look at this paper.

- Here are some examples:

Cast







Annealed	Cold hammered

Observed copper structures

Source: L. Ercanli: "The examination fo metal working technology in Kültepe", PhD thesis, Middle East Techn. University

It's not that easy, of course, and their are questions that cannot be answered by just looking at the microstructure. The figure above makes clear, however, that there are significant differences between different "kinds" of copper, and with experience and some specimens with known history for comparison, a scientist can tell.