MINERALOGY AND CULTURAL HERITAGE. G. Chiari Dip. Scienze Mineralogiche e Petrologiche. Via Valperga Caluso 35, I10125 Torino, Italy. giacomo.chiari@unito.it

Cultural Heritage can be defined as "any material testament regarding man and his culture" (A. Guarino, Progetto Finalizzato Beni Culturali of CNR). This implies that all Dante or Shakespeare or Beethoven cannot to be considered "Cultural Heritage". An old edition of the "Divine Comedy" or a Stradivari violin used to play the Fifth are instead Cultural Heritage since the material aspect is fulfilled. These concepts are fully analyzed. The role of the "conservation scientist" engaged in research and/or field work in the various domains of cultural heritage will be discussed. Various methodologies are reviewed, using examples from the author's experience. These include [1]:

1) A study of Neolithic polished axes in "green stone", coming from various parts of Europe proves that the material comes from Piedmont, in the Western Alps. A quick method to determine the omphacite/jadeite ratio in the stone was developed, which measures the d-value of three selected reflections in the powder spectrum. An ad-hoc built triangular compositional chart allows for the determination of the ratio Jd-Om-Ae in the pyroxene to better than ±8%. This can be done in a non-destructive way using the Goblemirrors, a special device which collimates, monochromatizes and causes the incoming beam on a powder diffractometer to be parallel. Using this tool it is possible to obtain powder patterns directly from objects (obviously of polycrystalline nature), even rough and of odd shape, without removing and preparing a sample (examples given).

2) The pro and cons of non-destructive, microdestructive and intrusive analysis will be discussed. A figure of merit is proposed in order to decide if and when to carry out one type of analysis or another.

3) Very simple, routine analysis gave unexpectedly good results on the censure panels of Michelangelo Last Judgement in the Sistine Chapel. The XRPD analysis of the pigments and of the tempera preparation divided the interventions into three well defined groups, two of which, dating from 1560-70, where kept as a testimony of historic events, while the later ones (from around 1750), where legitimately removed. The sky of the Last Judgement showed problems solved by mineralogical considerations on Lapis Lazuli, coupled with mural painting experience.

4) Egyptian Blue was compared with the Hun Blue, produced by the Chinese (the difference being a Ba instead of a Ca atom in the silicate framework). These were studied by Laser induced Photoluminescence (PL), an uncommon tool for the mineralogist, which proved to be useful in distinguishing subtle differences among various minerals of interest. For example we discerned an Afghan from a Chilean Lapis, or from artificial Ultramarine blue, etc.

5) The case of Maya Blue, made in Mexico around VII-VIII century AD, is more complex. It is a complex mixture of a clay (palygorskite or sometimes sepiolite) with an organic dye (indigo or añil as they call it in Mexico), whose molecule perfectly fits the channels in the clay structure. In order to elucidate the structure of the pigment we first made a good model of the complex, since the organic molecule occupies 3 clay cells. This model was refined using minimum energy calculations. Good synchrotron data were needed since there are two forms of palygorskite, (monoclinic and orthorhombic), almost superposed. The structure refinement by Rietveld methods showed evidence of the position of indigo in the structure. Solid state NMR may prove the presence of strong H-bonds on the –C=O of añil. Maya Blue was synthesized from a Mexican clay and Indigofera Suffructicosa leaves, according to the recipe of C. Reyes Valerio. Furthermore, Maya Blue is highly resistant to acids, solvents and chemical attack, and can easily be cleaned eliminating the organic matter adsorbed on the outside, while the indigo molecule in the channels provides the carbon for ^{14}C accelerator dating of single mural painting. We only measured 3 samples, but the results are promising. This interdisciplinary work shows how productive mixing different techniques can be when dealing with one complicated issue.

6) A new method for dating mural paintings is based on remanent magnetization of painted layers containing hematite (PiRM). The small grains of red pigment orient themselves toward the magnetic field when the painting is done. Upon drying they maintain the information which can be retrieved by oriented sampling. Examples from Pompeii and Teotihuacan will be shown.

7) A new procedure for measuring porosity in building materials, filling percentage in mortars, and in general, carrying out a modal analysis based on color is shown. This includes the correction of color aberrations due to image manipulation, based on a gray scale used as an internal standard. Absolute color measurements can be easily be performed on a PC, without other instrumentation.

References: [1] Chiari G. (2000) *Environmental Mineralogy*, EMU Notes 2, Chap. 10, 351-381.