X-radiography and archaeometalhrgy

X-radiography is a rapid imaging technique which is particularly useful for examining archaeological metalwork. The process is similar to conventional medical radiography and the two-dimensional negative image is usually produced on photosensitive film. Although X-radiography cannot identify the nature of the metals and other materials under examination, these may often be inferred from the morphology and densities in the image, and can be determined by analytical techniques such as scanning electron microscopy (SEM) based microanalysis and X-ray fluorescence (XRF) analysis (see Datasheet 12).

Applications

X-radiography is normally employed at the initial stages of study, prior to assessment and conservation, and additional exposures are sometimes made during the analysis and conservation stages. The primary uses are:

the assessment of materials for further analysis
to provide provisional object identifications
to clarify form, construction, and surface features such as inlays and tool marks
to facilitate conservation, description and illustration of artif acts · to detect the presence of more than one material
stereo-radiography of items with complex internal structures, such as locks and pattern-welded blades
the investigation of metal structure, for example weld lines in edged blades and pattern-welding
the detection of technological debris such as slag and hammerscale, in soil samples or in association with artefacts (see Datasheet 10)
the identification of crucibles in which metallic components have been incorporated into the fabric to assist metallographic examination of ferrous artifacts by enabling selection of the most appropriate sampling positions according to areas of interest and condition
the examination of soil blocks and containers such as ceramic vessels which potentially contain complex artefact groups.

What affects the image

X-rays are a form of electro-magnetic radiation, similar to light, but of shorter wavelength. The choice of intensity and energy of the X-ray beam enables the examination of a wide range of materials. The image produced depends on the degree to which the X-rays are able to penetrate materials, which is a function of the thickness, density and the chemical nature of the individual components under examination. Other factors affect the image, such as the duration of exposure and the type of film employed.

Quartz and most soil components, and bone and other organic materials are relatively transparent to X-rays. Conversely, metals are comparatively radio-opaque due to their density and high atomic numbers. Lead in particular is difficult to penetrate, but iron responds well, as also do copper alloys providing that they are not thick castings made from heavily leaded alloys. Corroded objects (with porous corrosion products and accretions) are more transparent to X-rays than thick and dense objects, the latter requiring exposures of longer duration or higher intensity or energy to achieve informative images.

Interpreting images.

The two-dimensional image will show all features superimposed which can result in ambiguities, for example between components of complex objects, through the effects of the matrix or corrosion, or because of the angle of exposure. It is therefore preferable to examine objects and images together. Seldom does a single image reveal all of the information potentially available. Interpretations can be enhanced by altering the orientation of the artefact in the X-ray beam, or by

varying the exposure according to the information sought.

Dimensional distortions need to be taken into account if images are to be used for measuring or illustrating artifacts. For example, a thin object which can be exposed in close contact with the X-ray plate will produce an image which approximates to its real size. Thick objects, or those distanced from the X-ray plate by accretions or a soil block, will appear larger and less sharp in the image. Conversely, severely corroded edges may be transparent to X-rays and objects may therefore appear smaller.

Radiographs should ideally be viewed in a darkened room against a light-box, with extraneous light masked off. The full scope of the information available in the X-ray image cannot be revealed by simply holding a plate towards the nearest available window or lamp since the eye is unable to adapt sufficiently to the contrasts in light.

X-ray facilities

The X-ray units employed for archaeological applications are either small cabinet units, or larger industrial or hospital type units which are capable of producing higher energy and more penetrating X-rays. Cabinet units, which are commonly employed in conservation laboratories, have the advantage of integral protective lead shielding and require no additional radiation protection for the operator. They are, however, limited in the intensity and energy of the X-rays produced, as well as having dimensional constraints.

Because X-ray film is sensitive to light, it is contained within,a light-tight cassette or envelope during exposure and is later developed in a darkroom. Details of the equipment, methods and processing are available in standard manuals on radiography *(eg* Agfa-Gevaert 1978; Kodak 1980).

Other radiographic techniques

There are other radiographic techniques which have been successfully applied to archaeological materials for specific investigations although some of these techniques require specialised facilities which are not always readily available. These techniques include image enhancement, tomography, real-time imaging, xeroradiography, micro-focus radiography, and also gamma- and neutron-radiography.

Caution

Radiography can upset certain dating techniques such as thermoluminescence and may therefore be an inappropriate technique for some ceramic and other materials. Metals are not affected.

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