ARCHAEOLOGICAL GLASS

Glass is found at archaeological excavations in a variety of conditions which can range from pristine, with no deterioration visible, to so heavily degraded that practically all the glass has been transformed into corrosion products. The deterioration of the glass surface is generally known as *weathering* and the deteriorated area as a *weathering crust*.

The corrosion process

The chemical and physical properties of the burial environment and the composition of the glass itself are the main factors that determine the rate of deterioration of glass in the ground.
In general, glass found in dry soils is in better condition than glass found in moist soils. This is because water is the primary cause of deterioration of glass. The exposure of glass to moisture causes alkali ions in the glass network to be slowly leached out and replaced by hydrogen ions from the water. This leached layer is referred to by several different terms: alkali-deficient layer, silica-rich layer, or hydrogen glass.

The deterioration of weathered glass can have an extensive variation of appearances. The visual effects of degradation most commonly found on excavated glass are *dulling, iridescence, opaque weathering, a total loss of glassy nature, pitting, cracking of the surface, and discoloration.*

Dulling refers to a loss of original clarity and transparency that is quite distinct from haziness caused by scratches or stains. It is closely related to *iridescence*, which is a rainbow-like effect on the surface of the glass similar to a thin layer of oil on a water surface. Both are caused by changes in the composition of the surface of the glass altering the refractive index. The weathering crust is made up of many thin layers leading to the iridescence, which is caused by "the interference between rays of light reflected from thin alternating layers of air and weathered glass crusts."
Opaque weathering also has a laminar structure, but has a much larger number of layers. "The layers may be adhering to one another and may penetrate the entire surface or they may be laminating and superficial." This type of weathering is characterized by opaque areas, usually white, on the surface gradually eating deeper into the glass, and is generally referred to as *opalescent weathering.* At more advanced stages the color can be black or brown or even a mottled polychrome. The incipient stage is sometimes referred to as *milky weathering* because of the small spots or streaks of white. At the most extreme stage it is termed *enamel-like weathering* and is present as a thick covering varying in color.
Glass which has had a *total loss of glassy nature* is so badly deteriorated that it may exists only as "a chalky mass of silica gel" and has a sugary appearance which is sometimes difficult to identify as glass.

Pitting can occur when the corrosion "eats" its way into the glass from a starting point either on or just below the surface, sometimes creating concentric circles around the starting point. When the weathering is lost, a hole or pit is left in the surface of the otherwise undamaged glass. Pitting often occurs simultaneously at individual sites throughout the surface of a fragment. Weathering from individual starting points can later grow into one another.

Shrinkage of the alkali-deficient layer, due to temperature and humidity changes, can cause *cracking* of the surface and within the weathering crust itself. Often the cracking does not become visible until some time after the glass has been excavated. This is especially true for glasses buried in wet soils.

Discoloration of the glass can be found in combination with any of the above mentioned types of weathering and is caused by the migration or alteration of coloring ions and other trace elements. The ions can be leached out of the glass network or be taken up by glass from the environment. Iron and manganese cause the weathering crusts to blacken and contact with copper corrosion products can cause green staining. Certain ions, most notably manganese and copper, may change color through oxidation.

Combinations of several of these manifestations of glass deterioration are usually found on a single object. The extent of the degradation can also differ from one area on an object to another.

The thickness of the weathering crust can vary greatly, depending on the chemical stability of the glass and the aggressiveness of the burial conditions. In extreme cases corrosion products may have completely replaced the original glass. Underneath the weathering crust the so-called *glass core* retains the original composition and color of the glass.

Importance of preserving the weathered surface

The surface of weathered glass is an integral part of an object because it often retains the shape of the original surface even if the composition has changed. Details such as incised decoration, and marks relating to the production or usage of the object can only be preserved if the weathering crust remains intact. These types of details contain information that is quite valuable for the technical, art historical, and historical interpretations of the object.
Preservation of surface details is not the only reason to ensure that the weathering remains whole. The removal of weathering often reveals a very irregular and often pitted surface because air bubbles and debris trapped in the glass during production are exposed as a result of the degradation. The exposure of such a surface can result in misinterpretation of the original appearance of the object and is aesthetically unattractive.

Finally, there is the aesthetic appeal of the weathering itself, especially iridescence, which has become so associated with archaeological glass and is much valued for its beauty.