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Mini Review

Corrosion Surfaces Associated with Patina on Glass

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Abstract

There is a variety of corrosion surfaces and corrosion interfaces on glass associated with the development of patina. This has been determined by examination of patina/glass contacts in 'mature', older patina, some 100 years old and 20 years old, in Australian settings, and in experimentally-produced patina in the laboratory. The form of these corrosion surfaces and corrosion interfaces largely determines, in the next stage of patina accretion, the form of accretionary patina as it invades glass. The types of corrosion surfaces and corrosion interfaces recognized are: large irregular, shallow concave depressional, scalloped or cuspate, lobate/semi-lobate solutional invasion fronts, meso-etched, micro-etched, plain, fungal micro-bore architecture (invaginated), cuspate structure, and brecciated. The various types of corrosion surfaces and corrosion interfaces appear to reflect the heterogeneity of glass chemistry and extent of fungal bio mediation. The geometry of the corrosion surfaces determines the geometry of accretionary patina.

Introduction

Most of the research on patina has focused on the weathering of glass that results in an ultra-thin crust that exhibits a multitude of structures, micro-structures, and micro-lithologies that record its (geological) paragenesis and diagenesis [1-3], (Figure 1A). For instance, Scanning Electron Microscopy (SEM) of patina from Australia shows it to be laminated, complexly laminated, colloform, to micro-brecciated, to mottled and clotted, with micro-unconformities, and micro-lithologies of laminated silica, or inter-laminated silica and calcite; there are also desiccation cracks, vughs, and exogenic infiltrations of dust [4-6]. This diversity of structures, micro-structures, and micro-lithologies arrayed as lenses, sheets and as intra-patina masses (termed 'patinelles') illustrate complex patina history that Clifford & Semeniuk [4] suggest can be used to determine the paragenesis of patina. However, an under-estimated feature of patina on glass is the investigation of the corrosion surfaces and corrosion interfaces under patina crusts or within patina that form the template for patina accretion. This paper explores these corrosion surfaces and corrosion interfaces.

Classification of Corrosion Surfaces and Corrosion Interfaces

Corrosion surfaces and corrosion interfaces in our study samples can be grouped as: 1. relatively large-scale geometric forms (~ 100-300 µm in lateral size), 2. smaller-scale features (some ~ 5-20 µm in lateral size), and 3. smaller-scale features embedded in larger-scale geometric forms (Figures 1 & 2). Note that the adjectival descriptors 'large', 'meso', and 'micro' are relative terms specific for this paper and do not refer to the geological definitions of scale of Turner & Weiss [7] and Hobbs et al. [8].

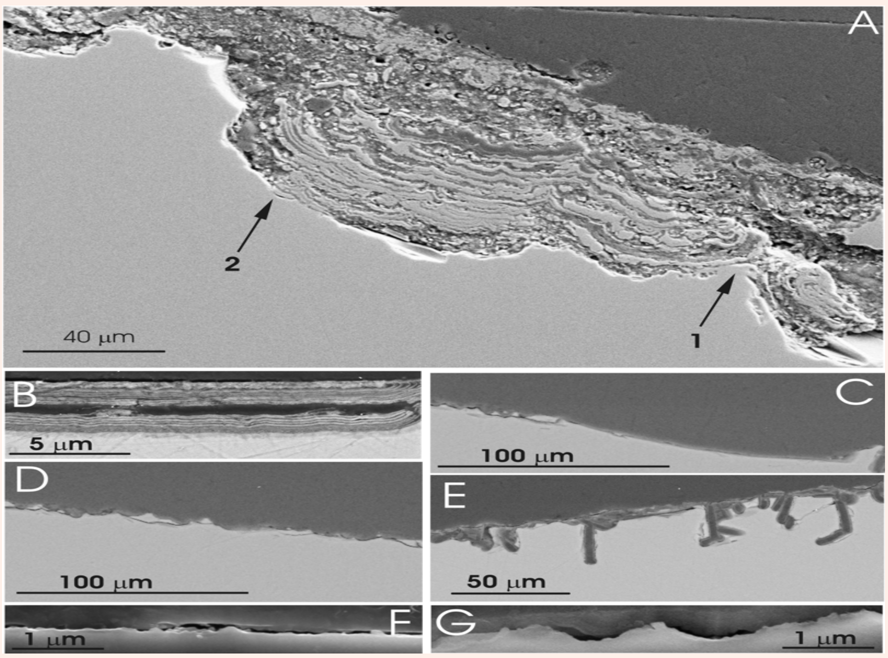

Figure 1: SEM images of corrosion surfaces and their adjoining patina. A. large irregular corrosion surface with overlying laminated and brecciated patina; (1) is a cuspate remnant protrusion, (2) is incipient brecciation; B. laminated patina on a plain corrosion surface; C. shallow concave depression surface; D. micro-etched surface; E. invaginated surface (fungal micro-borings); F. micro-etched surface; G. scalloped surface.

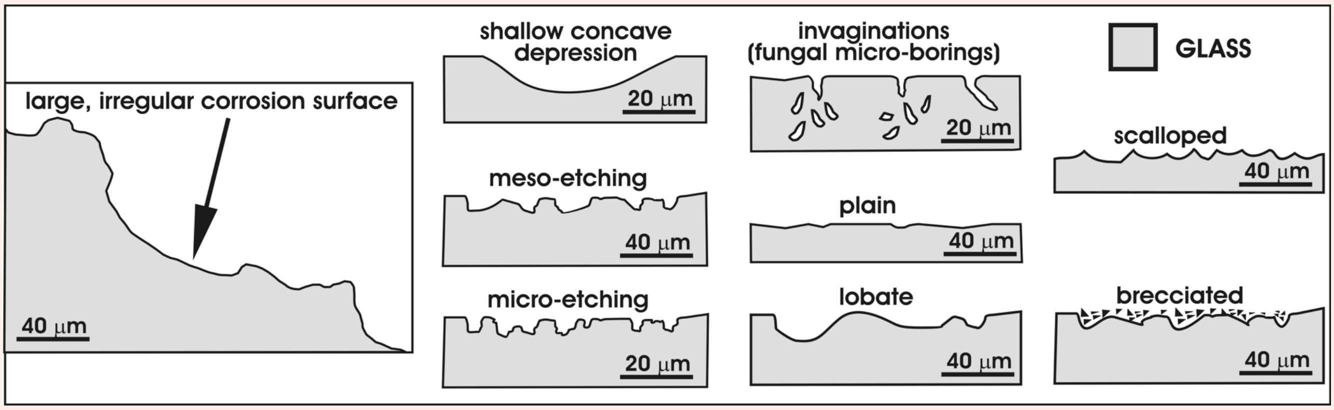

Figure 2: Line drawings of the range of corrosions surfaces showing: large, irregular corrosion surface; shallow concave depression; meso-etched; micro-etched; invaginated (fungal micro-bored); plain; lobate; scalloped, and brecciated surfaces.

Fine-scale corrosion surfaces and corrosion interfaces are classed as follows (Figures 1 & 2): 1. large irregular corrosion surface, 2. shallow concave depressional, 3. scalloped, or cuspate, 4. lobate/semi-lobate solutional front, 5. meso-etched, 6. micro-etched, 7. plain, 8. fungal micro-borings (invaginated), 9. cuspate structure, and 10. brecciated. A selection of these as SEM images is illustrated in Figure 1; features of these forms are briefly described in Table 1.

Table 1: Description of features of fine-scale corrosion surfaces and interfaces.

Forms	Description of Features
large irregular corrosion surface	a large corrosion feature over 100 µm in size with an irregular floor
shallow concave depressional	a smooth, concave depression on the surface of the glass
scalloped	a series of small- to medium-sized scallops
lobate/semi-lobate solutional invasion fronts	smooth, u-shaped solutional features
meso-etched	a series of small- to medium-sized corrosion features > 20 µm in size on the surface of the glass
micro-etched	a series of small corrosion features ~ 5-20 µm in size on the surface of the glass
plain	a relatively straight corrosion surface
fungal micro-boring architecture (invaginations)	micro-boring tubes penetrating vertically into the glass or oriented horizontally along the interface with the glass
scalloped or cuspate structure	small- to medium-sized cusps or peaks at the surface/corrosion interface.
brecciated	comprised of small detached pieces of glass along the glass/patina interface

Discussion and Conclusion

Glass can be chemically heterogeneous, and this heterogeneity can be the cause of differential solution of glass [4]. Further, fungal micro-borings also can result in a patchy response of glass to weathering [4]. What is clear is that glass behaves heterogeneously to weathering and this can result in a diversity of corrosion forms. Since patination accretes downwards into glass, the geometric form of corrosion surfaces (and corrosion interfaces) can have influence on developing the initial geometric form of accreting patina (viz., for laminated patina, for instance, scalloped surfaces, or micro-cuspate forms, or lobate forms, or plain form can initiate and control the geometry and accretionary shape of patina laminae). The variety of corrosion surfaces and corrosion interfaces documented herein will have a profound underlying influence on internal patina geometry.

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