THE AIR–WATER INTERFACE, SURFACE FILMS AND HABITAT: METALLIC SURFACE FILMS CONTAIN CLUES TO PAST AND PRESENT WATER ENVIRONMENTS AND BIOFILM STRUCTURE.

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Introduction: Evidence for aquatic environments, life and the air-water interace as an active habitat can be found with the formation of organic and metallic surface films. Forming at the air-water interface, mineralized transition elements may be a clue to biosignatures, nutrient metabolism or structural evidence of life on other planets [1][2]. Structural analysis at the interface helps to better define both habitat and habitability and expands our knowledge of both biota and properties of the air-water interface as a potential habitat for living forms and indoing so helps to define habitability.

Methods: Emerging methods and techniques for the examination of metallic surface films (MSF), particularly by scanning electron microscopy (SEM) with analysis by energy dispersive spectroscopy (EDS), and by dual–beam focused ion beam technology (FIB) with secondary ion mass spectrometry (SIMS), shows that metallic surface films can be used as biomarkers and biosignatures for past water and ancient life forms. A prototype, modified FEI™ FIB with SIMS was used to examine metallic surface film samples. Natural films from wetland environments were collected on 12 mm aluminum SEM stubs for examination by both SEM and dual–beam FIB. FIB milling technology with a gallium ion beam was used to mill away thin areas of the metallic film to expose internal structure and mineralization. The SEM was used to document how bacteria, cyanobacteria and algae interact with the surface films to form impressions, pits or casts of the bacterial form. Corrected electron optics for photoemission electron microscopy (CPEM) was also used to examine bacterial colonization of metallic surface film habitat and surface morphology of the bacteria and cyanobacteria. Instrument development is discussed.

Microbial Footprints: Living microbes demonstrate integration into metallic surface films in the form of impressions or casts of living forms, whichwe call the 'Bacterial Footprint'. Fossil impressions of these structures and forms are likely to occur, and are comparable to bacterial or cyanobacterial forms attributed to Martian meteorites [2]. This is a different aspect of possible fossilization and geological record. From the ALH84001 meteorite to the Yamato 000593 [2], several pieces of microscopical evidence of early aquatic environments, water and organisms, suggest that imaging 'footprints' are key features in defining active habitat and examining metallic–rich environments in our definition of habitability. This research not only demonstrates possible pathways for bacterial casts to occur, but also expands our knowledge of metallic–rich or metallic–oxide environments of mixed–valent transition metals as substrate, habitat or nutrient source over a range of trophic metabolites.

The Air–Water Interface: For any planet with water, surface tension allows for the accumulation fo not only organic molecules as aquatic surface films (ASF), but also as metallic surface films, sometimes referred to as iron–oxide surface films or floating iron films. These are silvery, sometimes iridescent, thin mineralized surface film containing manganese, iron, zinc and other transition metal components [3]. What is clear is that metallic surface films are much more than floating iron oxides. Ferromanganese structures were found, as were nickel/zinc biofilms and copper/zinc metallic surface films [3][4]. Metallic surface films represent air–water interfacial properties of an aquatic boundary layer, thus including water conditions, biotic conditions, and structural forms of mineralization [5]. Structural analysis reveals that several mineral structures should be included in order to locate previous or present microbial casts as an interactive part of surface film formation and use as habitat. The structural analysis of metallic surface films suggest a broader characterization of habitability to include properties of the atmospheric–water boundary layer and boundary layer conditions and properties.

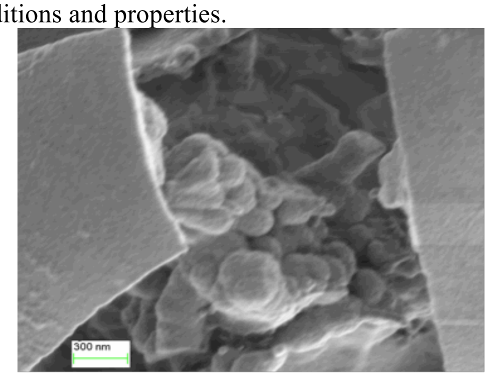

Fig. 1. Mineralizing layer at 91kx.

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