# Environmental SEMs: A New Way to Look at Samples

Don Chernoff, Small World

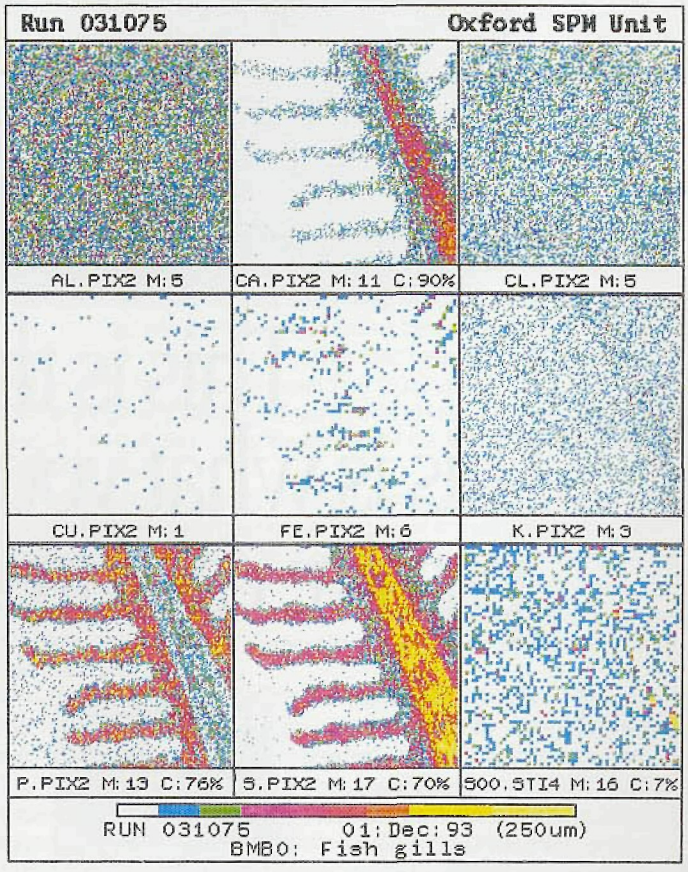
A new class of SEM has evolved over the past few years which provides some startling capabilities never before available to electron microscopists. These instruments, typically referred to as environmental SEMs or variable pressure SEMs, have opened up a host of new applications that are difficult or impossible with a standard SEM. Many of the constraints of sample preparation and handling that exist with a conventional SEM do not apply to environmental SEMs.

An environmental SEM functions like a conventional SEM except that you can introduce air or any other gas into the chamber and raise the chamber pressure above the normal high vacuum range of $10^{-5}$ or $10^{-6}$ Torr. In most instruments the vacuum can be raised to as much as 1 Torr. This represents a 6 order of magnitude increase in chamber pressure. Environmental SEMs can achieve this high chamber pressure without damage to the electron source by using differential pumping apertures in the column. This technique limits the amount of gas which can get into the column. A more robust vacuum system removes any gas molecules which make it past the differential aperture before they can reach and damage the electron source. A pressure control system allows the user to precisely vary the chamber pressure. Because the chamber is no longer at high vacuum, the environmental SEM cannot use the secondary electron detector but must image the sample using a backscatter detector.

The benefits of running samples at high pressure (low vacuum) are many. For non-conducting or poorly grounded samples, introducing a small amount of air into the chamber serves to neutralize surface charge and allows imaging of samples which would otherwise have to be coated. But the capabilities of running at low vacuum go far beyond sample charging. Biological samples are generally very difficult to image in a SEM. They typically have to be carefully dried to avoid being distorted under vacuum of the SEM. By running biological samples at relatively low vacuum the samples can be imaged in their natural state with little or no preparation. Another class of samples which could not be looked at before are wet samples. Samples like clays or green ceramics, which would be interesting to study in their hydrated state, can now be viewed without the need to dry them out and destroy the features of interest. Minerals can be studied straight out of an oil well. Failure analysis can be conducted on samples without cleaning - which may remove what you are looking for.

Some materials are difficult to image even with a conductive coating. Certain ceramics and polymers, especially fibers and complex shapes, can be difficult to coat uniformly. The result is that the sample charges no matter how heavily it is coated with gold or any conductive coating. By running these samples at elevated pressures the charge build up on the sample can be neutralized. Other classes of samples may not allow any kind of sample preparation. Archeological or artistic pieces fall into this category. Forensic samples which serve as evidence in legal proceedings may not allow for sample preparation for fear of altering evidence (sound familiar?).

Environmental SEM's offer a new way to look at an almost limitless number of samples. As these instruments become more common and get into the hands of experienced microscopists, a myriad of applications will be discovered which could not have been imagined just a few years ago. ■




The above is an interesting elemental map of brown trout *(Salmo Trutta)* gill filament exposed to a very small level of copper (30 µg $l^{-1}$) at 5° C water temperature using proton induced x-ray emission (PIXE) to localize copper inside the tissue. The sample was embedded in wax and sectioned at 10 µm using a Richert-Jung 1150 Autocut microtome. It was then mounted on an aluminum carrier for analysis by the Scanning Proton Microscope at the Nuclear Physics Laboratory in Oxford University. The color bar shows the concentration of elements from low (blue) to high (yellow). The scan size is 250 µm.

This work, under the supervision of Professors E.W. Taylor and P.J. Butler, is part of my (yet unpublished) thesis.

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