Scanning Electron Microscope: Transmigration of Scientific Photography into the Domain of Art

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Abstract

The author's visual art project is concentrated in the specific area of scientific photography of the Scanning Electron Microscope (SEM), which has expanded the boundaries of observation and representation of the micro world since it was introduced to scientific research in the mid-1960s. Like a number of other artists who have preceded the author, she investigates how to interpret scientific images captured by the SEM as aesthetic forms. In particular, the author considers microscale drops of water from different aquatic systems after evaporation. She does so in an attempt to discover morphological features of the patterns related to water contamination and thus continue in the lineage of artists' attempts to turn scientific photography into a creative art form.

The main purpose of my doctoral visual art project is to uncover the inherent features of water that are invisible to the eye through using the Scanning Electron Microscope (SEM) and, by doing so, to use the process of evaporation as an alternative and unusual artistic method of visually presenting the composition of water. My approach is unique in the specific way in which I use water to create images using the SEM. This process of revealing the nature of water (water chemistry) allows me to play with it like an artist. I am not aiming to produce scientific records through my use of the SEM; instead, like several artists before me, I am using scientific photography methods to create aesthetic images.

For example, artist Claudia Fährenkemper also works with the SEM as well as digital and analogue photography. Her artistic vision seems close to Max Ernst's surrealist sense of the microcosm in a world of unimagined shapes and forms.

In her black-and-white series of photographs *Planktos,* created in 2005–2006, she was inspired by Ernst Haeckel's illustrations of marine life in his book *Kunstformen der Natur,* which was released in 1904. In contrast to the Art Nouveau style used in Haeckel's natural forms, Fährenkemper focuses on clarity in this series on plankton. She reduces the severity of the presentation of selected kinds of plankton and tries to find patterns in the diversity of life through the use of the SEM [1].

According to Martin Kemp, eminent art history professor at the University of Oxford, the processes of science and art share many aspects: observation, speculation, visualization, exploration of analogy and metaphor, experimental testing and representation of this experience in particular styles. The visual frequently has a central role in these shared features [2]. The scientific approach of studying water through photomicrography appeals to me due to the amount of useful knowledge that can be gained through this process.

Scientific photography aims to record and illustrate data and experiments that differ according to specific disciplines. Although scientific photography can be considered non-aesthetic, since its main purpose is to convey not beauty but rather accurate information, its ability to record material in addition to that which is merely informative allows it to also serve expressive, subjective and aesthetic purposes.

In my project, I use scientific photography to achieve an objective (scientific) resemblance of individual water drops to their subject, but the resulting images are highly selective in what they show and how. I try to create "expressive portraits" of water drops.

My artistic intervention into a scientific process through experimenting with the SEM is a way to find what potentially different things my images can say about water to a viewer. Transforming the microworld to a macro level, I play with the meaning of presented images. I also make the captions for my photographs intriguing, as they can resemble aerial photographs of topographic features of water reservoirs (Fig. 1).

My images evoke an irony in that pollution is shown as being beautiful. This causes a dilemma for viewers, particularly because the gallery space is different from a laboratory.

SEM Photography

Scientific photomicrographs aim to provide scientific evidence of data as accurately as possible. The quality of scientific representations depends largely on reducing any stain and artifacts. However, the results obtained through the SEM can be disorienting, because the process of producing a picture is camera-less. Additionally, there is no light or light-sensitive surface involved. The apparatus tries to recreate a reality that is not visible to the naked eye, which scientists analyze from the images that are captured through the SEM technology.

SEM work is based on the very precise scanning of objects' surfaces using an electron beam that provides a deep focus effect. The brightness of the surface brings to the pictures the effect of plasticity and three-dimensionality. Adjustments can be made by rotating and tilting the sample plate for details. Despite the fact that light seems to come from a particular illuminant, the contrast actually depends on the tilt of the plate, with a sample positioned to the electron beam that hits it. Structures that look bright are protruding, while dark parts are lying deeper. Additionally, colors cannot be reproduced.

Exploring the Medium

Interestingly, scientific microphotographs often record too much information, such as dust or scratches, and, as Peter Galison points out, scientists discuss whether to remove this unnecessary information or to accept it [3]. Moreover, the same sample can look completely different across two pictures of it. The way the pictures look depends on the interaction between various methods of sample preparation, the way the

Fig. 1. ***Brown Lake. North Stradbroke Island*, photomicrograph, 2015. (© Anastasia Tyurina. Photo: Anastasia Tyurina.)**

microscope is used, image-capturing settings, etc. Dee Breger explores "compound reality" in the nature of SEM photomicrographs in her book *Journeys in Microspace: The Art of the Scanning Electron Microscope*. She states that not only will two different microscopists produce different micrographs using the same instrument and sample, but results by the same microscopist will also differ [4].

One of the ways to manipulate the image while operating SEM is sample preparation. In order to produce a clear image, I coat specimens for the SEM with gold sputter, as it increases their electrical conductivity and ability to reflect electrons. I leave the gold sputter on for different durations that vary from 1 to 10 minutes. Gold covering, in this case, is a direct way to obtain a higher-quality image: The less time the specimen is covered, the more some areas look as if they are overexposed, which is a result of electron attack. It also explains why the edges of objects may look solarized.

Some manipulations are carried out through adjusting the microscope settings and others through the interface of its supporting software. The most illustrative manipulation in this case is changing the electrical stress/tension, which allows me to see the image with different stages of contrast and to make an accent at completely different details, which in turn affects the cognition from picture to picture.

Drying Drops

The droplet evaporation phenomenon has been studied in the last few decades. It was first mathematically described by Robert D. Deegan as a natural model for studying dynamics of self-organizing processes actively used in physical experiments [5].

Numerous studies report the application of the droplet evaporation method as a diagnostic tool for all sorts of scientific purposes. For example, medical researchers Savina, Shabalin and Shatokhina, and Rapis have shown experimentally that microscopic structures in dried drops of biological fluids create different patterns depending on the patient's state of health, which allows for the diagnosis of several disorders [6].

The evaporation of droplets of different suspensions often leads to the formation of complex patterns, such as ring structures, rhythmic patterns, dendrite-like patterns, fractals and hexagons [7].

Considering the results of the research above, it can be argued that factors such as liquid composition and structure, wetting ability, liquid thermal conductivities ratio, substrate roughness and initial level of pH and salinity are related to such characteristics as a drop shape, surface thermocapillary flows, redistribution of the chemicals in accordance with their surface and diffusive properties, total evaporation intensity and diffusion capacity. Thus, if the environmental conditions, drop volume and substrate are standardized, all the processes in the drying drops can be defined solely by liquid composition and structure [8].

Dynamic sediment-forming processes in desiccated drops detected and traced by acoustical measurement also can be considered as a factor for a liquid's characteristics and quantitative comparison [9].

Watermarks

The composition of water, even that which is completely free from mineral and organic impurities, is complex and diverse, because water is constantly in contact with all sorts of substances. The variety and frequency of unusual properties of water are determined by the physical nature of its atoms and their association in the molecule and the group-formed molecules.

During experiments for my project, the structure of the water impurities visually transforms and leads to a unique connection between evaporation and solidification. This natural process of drying reveals the unique informative capacity of droplets as well as the shapes, patterns, details and characteristics of water. The SEM technique uses secondary electrons to detect specimen features, whereas the microscopic investigation used in the research mentioned above uses a Levenhuk C-series microscope digital camera, which is an optical tool.

Desiccated drops of water that were attacked by secondary electrons look different from one another in the same environmental conditions. In other words, the structure of water visually represented by the SEM can be seen as an alternative and unusual method of visually presenting the composition of water.

Nature produces morphologies down to the smallest detail. The Swiss science photographer Martin Oeggerli, who operates under the name Micronaut, believes that collecting, analyzing and combining the details and richness of shapes help us to understand life and existence. Oeggerli's works are all handmade with impeccable details [10]. His work has inspired me to ensure that the highest quality of my digital prints is a primary focus. I believe that the very detailed images of desiccated drops of water generated by the SEM are worth interpreting through artistic methods. In the process, they successfully transmigrate into the domain of fine art and uncover new aesthetics and perceptual possibilities.

References and Notes

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