Arts and Science Collaborations for Mineralogy and Cultural Heritage:
The Social Aspects of Mineralogical Visualisation and Representation as Knowledge Creation Connecting Physical and Virtual Worlds

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Introduction

New authoring technologies and presentation media are giving us novel ways of experiencing representations of familiar objects in the physical world. Similar technologies have also extended the long history of scientific visualisation of dynamics, particles and other material not visible to the human eye. These technologies have also provided visual information for the interpretation of conditions at great distances and time in space.

The ambiguity of the visual is explored through a discussion of the use of old and new technologies for the visualisation of rock and mineral samples. Examples of mineralogical visualisation within pioneering European collections of minerals from the early years of the Industrial Revolution and colonialism, such as the Rashleigh Collection of Minerals from the Royal Cornwall Museum, Truro, UK, are compared with current 21st century visualisation that uses digital imaging and 3D stereo display systems.

This contrast of technologies used for mineralogical visualisation, spanning over two centuries, shows how the process of visualisation of minerals and rocks is also a history of wider shifts in scientific knowledge; as the history of ideas and as pragmatic solutions.

3D mineralogical images created within a scientific context for the mining and resources industries can be integrated into an arts and cultural heritage context for a broad-based audience. This study, therefore, informs wider considerations of collaborative knowledge production across the arts and sciences.

Mineral identification

Early naturalists relied upon simple observations of colour, habit, streak and other physical properties to classify and often name a mineral. The mineralogist, Philip Rashleigh (1729-1811), amassed a highly regarded collection of minerals from the 1760s until his death in 1811, and also recorded those specimens through print editions derived from water colour drawings. His *Specimens of British Minerals* was published in 1797, which was the first work in Britain to provide accurate illustrations of mineral specimens in their natural colours.[1]

These observed physical properties were the result of a mineral's chemistry or structure, but it was not until much later that classical mineralogists made this connection and expanded upon these simple observations to include a mineral's reaction to chemical reagents, the specimen's apparent chemical make-up (as evidenced by blowpipe and similar analyses) and the mineral's optical properties.[2] During the last century, microscopes and spectroscopes were the means of investigating the internal structure of rocks and minerals. Crystallography then developed as the means of visualising this information, first through geometry and then with the help of X-ray diffraction.

Imaging the mineral specimen

Scientific and technological advances provide us with the means for the multi-scale imaging of the external shape and texture, and internal structure of rocks and minerals.[3] The data generated through all the means available now allows us to visualise rocks at the planetary, continent, regional, kilometre, metre, millimetre, micron, nano and atomic scales. This is achieved, across all these scales, via techniques such as remote-sensing (laser ranging and photogrammetry); computed tomography (CT), microCT and nanoCT scanning and atomic force microscopy.

The movie and manufacturing industries have also prompted the development of other technologies that are of use in the imaging of rocks and minerals, namely hand-held laser scanning and rapid prototyping ("3D printers").

Through these techniques we are now able to photograph and scan (laser and CT) rock and mineral specimens and generate realistic models of their external shape and colour, and internal structure. That is, a realistic replica both as a virtual computer model (3D visualisation) and as a physical model (tactile visualisation).

While photogrammetry is as old as modern photography itself, and can be dated to the mid-nineteenth century, the majority of the technologies that are used to image rocks and minerals are less than a hundred years old. The CT (computed tomography) scanner has its origins in 1930s tomography and its computer-aided form was conceived in 1967, with first commercially viable CT scanner being publicly announced in 1972, and the micro and nano scale versions being very recent additions. Laser ranging was first carried out in the mid-1960s[4] and the first airborne LiDAR measurements were carried out in 1967.[5] The first atomic force microscope (AFM) was invented in 1986.

Creating the virtual mineral

With the available imaging technologies it is now possible to create computer and physical models representing exposed rock faces, down to individual rock and mineral specimens, and ultimately crystal structure and atomic levels. For example, through the use of a CT scanner it is possible to derive 2D grey-scale 'slices' through a rock specimen and from these to generate a 3D visualisation and model of the internal structure and distribution of minerals and rock grains. This CT data can then be used in conjunction with a 3D laser scanner to produce a full 3D representation of the outer shape and colouration of the specimen, effectively creating an exact copy of the original specimen (Figure 1).

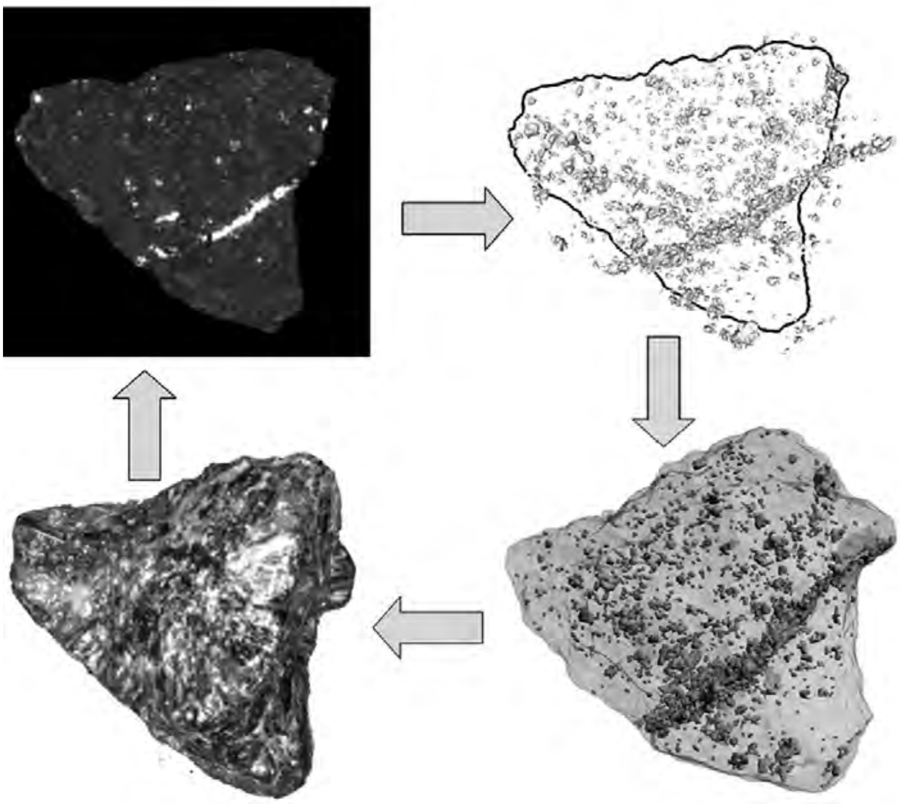

Figure1: A mineral specimen goes full circle via 2D slices to complete 3D model

Exploring the *Virtual Pit*

The collaboration of art and science for mineralogy and cultural heritage purposes will be realised in the *Virtual Pit*, wherein the concept is to travel in scale from the whole mining pit to a section of the pit (rock) wall and individual rocks, then down to mineral grains, crystal lattice and atoms. The *Virtual Pit* will move beyond experiments that use virtual environments and interactive displays to create a virtual museum for minerals and molecules.[6] The *Virtual Pit* will also seek to integrate a "journey" where sensations of space, scale, excavation, displacement and removal can be explored with narratives of from people whose exploration and labour formed the pit, or whose lives were shaped and affected by its formation, transformation and growth. In this context, changing methods of visualising and representing scientific knowledge is one of many strands of historical narrative.

One challenge is that, although the techniques described above are available, there is no data or visualisation cues to seamlessly transition from one scale to the other. Artistic techniques will, therefore, need to be employed to deliver a meaningful and enjoyable observer experience.

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