5 Light Microscopic Techniques in Quantitative Soil Mineralogy

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Optical methods are among the oldest of techniques to analyze and characterize the objects and phenomena around us. The light microscope is simply an extension of the human eye. It allows for greater resolution of smaller sized particles. Russ (1990, p. 14) has stated that "the light microscope has been perhaps the most important scientific instrument of all time in both biological and materials research, again emphasizing the reliance that we place upon images to learn about the things that interest us." We would only add soils and minerals to the above list of research topics. With suitable accessories, the light microscope permits the measurement of unique optical properties of minerals that reflect their chemical composition and crystal structure. It also permits observation of secondary features, such as grain size, shape, spatial relationships to other minerals or pedological features, and alterations due to weathering. Optical microscopy is one of the few techniques that can examine each mineral separately rather than as a homogeneous composite. One of its benefits is that in thin sections, the constituents are assumed to be in their natural setting, undisturbed by either sampling or preparation procedures. Optical techniques are also applicable to nonmineral constituents in soils (e.g., organic matter), noncrystalline or poorly crystalline components (e.g., some of the Fe oxides and amorphous silica), and voids. Because the light microscope has unique functions, its use is appropriate for solving pedological problems where its power can be fully utilized.

In today's environment, pedologists need to be more quantitative concerning mineralogical composition, pore size and distribution, and the spatial distribution of soil constituents and pedological features. Quantitative statements are needed (i) for appropriate taxonomic classifications of soils, (ii) to document the effects of tillage and land management, and (iii) to help understand fluid-flow dynamics for hazardous wastes which could endanger water quality. Although descriptive micromorphology is important, quantitative statements are more convincing and acceptable than their qualitative analogs for solving many soil-related problems.

Quantitative mineralogy has been given several names. Modal analysis is probably the more common term used and applies to mineral composition (Chayes, 1956) as well as to pedological features (Anderson & Binnie, 1961; Milfred et al., 1967). Modal analysis is a term used in the geological sciences, from which pedologists have obtained most of their microscopic techniques and terminology. The term "quantitative microscopy" is applied to many disciplines and is also concerned with size, shape, and spatial distribution of constituents. Image analysis is the measurement of geometric features that are exposed on two-dimensional images. This is a broad term that refers to the extraction of visual information from spatial data, and ranges from the analysis of satellite images to high-resolution TEM micrographs. Currently the term is most often applied to computerized analysis of video images. However, any technique that measures geometric features (e.g., minerals or pedological features) of two-dimensional images (e.g., grain mounts, polished blocks, or thin sections) qualifies as image analysis. In this chapter, image