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Refractive indices of minerals through the microscope: a simpler method by oblique observation

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Abstract

A new technique is introduced by which differences in refractive index between minerals can be visually assessed. This new method avoids the microscope manipulations that are inherent to the classical techniques of Becke and of Schroeder van der Kolk.

Introduction and history

In studying thin sections of rock samples geologists and petrographers use polarizing microscopes to measure optical properties which will help to identify the minerals present. One of the features observed is the difference in refractive index between minerals or between minerals and the surrounding medium. For this purpose the classical techniques of Becke and of Schroeder van der Kolk have been applied since the beginning of this century.

Their techniques and the one introduced in this paper, are based on the behavior of a homogeneous beam of light as it interacts with the interface between two media of different refractive index; as a rule it appears irrelevant what shape this interface may have, whether straight, wedgelike or irregular. Due to both total reflection against the interface and refraction through it, the emerging light-beam will become heterogeneous; its intensity will be higher above the medium with the higher index of refraction (see, for example, Hartshorne and Stuart, 1970). In Figure 1 this is schematically shown by a higher density of the emerging light rays on the side of the mineral of higher index. If this high intensity part of the light-beam can be traced, information on the relative values of refractive indices between two minerals can be deduced.

Becke (1893) found that defocussing of the microscope produced a bright line—the 'Becke line'—to one side of the imaged interface between minerals. Raising of the tube (or lowering of the stage) made this bright line, produced by the high intensity part of the beam, move into the imaged medium with the higher index of refraction.

The introduction of oblique illumination has been ascribed to Schroeder van der Kolk (1898, 1906), who once taught at the same Department as the present author. Oblique illumination may be brought about by partly intercepting the beam either above or below the stage. By this method the imaged interface darkens when the high intensity part of the beam is intercepted by an opaque object partly inserted into the light path. Alternatively, interception of the low intensity part of the beam makes the interface markedly brighter than its surroundings. From these effects the relative values of the refractive indices on either side of the interface are readily estimated.

While reading the original articles I was surprised to find that Becke should also be credited for this second method. Some five years before Schroeder van der Kolk (1898), Becke (1893a, p. 364, and 1893b, p. 387) had already clearly described this method of 'schiefe Beleuchtung' (*i.e.*, oblique illumination) and its practical value for this kind of microscope work.

A new technique

The initial heterogeneity of the interface beam with high and low intensity halves is maintained along its path through the microscope up into the observer's eye (Fig. 1). The combination of these halves, when focussed on the eye's retina, results, of course, in a uniform intensity of the interface illumination.

Now, by looking obliquely into his microscope, *i.e.*, by making a slight sideward movement of the head, the observer may again survey the distribution of intensity of the interface beam (Fig. 2). This reduces the illumination of the total image because

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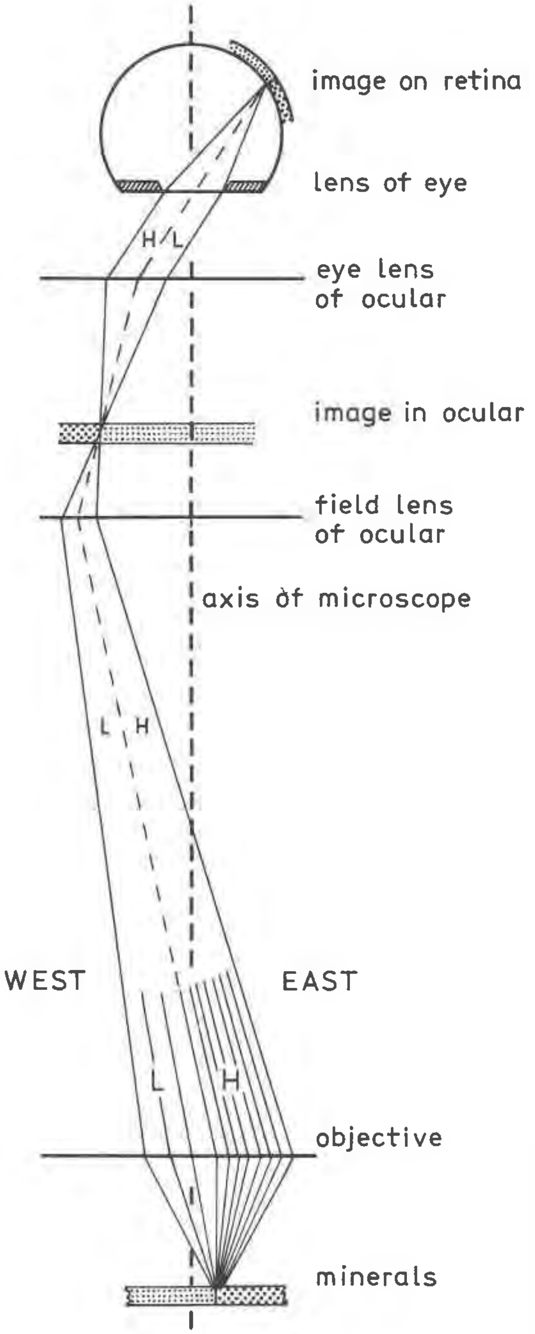

Fig. 1. EW-section through microscope focused on NS-trending interface between two minerals with different indices of refraction. Light rays departing from the interface between the minerals have been drawn only. Their density is higher (H) above the mineral with the highest index (darker shade).

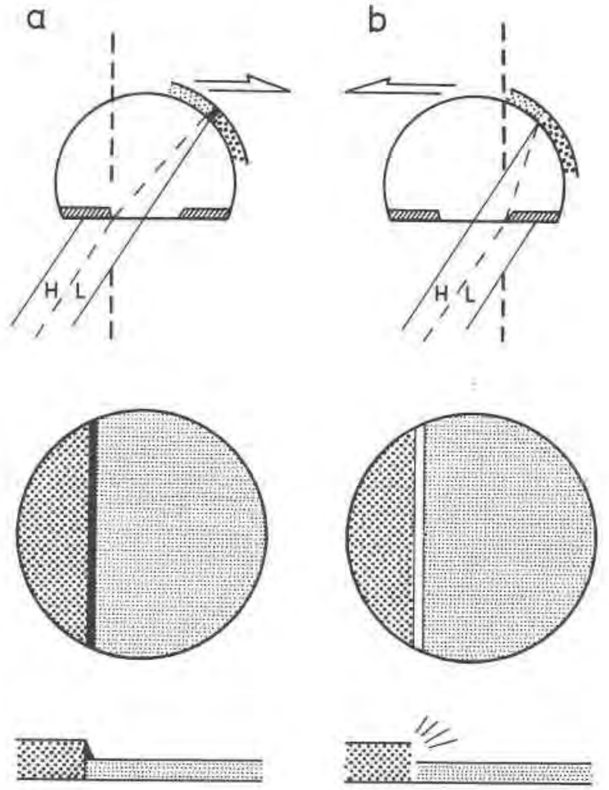

Fig. 2. The interface beam under oblique observation. (a) eastward displacement (arrow) of the eye with respect to the microscopic axis (dashes): the high intensity part (H) of the beam is blocked; therefore, the resulting image (below) shows a dark NS-running interface; (b) westward displacement produces a bright interface.

only part of the eye opening is still available for light passage. By an eastward movement of the eye (Fig. 2a), only the low intensity part (L) of the heterogeneous interface beam passes the eye lens, the rest being blocked by the iris, so that the image of the interface receives less illumination and will look darker than its surroundings. Alternatively, a westward movement (Fig. 2b) of the eye with respect to the axis of the microscope will make the interface look brighter than the adjacent minerals. These visual effects are much the same as those of the Schroeder van der Kolk method. This is not surprising as the eye's diaphragm functions as Van der Kolk's beam interceptor, albeit high on the optical path. The effects mentioned are enhanced by a narrowing of the substage diaphragm of the microscope. This new method is equally sensitive and applicable as that of Schroeder van der Kolk.

In order to get acquainted with the effects of oblique observation, additional lines of reasoning may help the beginner's memory: the microscope image may be looked upon as a topography with highs and lows (minerals with respectively high and low indices of refraction) illuminated by a light source positioned at the corner of the field of view from which the eye moved away (Fig. 2, bottom).

For routine microscope work I prefer employing this method of oblique observation as it avoids manipulations like defocussing and refocussing (Becke's method) or influencing the illumination by inserting and removing a light stop (Schroeder van der Kolk's method).

Acknowledgments

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