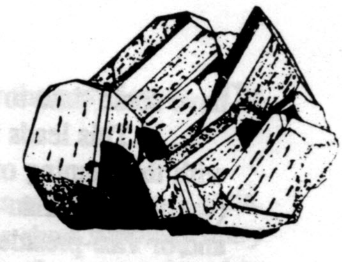
friends of mineralogy colorado chapter



Friends of Mineralogy - Colorado Chapter
Newsletter No. 9, February, 1993 4

March Meeting: 7:30 p.m. Thursday, March 10, 1993 4 1994
Denver Museum of Natural History
VIP Room of the Cafeteria
(enter through employees entrance on the north)

Board Meeting at 6:30 before March Meeting in the Geology Department Office as the Museum has other functions taking place that night.

The first part of the program for the March meeting will be a report on the Tucson Show by several attendees, with slides brought by the members.

The second part will be a talk by Ed Raines on the Cripple Creek District.

ANNOUNCEMENTS

Bruce Geller wants to buy a microscope. He would like it to be binocular with zoom to 50 or 100 power. If you have one to sell please call him at home 237-2947

Roger Pitman the Colorado State Director for the Rocky Federation of Mineralogical Socicties, reports that the State of Colorado has not been represented at their regional conventions. Many of the states in the federation have furnished cases representing minerals from that state. He is requesting that members donate typical state minerals for this case. He can be contacted at 5590 Rennsberger Rd., Falcon CO 80831, phone 719-683-2603. Please contact him if you have a specimen to furnish.

MESSAGE FROM THE PAST PRESIDENT - **Now that my job as president for the past two years is finished, I hope I can take a breather and sit back a little to contemplate what is going on in FM; and perhaps catch up on doing a few things for FM that I've promised to do, or would like to have done. These include helping to finish FM's application for tax-exempt status to the IRS; and, for example, does anyone remember my promised summary of our "Mineral Specimen Appraisal" experiment at an FM meeting over a year ago? Of course, work on the final stages of the *Minerals of Colorado* "Update" is still keeping a number of us quite busy.**

Regarding the Update, we can still use the help of additional people for such things as proofreading and checking the correctness of bibliographic references cited in the *Minerals of Colorado* manuscript. If you are a generally reliable person who knows how to use Word Perfect (DOS version) on a computer, the Update committee could definitely use your help; please contact Jim Hurlbut if you

have some time to offer.

This leads me to put in a reminder for all of our members to think about helping out the officers with the running of FM. Keeping this particular organization going is not the biggest job in the world (we have less than 100 members), but it does take some effort. Many of the duties fall upon the president and/or vice-president, including arranging the programs, making logistic arrangements for our meetings, and writing and printing the newsletter. Jim and the other officers can use any help the rest of you can offer. So, let them know about any suggestions you have for programs; if you know of something that should or could be printed in our newsletter, send it to Jim (he'll be most happy; and otherwise, don't expect it to be in there!); and consider helping by volunteering to bring refreshments to one of the meetings. For these and any other means of assistance you might be able to offer, I know that all the officers will be most appreciative.

---Pete Modreski

NOTES ABOUT THE TUCSON AND DENVER SHOWS - *In case you wanted to know*--The theme mineral of this year's Tucson show was *Silver*. Next year's (1995) Tucson theme mineral will be *Topaz*, and the 1996 Tucson theme will be *Calcite and other fluorescent minerals* (the show poster will feature fluorescent calcite under UV light, and the species competition will be calcite). The 1994 Denver show theme mineral is *Pyrite*, and the 1995 Denver theme will also be *Calcite*. Now is the time to get out and collect your best-in-the-state Colorado calcite and pyrite specimens for the coming shows! Have you seen the Denver 1994 show poster? It shows a pyrite cluster from Leadville, and the photography is by Chauncey Walden.

Two FM chapter members gave talks at the FM-MSA-TGMS Tucson symposium on "Silver and silver minerals". Bill Smith presented "Silver minerals from the F. John Barlow collection", and Ed Raines spoke on "The mineralization pattern of Clear Creek and Gilpin Counties, Colorado". Abstracts of these and the other talks can be found in the Jan.-Feb. Mineralogical Record, p. 69-76.

NEW BOOKS - A few recently publishing books and periodicals that have come to our attention during the Tucson show or thereabouts:

Colorado Rockhounding, a Guide to Minerals, Gemstones, and Fossils, by Stephen M. Voynick (1994, Mountain Press, Missoula, Montana, 372 p., softcover, $14.00) is a just-published new guide to mineral and fossil collecting in Colorado. It covers the sort of material that Richard Pearl's "Colorado Gem Trails" did, but is much more up-to-date. The book includes location maps, a number of black-and-white photos, and 8 pages of color plates. Perhaps in the future our newsletter will print a more complete review of this book.

Bibliography of Colorado Mining History, by Arthur E. Smith, Jr. (1993, L.R. Ream Publishing, Coeur d'Alene, Idaho, 45 p., softcover, $9.95) is a bibliography listing some 740+ books dealing with Colorado mining history. Most items are listed with short annotations describing their content, and the booklet includes an index by geographic area and major subjects. It should be useful to mining history buffs, and anyone writing an article or researching a subject relating to Colorado mining. The booklet may be ordered directly from L.R. Ream Publishing, P.O. Box 2043, Coeur d'Alene, ID 83816-2043, for $9.95 + $1.50 shipping and handling.

Fluorescence, Gems and Minerals Under Ultraviolet Light, by Manuel Robbins (1994, Geoscience Press, Phoenix, 374 p., hardbound, $40.00) was also newly available at the Tucson show. This is probably the best book currently available about fluorescent minerals. Rather than a beginner's introduction to fluorescence, it consists of chapters about specific minerals that commonly fluoresce, notable localities for fluorescent minerals, activators of fluorescence, fluorescence of gemstones, etc. Much of the book is taken from columns by Manny Robbins which have appeared in *Rocks and Minerals* over the past decade. The book includes 12 pages of color plates.

World of Stones (Plus Ltd. Publishing, Moscow) is a new magazine about minerals and gems in Russia. It is written in English and is well illustrated with good-quality color photographs; a short supplementary section also gives the text of the articles in Russian. Two issues of "World of Stones" were produced in 1993 (a few copies of the first issue were available from Russian museum curators and dealers at the Denver show), and the regular run of four issues per year will begin with 1994. The first issue (58 p.) contains articles about "Axinite finds in Russia", topaz with lepidolite inclusions, "Siberia's crystals", "Belovite and Nikolai V. Belov", "The Inder boron deposit and its minerals", "A mineralogical guide to the South Urals", the Yershov Geological Museum (Moscow), and about personalities Vladimir I. Vernadsky and Alexei V. Sverdlov. The magazine should be a good source of information for those interested in Russian mineral specimens and localities. Subscriptions are $52, and may be ordered in U.S. funds through Herb Obodda, Box 51, Short Hills, NJ 07078.

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Hey's Mineral Index, Mineral Species, Varieties, Synonyms, by A.M. Clark (1993, Chapman and Hall/Natural History Museum Publications, London, 852 p., hardbound, about $90.00) appeared last year. It is an updated version of an old standby mineralogical reference, Max Hey's *Chemical Index of Minerals*. The book is an alphabetical guide to all known mineral names, including valid species, obsolete names, and varieties. It generally gives more information and is more authoritative than what is found in the *Glossary of Mineral Species* or *Encyclopedia of Minerals*--it includes the chemical formula, crystal system and unit cell dimensions, one or more references, and information about the type locality and derivation of the mineral's name. The price of the book will be intimidating to most collectors, but it is a valuable resource for mineralogical information.

Optical Identification of Minerals - The Petrographic Microscope

Part III

Daniel E. Kile
Mineralogical Technical Chairman, RMFMS

<u>A Brief Dissertation on Some Fundamental Optical principles</u>

Before one can understand the practical use of a petrographic microscope, it is necessary to understand, at least intuitively, a few optical principles. Below are summarized some important concepts pertaining to polarized light, as well as fundamental microscopic procedures for analyzing mineral grains.

1. <u>Polarized light.</u> Ordinary light can be considered as composed of many waves, each traveling along a straight line but vibrating (oscillating) in all possible directions. Plane polarized light is composed of light vibrating only in <u>one</u> direction, the other rays having been eliminated.

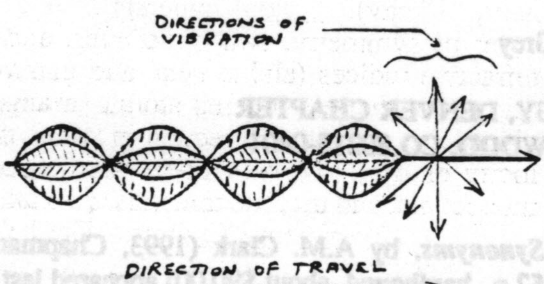
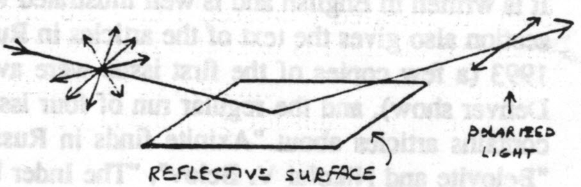


illustration depicting unpolarized light composed of individual rays vibrating in many directions

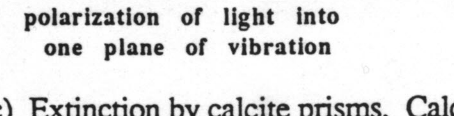
There are three ways to produce polarized light:

(a) Reflection. Reflected light is polarized and vibrates in a direction parallel to the surface of the reflecting medium, i.e., light reflected from a pool of water vibrates in a horizontal direction. A good example of how this works is illustrated by Polarized sunglasses worn while driving: much of the "glare" is eliminated because most reflected light from horizontal surfaces such as pavement or chrome bumpers is polarized and vibrates in a horizontal direction. The Polaroid in sunglasses is oriented such that only light vibrating in a vertical direction is passed through, thus eliminating the glare that is polarized in an opposite direction. This concept was utilized in some of the earliest polarizing microscopes that incorporated two sets of reflecting glass plates, each polarizing light rays at 90° to one another.



polarization by reflection

(b) Absorbtion. This is exemplified by the Polaroid described in the preceding paragraph: all light is eliminated by absorbtion except that traveling in only one direction (the absorbed light is radiated as heat). If two such lenses are placed one on top of the other, and one rotated 90°, all light passing through is blocked (it becomes "extinct") because the vibration directions of the two lenses are mutually perpendicular. Further rotation realigns the lenses such that their two vibration directions coincide, and light can again pass. Certain crystals, such as tourmaline, also show this phenomenon, where light traveling through a prismatic face will be polarized; crossing two tourmaline crystals will thus produce extinction.



polarization of light into one plane of vibration

(c) Extinction by calcite prisms. Calcite prisms polarize light by splitting light into two rays of unequal velocity (these rays vibrate in directions mutually perpendicular to one another); their construction of two or more components, cemented by balsam, is such that one ray is refracted (bent) outside the field of view (see part I of this series for a diagram and discussion of the Nicol prism).

The petrographic microscope has two

such prisms (Polaroid is generally used in newer instruments). The upper polarizer, called the analyzer is generally located in the lower part of the microscope tube; the lower polarizer is located in the substage condenser. When both are inserted ("crossed") they are oriented such that all light is extinct. This extinction is caused by the 90° orientation of the polars, and insertion of any anisotropic mineral will deviate the vibration direction of light such that it will now pass through the upper polar. Analysis of the light passing through the upper polar is diagnostic for the mineral in question.

2. Refraction. Refraction is a measure of how much light is bent as it travels through a different medium, ie., from water to air (note, for example, the displacement of the image of an object that is underwater). The degree to which light is bent on traveling through a mineral is intrinsically related to the mineral's chemical composition, which in turn affects its internal atomic order, its external symmetry, and ultimately the change in the speed of light as it passes through. The refractive index (the ratio of the velocity of light in air to that in the mineral) is a measure of the degree of refraction as light passes through a mineral, and is inverse to the velocity of light.

3. Isotropic/Anisotropic Minerals. The speed of light traveling through a crystal is affected by the atomic environment it encounters in a given direction. The external symmetry of a crystal is controlled by its internal atomic order, and thus it is intuitive that while light traveling or vibrating in different directions within a symmetrical crystal will show little or no difference in velocity (therefore refractive index), light traveling or vibrating in different directions through a relatively asymmetrical mineral will show significant differences in velocity. Therefore, the uniform arrangement of atoms in an isometric mineral implies that light will be relatively unaffected as it passes through in any given direction. Such minerals are isotropic, and have only one refractive index.

Light passing through an anisotropic mineral is split into two rays that vibrate in mutually perpendicular directions as they enter a less ordered crystal lattice. The velocities of these two rays are different because they encounter a different atomic electronic field depending on the vibration direction of the ray. They are thus refracted (bent) to different degrees. A good example of these phenomena is given by calcite. A clear cleavage fragment, placed over a single dot on a piece of paper, will give an image of two dots. Rotating a piece of Polaroid over this calcite will alternately extinguish one, then the other dot, as the vibration direction of the Polaroid sequentially aligns with each dot. Calcite gives an image of two dots because of the relatively extreme difference in velocity (thus refraction) of the two mutually perpendicular rays transmitted through it.

There are two classes of anisotropic minerals, which are related to the crystal system. Each class has at least one optic axis, which is the direction that light, passing through a crystal, encounters a uniform crystal lattice (atomic field), and thus the velocity (and refractive index) is not altered in any vibration direction. Uniaxial minerals, those in the tetragonal, or hexagonal crystal systems, have one optic axis (usually along the c-axis) and two refractive indices (the ordinary, "o", and extraordinary, "e" ray). Biaxial minerals have a lower order of symmetry, two optic axes, and three refractive indices (alpha, beta, and gamma) on account of the less ordered atomic arrangement giving rise to another direction in which the velocity of light can be varied. Orthorhombic, monoclinic, and triclinic minerals are biaxial.

4. Interference Figures. The behavior of light passing through a mineral grain on a microscope stage results in a distinctive pattern of light that is formed on the rear element of the microscope objective; these patterns are characteristic of intrinsic crystallographic and optical properties. The pattern of the interference figure is thus diagnostic for crystal system, since one can determine if the mineral is isotropic or anisotropic, uniaxial or biaxial. Interference figures are obtained by inserting the Bertrand lens (that is usually in the upper part of the body tube) which magnifies the image on the rear of the objective, and swinging in the auxiliary substage condenser element to give an intense converging light (called "conoscopic" observation, as opposed to "orthoscopic" lighting used otherwise). Interference figures also indicate the orientation of the mineral with respect to the plane of the microscope stage, which is necessary for refractive index determination.

uniaxial interference figure

biaxial interference figure

5. Refractive Index. The refractive index is inversely related to the velocity of light, and is a fundamental property of all minerals. Because velocity can vary depending on the direction of travel and wave vibration through the mineral, proper orientation is needed to determine which refractive index is being measured. The mineral is immersed in a suitable oil of known refractive index, the orientation determined by the interference figure, and then the refractive index is assessed with only plane polarized light - the analyzer (upper polarizer) is moved out of the light path. The behavior of light at the fringe of the grain is observed as the objective is raised (or the stage lowered); if a bright fringe at the border of the grain (called the Becke line) moves into the grain, then the $RI_{mineral} > RI_{oil}$; the opposite is true if the light fringe moves into the oil. Isotropic minerals have one refractive index, uniaxial minerals have two refractive indices (ordinary and extraordinary), and biaxial minerals have three indices (alpha, beta, and gamma).

Refractive index oils are calibrated in increments of 0.002 units, and can be expensive when purchased new. Alternatively, a few inexpensive media such as microscope immersion oil (RI = 1.5150), mineral oil (RI ~ 1.467), and balsam (RI ~ 1.54), can be used to narrow the range of possible indices. Pure organic liquids, purchased in small quantity, also give good results, but some may be quite volatile, and others are toxic to varying degrees.

The difference between the highest and lowest refractive index is called birefringence; highly birefringent minerals such as calcite are characterized by being quite colorful under crossed polars.

6. Optic sign. Optic sign is another fundamental characteristic of all anisotropic minerals. It indicates, in uniaxial minerals, whether the light vibrating perpendicular to the c-axis is the fast or slow ray, and in biaxial minerals whether the intermediate refractive index (beta) is closer to the highest (gamma) or lowest (alpha) refractive index. Optic sign is measured using a retardation plate (also called a wave plate, but not a "filter") that retards the velocity of light by a known wavelength. The most useful plate is the gypsum (or "first order red") plate, with a retardation of 550 mμ. This plate produces vivid colors when inserted into the accessory slot, and in early days "selenite" plates were common accessories for recreational microscopy. Observation of the "northeast" quadrant of the interference figure of an oriented grain, with the gypsum plate inserted, will indicate the optic sign: blue = optic (+) and yellow = optic (-). A "mica" (1/4 wave) plate is also sometimes used (retardation 147 mμ), as is a quartz wedge, which gives sequential color changes as it is inserted into the accessory slot, due to a progressive increase in thickness (hence retardation) of the quartz. This latter accessory is generally quite expensive, but useful for determining optic sign in some ambiguous situations.

7. Extinction Angle. A grain under crossed polars will become dark (extinct) every 90° as it is rotated on the microscope stage. If the mineral shows either a cleavage trace or crystal face, an angle (called the "extinction angle") between it and the point of extinction can be measured, which is another diagnostic feature of a mineral species.

8. Sign of Elongation. Light vibrating parallel to elongated crystals or mineral grains can be assessed to determine whether it is the fast or slow ray by using the gypsum plate.

9. 2V Angle. The angle between the two optic axes of biaxial crystals is the 2V angle, and is a fundamental property. It is readily determined from an oriented interference figure using the Bertrand lens.

To be Concluded in Part IV