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Notes on Cathodoluminescence Microscopy using the Technosyn Stage, and a Bibliography of Applied Cathodoluminescence

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NOTES ON CATHODOLUMINESCENCE MICROSCOPY USING THE TECHNOSYN STAGE AND A BIBILIOGRAPHY OF APPLIED CATHODOLUMINESCENCE

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INTRODUCTION

Cathodoluminescence (CL) microscopy has become an essential tool in the petrographic description of sedimentary rocks. CL also has important applications in igneous-metamorphic petrography, ore deposits, and mineralogy. In this brief treatment, the primary goal is to summarize our techniques in CL microscopy because of requests from other users. This report also summarizes our experience in the operation of the Technosyn[1] CL stage. The Technosyn stage is used here as an example of a CL system for descriptive purposes only. The other commercial CL stage we are aware of is made by Nuclide Corporation.

Cathodoluminescence in Minerals

In the vacuum chamber of the CL stage, the electron beam is absorbed by the surface it hits. Much of the energy of the incident electron beam is absorbed by the specimen molecules causing an increase in the energy levels of absorbing atoms. Normally the excited atoms (also termed cathodoluminescent centers) return to the ground state by transfer of the excess energy to adjacent atoms by inelastic collisions. Under certain circumstances, the absorbed energy is re-emitted as light energy in the visible range before these collisions can take place. The conditions for luminescence often occur in impure crystalline substances where the impurities act as the luminescent centers. The intensity of light emitting from any particular point will be proportional primarily to the surface density of luminescent centers. The electron energy is readily absorbed in the sample, and little luminescence is emitted from below the surface. Transition metals and the rare earth elements are particularily susceptible to electron beam excitation. For instance, in transition metals, the 3d electron shells are available for excited electrons to enter these levels.

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[1] The use of trade names in this report is for descriptive purposes only and does not constitute endosement by the U.S. Geological Survey, or S and M Microscopes, Incorporated. The complete address of the manufacturers cited in this report are listed in appendix 1.

Electrons in this excited state are unstable, and they decend to lower energy shells by radiating visible light. Manganese is a common activator in minerals and rocks. Iron is a common quencher. This is largely due to the abundance of these trace elements in minerals (Sommers, 1972). Luminescent centers are also caused by radiation damage, and sometimes still unidentified sources. We refer the interested reader to Nickel (1979) and Amieux (1982) for a detailed discussion of CL phenomena, petrography, and a list of CL colors in minerals.

X-ray radiation

CL stages use an electron beam to produce cathodoluminescence in susceptible materials. The Technosyn stage generates an electron beam rated at 25 kV at 250 microamps. This electron beam is capable of producing X-rays from any material it strikes. The stage is designed to absorb this radiation, but periodic inspections are important to assure leaks have not developed. Nuclide Corporation makes a compact radiation detector suitable for testing the CL stage while mounted on the microscope.

Tests of X-ray production from the Technosyn CL stage indicate that it is safe. This test involved placing a nickel target under an electron beam in the stage that optimizes the production of X-rays. The stage was operated between 20-30 kV and 400-100 microamps respectively. X-ray production from silicate, carbonate, or glass targets would be less under the same stage operating conditions. X-ray production was measured using a Philips monitor type PW 4517 placed directly above the top window. The stage windows were the only place X-rays were detectable during these tests. With the stage mounted on a microscope, a maximum X-ray level of 0.1 mRad/hour was measured 5 cm above the top window.

Safety regulations specify that anyone without special training or regular medical checks should not be exposed to more than 0.5 Rad/year above background radiation level (normally about 0.5 Rad/year). This radiation level divided into 2000 working hours indicates the maximum level is 0.25 mRad/hour. None of the measured values exceed this value, and the unit is safe under these standards.

Any alteration of the CL stage can potentially alter its X-ray production levels. After modification of the stage, it should be checked for excessiv radiation levels.

SAMPLE PREPARATION

Thin sections, rock slabs, and loose grains can all be examined in the CL stage. Fine grains should be cemented to a glass slide so they will not enter the vacuum system. The Technosyn stage will accomodate thin samples of maximum dimension 70 x 80 x 1 mm. Thick samples are restricted to 50 x 70 x 17 mm. The view area in both cases is 50 x 70 mm.

Optimal details under CL are produced by using high quality polished surfaces. Although polishing is not absolutely necessary, we recommend it for most microscopy, especially if photomicrography is anticipated. Methods of polishing rock specimens are listed in the bibliography.

Thin sections for CL microscopy should use a cement that is stable at the moderate temperatures generated in the sample. Heating and outgassing from the cement can coat the stage window and delay vacuum stabilization and extend pumpdown time. Epoxide or epoxy resins (Buehler, Ltd. or Hillquist) are satisfactory. Cover glass should not be used because the electron beam will be absorbed by it before reaching the sample. A conductive coat on the sample is not necessary.

Cleaning the Sample

After sample preparation, lubricants, water, fingerprint oils, and other volatiles must be removed from the sample. These volatiles will vaporize in the chamber during pumpdown or CL observation, extending pumpdown time to operational vacuum levels, and also potentially depositing material on the chamber window. An effective cleaner and dehydrator for samples is a freon solvent (Miller-Stephenson brand MS-180).

REQUIREMENTS FOR THE MICROSCOPE

Light intensity transmitted to the operator during luminescence observations is proportional in part to the degree of magnification. The lower power objectives transmit a brighter image. The lowest power objective possible should be used as long as the feature of interest is seen in sufficient detail. The point is that the fewer optical elements in the microscope light path, the brighter the image. This is one case where a more complex, optically sophisticated microscope may degrade the CL image rather than improve it.

Objective Lens

The objective lens must have a minimum free working distance of 9 mm. Selected objective lenses with the required working distance are listed in Table 1. Other objective lenses with appropriate free working distances are listed in Delly and Wills (1985). The objective lens should be cover slip corrected in those above 10X power--otherwise optical abberations can occur. The electron beam forms a 4 mm by 7 mm ellipse of luminescence on the sample surface, and a very low power objective lens may view a spot greater than that illuminated by CL.

A simple objective lens set for CL observations would be a 5x and a 10x. Higher power lenses may be useful in specific cases but generally have poor CL characteristics and transmit inferior images.

Table 1

Objective Lenses for Cathodoluminesence Microscopy
(As used by the U.S. Geological Survey)

Source	Lens[1]	Power(n.a.[2])fwd[3]	Notes
Lietz	EF4	4X(0.12) 24.0mm	Inexpensive
Lietz	L25	25x(0.35) 13.5mm	Long fwd lens
Nikon	CF 4	4x(0.10) 20.0mm	Inexpensive
Nikon	M Plan 5	5X(0.10) 20.0mm	210mm tube length[4]
Nikon	M Plan 10	10X(0.25) 9.0mm	Long fwd lens
Ziess	UD16	10X(0.11) 13.5mm	Universal-stage lens[5]

Notes: (1) Manufacturuers identification code engraved on lens. (2) n.a. = numerical aperture. (3) fwd = free working distance. (4) All Nikon Mplan lens are designed for microscopes with a mechnical tube length of 210mm and their use on 160 mm tube length microscopes reduces the rated magnification power and n.a.. (5) A universal-stage lens, designed for use with glass hemispheres. These lenses have a poor image, lower than rated magnification and n.a., when used without the spheres (effective magnification and n.a. shown). Any low power universal stage objective lens usually can be used but most lack the high n.a. necessary for good CL observation.

Oculars

The same limitations on image brightness apply to oculars as discussed in the objective section. The optimal oculars are those with the lowest power that allow adequate resolution of details in the sample. For instance, 8X Nikon oculars are 56 percent brighter than the Nikon 10X. Remember that the effective resolution of the system is determined by the numerical aperture of the objective lens, and trying to increase the magnification beyond this value provides a larger image but poor resolution. Low power objective lens tend to have small numerical apertures and low effective magnification levels, such that using high power oculars is not recommended.

Substage Condenser

A long working distance substage condenser is essential to provide an adequate image quality in the CL stage during observation and photomicrography in transmitted light. The substage condenser will not improve the CL image or photographs because the image is formed by light emitted from the upper surface of the sample. The free working distance of the condenser should be sufficient to focus a condensed beam of light on the upper plane of the sample. The longer working distance required by the Technosyn stage, only allows the closed condenser diaphram image in the plane of the sample to a near-sharp focus. This image should be sharply focused for Kohler illumination.

Polarizer and Analyzer

The analyzer (or any accessory plate) absorbs light and reduces the image brightness. It must be removed for CL observations. The polarizer, as it is placed below the sample, will not effect the CL image.

Stage Clearance

The minimum clearance necessary to fit the stage between the objectives and microscope is 5.0 cm. Microscopes that have sufficient clearance are: Nikon Labophot or Optophot; Zeiss Universal; Zeiss WL, and some Lietz Labrolux. The Leitz Labrolux models 11, 12, and D require modification to allow the stage to be mounted. Microscopes without the necessary clearance is the Ziess model 16 and model 18.

It is also possible to put the CL stage on stereo microscopes, but these must be used in a completely darkened room. Stereo microscope objectives have a very long free working distance, and a low numerical aperture, allowing room-light to enter the system which degrades the image quality.

Microscope Room

The area in which the microscope is used must be enclosed such that all light can be eliminated. Cathodoluminescence in certain samples is extremely dim and a darkened room allows the observer's eyes to adjust to lower light levels. A small light should be provided to allow ease of movement and allow writing notes.

A CL control box, cables, and the microscope will fit on a standard office desk or table. The vacuum pump should be set on the floor so that vibrations transmitted to the microscope are minimized.

CL systems require 10 amp, 110 volt outlet (in the United States). If the system is operated near equipment that draws a lot of electricity, the resultant power surges when this equipment is operated may damage samples during CL observations. A line voltage stabilizer may be required to correct this problem.

Photomicrography

Photomicrography is an essential but difficult aspect of CL microscopy. Experience with a particular sample suite is perhaps the best guide. A good starting point is the discussion in Nickel (1979) or Mariano (1983). Since those publications, new films have been introduced that offer higher speed without loss of resolution. We have found these films to be useful:

1) Kodak Ektachrome P800/1600, EES 135 (for color slides)
2) Kodak Kodacolor 400 (for color prints)
3) Kodak 5294 or equivalent (for both color negatives and slides)

Color processing can distort the true color as perceived by the microscopist. We have found it useful to send to the processing laboratory a photograph that has the color qualities that are close to the actual CL view. This photograph allows the color analyzer to be set properly and realistic color reproduction.

OPERATING THE TECHNOSYN STAGE

System pressure and power supply for the electron gun are set from the front of the Control Unit. The POWER switch controls electrical power to the control unit. VAC PUMP switch controls vacuum pump operation if the pump power line has been wired into the back of the control unit (otherwise it can be manually switched at the pump). INTERLOCK light is only lit when the interlock circuit is complete (jumper wire between pins 3 and 5 of EXT socket on back of control unit). VAC READY light lights up when system pressure is lower than 0.2 Torr. <u>Both</u> the INTERLOCK and VAC READY lights must be on for the control unit to allow the electron gun to turn on. kV ON (or EHT ON for some machines) switch turns on the electron gun. The LED on the kV ON switch is lit when the electron beam is on. GUN CURRENT meter indicates the gun current in microamps. When the gun is not switched on the gun current meter should be within -/+ 9 microamps of zero. The VAC CONTROL is a vacuum bleed valve that controls the amount of air leaking into the system, and therefore the pressure inside the stage chamber. The VAC CONTROL should be gently turned fully to the right (clockwise) before each pumpdown. ADJUST kV controls the level of drive to the extra high tension supply. The actual level of high voltage in the electron gun, indicated by the kV METER, is determined by the vacuum present: (1) low vacuum (high pressure) produces a low kV METER reading; and (2) high vacuum (low pressure) produces a high kV METER reading. The level indicated by the kV METER should not be left above 30 kV as this shortens the life of both the electron gun and gun power supply cable. MONITOR (test) meter indicates the vacuum level at the control unit in Torr (or in test mode, it is a voltmeter). The stage chamber vacuum slightly lower than the meter reading because it is further down the pumping line. Normal operation in air is achieved at meter readings of 0.07 to 0.04 Torr. Vacuum levels higher than 0.04 Torr will cause the electron gun beam to extinguish. Vacuum levels lower than 0.07 Torr enable the system only to opeate at low levels around 3-5 kV. The MONITOR meter also acts as a voltmeter to check the control unit electronics in conjunction with the SELECTOR switch located near the lower left hand corner of the front of the control unit (see troubleshooting section).

Striking an Electron Beam and Controlling the System

(0) The sample should be observed through the microscope. The analyzer and any compensators, shutters, etc., should not interfere with the optical path. Center a well polished portion of the sample which optimally should contain brightly luminescent material, such as calcite. This aids the initial observation of CL and further adjustment of the system.

(1) After plugging the control unit in, turn the switch on the front of Unit marked "POWER" <u>on</u> (red light on). INTERLOCK LED lights up with power on. Turn the VAC PUMP switch <u>on</u> (red light on). Rotary vacuum pump comes on. Sometimes it is necessary to hold the stage cover in place and press the stage drawer closed when the vacuum pump is turned on.

(2) When vacuum in chamber is sufficiently low for the electron beam to strike and hold, the green "VAC READY" light will come on. This occurs at a chamber pressure of 0.08 and 0.05 Torr (see MONITOR meter). The first daily pumpdown time varies in the range of 5 to 10 minutes. After this time if the VAC READY light does not come on proceed to troubleshooting section.

(3) At this chamber pressure the kV ON (or EHT ON on some machines) switch is turned <u>on</u>. An additional 5 minutes or so of pumpdown is necessary to allow the specimen to complete outgassing from heating by the electron beam. Soon the vacuum will improve to the point that the electron beam will strike the sample and hold (kV ON switch LED comes on). This process is optimized by holding the beam on the sample surface rather than the glass slide. The beam tends to stabilize quicker when impinging on the sample. If the electron gun does not come on proceed to the troubleshooting section.

(4) USE OF THE "VAC CONTROL" knob: At any operating voltage the gun current can be adjusted by using the vacuum bleed control valve (labeled VAC CONTROL) to vary the pressure in the stage. There is a minimum current below which the gun is unstable, generally 150 microamps. The vacuum in the chamber must be controlled to stabilize the beam current. This is done by turning the VAC CONTROL knob counterclockwise until the beam strikes. Under these conditions, rotation of the VAC CONTROL knob in either direction produces a change in the gun current. Counterclockwise rotation produces an increase in GUN CURRENT meter (the digital microamp meter) and a decrease in beam voltage (kV METER). Conversely, clockwise rotation will produce a decrease in gun current and an increase in gun voltage. The system is

quite sensitive at this VAC CONTROL setting. Further adjustment should be done carefully in small increments. The gun current should not exceed 600 microamps to avoid damage to resistors in the control unit. Never overtighten the VAC CONTROL -- finger tight is always sufficient.

(5) USE OF THE "ADJUST kV" CONTROL: Initially the ADJUST kV control should be turned clockwise to the far right. Under normal operating conditions, the ADJUST kV control remains in that position.

In some cases, further adjustment of the ADJUST kV control may be desirable. After the electron beam strikes and holds, the kV METER will show the beam voltage. The electron gun voltage and current are interdependent on the operating vacuum. Once the beam has stabilized the gun current is controlled by adjusting the VAC CONTROL knob. The current is reduced by turning the VAC CONTROL knob counterclockwise. The kV METER indicates the accelerating potential in the electron gun. The ADJUST kV knob may be turned counterclockwise until the kV METER responds. In this way the uppermost kV limit may be set. However, the kV is not controlled directly by the ADJUST kV knob -- only indirectly through VAC CONTROL adjustments. We have found this adjustment to be more useful at lower settings in the 10-12 kV range rather than at higher kV levels.

Centering the CL Image in Optical Path

The area on the sample struck by the electron beam will appear as an elliptical spot of light approximately at the center of the window. For proper microscope observations this light spot should be centered until it fills the field of view in the oculars. This adjustment becomes critical at 5 power objectives or lower. This stage is physically centered using three 3 mm allen-head screws on the underside of the vacuum chamber. These screws should be loosened such that the chamber may be moved about by hand into the correct position. All three screws are then lightly tightened without moving the stage, and finally retightened with the allen wrench. These adjustments must be done with the beam on. The field of view will be completely filled when using a 5X objective. Lower power objectives will have a field of view that is not completely filled by the electron beam.

OPERATION SUMMARY

Initial Pumpdown

(1) Place specimen or prepared microscope slide in stage using top cover or drawer. VAC CONTROL and ADJUST kV controls are turned fully to the right.
(2) Close both the air admit valve on chamber and VAC CONTROL (a controlled leak valve) on Control Unit.
(3) POWER switch on -- red power light on, INTERLOCK LED on.
(4) VAC PUMP switch on -- red vac pump light on, rotary pump on. When vacuum is low enough -- green LED "VAC READY" light on.
(5) kV ON switch on -- red LED on.
(6) Adjust the gun current by turning the VAC CONTROL knob -- kV METER

indicates kV.

Changing Samples

(1) Turn POWER switch off.
(2) Turn VAC PUMP switch off.
(3) Open air admit valve on chamber, let it bleed to atmospheric pressure.
(4) Open chamber using top cover or drawer, exchange specimens.
(5) Repeat SAMPLE RUN instructions.

System Shut-Down

(1) Follow CHANGING SAMPLES instructions, take specimen out, omit step five.

TROUBLE SHOOTING

Vacuum Leaks

Vacuum leak detection can be difficult because even a small leaks can reduce system vacuum below operating levels. Vacuum leaks are usually indicated by dim CL or the electron beam cannot be struck and stabilized.

First order leak elimination procedure. Tighten all hose clamps until firm. Wipe the O-rings clean -- make sure dust and oils removed. Coat O-rings lightly with Apiezon-L (Biddle Instruments) vacuum grease. System may respond and pump down to useful range. The majority of vacuum leak problems will be solved with this method.

Second order leak elimination procedure. This level of leak detection involves isolation of system components and checking the system response to identify the leaking subsystem. For instance, chamber leaks can be detected by removing the system to chamber vacuum hose, plugging it, and checking to see if this improves the system vacuum to a usable range.

Third order leak elimination procedure. If helium gas is available it can be used to test for small leaks in the vacuum system. Helium under low pressure from a lecture-type bottle is projected towards potential leak locations through a rubber hose with a Pasteur pipette inserted at the tip. Any vacuum leaks will be noted by a rapid decrease in system pressure when helium is directed to the location on the stage or vacuum hoses.

Electron Gun Leaks. If the beam voltage does not increase above 10 kv after 5-10 minutes, this may indicate a leak in the electron gun. Unscrew the electron gun being careful not to scratch the barrel. We wrap the gun in cloth or tape to prevent marring by the pliers. Considerable force may be necessary to start unscrewing the gun counterclockwise. When unscrewing the gun be sure not to loose the metal nipple (this is the anode) located at the base of the metal tube. The O-ring on the glass tube should be cleaned and greased with a generous amount of Apiezon-L (for moderate temperatures) or Apiezon-T (for high temperatures). A generous amount of grease because these tubes are often loosely fit into the gun. During reassembly, the position of the O-ring on the glass tube is not critical, however, the narrow end of the metal nipple should be pointed towards the glass tube. Reassemble the electron gun. This procedure may not correct the vacuum problem in systems that have had extensive use. In this case, the gun may need to be replaced.

High Voltage Problems

No High Voltage. First, check interlock LED. If not on, is shorting plug inserted in EXT socket on back panel of control unit? Second, check kV ON switch, it must be on. Third, check the MONITOR meter, the vacuum must be at least 0.07 Torr for the electron gun to operate, and it may be necessary to find and repair an air leak.

If the there is still no electron beam, turn off the control unit with the POWER switch. Remove the high voltage cable from the back of the control unit. Turn POWER switch on, and pumpdown the vacuum system to operating levels (0.04-0.07 Torr) and switch on kV ON. Turn the ADJUST kV knob from fully right to fully left. The MONITOR meter should move continuously from 30 kV to about 5 kV. If this does not occur, test the control unit electronics, as described below.

Unstable high voltage. Unstable high voltage in the electron gun are usually caused by a dirty electron gun, chamber or small vacuum leaks in the area around the gun. Cleaning the chamber is discussed in the maintanence section. Check for vacuum leaks using the procedures outlined above. A dirty electron gun is cleaned by disassembling the gun as described above. Remove the glass tube from the brass housing that forms the electron gun. The inside of the brass tube can be cleaned using a fine-grit silicon-carbide sandpaper or a diamond polishing compound. The gun normally has coating from being burned in at the factory. It is not necessary or desirable to remove all of this coating. In any case, the gun should be only lightly cleaned.

Control Unit Electronics Test

The SELECTOR switch changes the function of the MONITOR meter to a voltmeter. In normal operation the selector switch is turned fully to the right and the meter reads the system vacuum. The top LED next to VAC is then illuminated indicating vacuum gauge power supply is present. When a system check is required, use a small screwdriver to rotate the SELECTOR switch to the left through each position. The illuminated LED indicates which test is selected. If any of these readings are not normal (Table 2), call the Technosyn dealer for advice.

Table 2

Control Unit Electronics Test

POSITION	TEST	NORMAL RESULT ON MONITOR METER
VAC	Normal operation	Vacuum level reading[1]
A+	Analogue + supply	12 volts -/+ 1 volt
A-	Analogue - supply	12 volts -/+ 1 volt
D	Digital supply	5 volts -/+ 0.5 volt
EHT	Gun supply	21 volts -/+ 2 volts

[1] read vacuum level with vacuum pump on, VAC CONTROL valve fully closed to the right, and stage chamber closed.

Stage Maintainence

Maintaining a CL system routinely requires: (1) the gaskets be kept clean and lightly lubricated with vacuum grease; (2) volatile substances be removed from the chamber surface (fingerprints, vaporized plastics, etc.); (3) chamber window cleaned.

All cleaning that uses volatile substances should be done the night before to allow evaporation from the stage surfaces. After cleaning the CL stage will probably take longer than normal to stabilize. We usually run the stage for 5 minutes without a sample inside to allow the volatiles to vaporize.

Stage maintainence also requires that the stage be run daily to keep it in top operating condition. The daily routine is to operate the stage for five minutes with a sample in it. After a long period of inactivity, it is best to put in a sample and turn on the unit the day before actual microscopy, to minimize initial pumpdown time or indicate if the stage needs cleaning to pumpdown adequately.

Cleaning O-rings and Chamber. Remove O-rings from chamber cover. Clean the gaskets and mounts with a dry cloth and (or) cotton swab. Lightly lubricate the O-ring with Apiezon-L vacuum grease (Biddle Instruments). Routinely clean the top cover of the chamber and gun port with metal polish to remove condensed material. Rinse with freon solvent (Miller-Stephenson brand MS-180). Replace O-ring on chamber cover.

Freon-solvent-impregnated lint-free pads (Miller-Stephenson) are also useful for degreasing chamber surfaces.

Cleaning the Chamber Window. After each day's use, the chamber window should be cleaned of the material that condenses on its surface with ethyl alcohol. Alumina oxide polishing compound 0.3 micron (Buehler) in a water slurry, applied with a cloth and rubbed vigrously but lightly, does an adequate job of cleaning very dirty windows. A chrome polishing paste is also satisfactory.

REFERENCES

AMIEUX, P., 1982, Cathodoluminescence: method of sedimentological study in carbonates. Bulletin des Centres de Recherches Exploration-Production Elf-Aquitaine, v. 6, p. 437-483.

DELLY, J. G., and WILLS, W. F., JR., 1985, How to buy a compound microscope: an update. American Laboratory, v. 17, p. 66-115.

MARIANO, A. N., 1983, Macro-photography of CL. Nuclide Corporation, publication number 1080-1083.

NICKEL, E., 1979, The present status of cathode luminescence as a tool in sedimentology. Mineral Science Engineering (Johannesburg), v. 10, p. 73-100.

SOMMER, S. E., 1972, Cathodoluminescence of carbonates; 1. Characterization of cathodoluminescence from carbonate solid solutions. Chemical Geology, v. 9, p. 257-273.

APPENDIX 1

Manufacturers Addresses

Biddle Instruments, 510 Township Line Rd., Blue Bell, PA 19422. (215) 646-9200

Buehler Limited, 41 N. Waukegan Rd., Lake Bluff, IL, 60044. (312) 295-6500

Hillquist, 1545 northwest 49th St., Seattle, WA 98107. (206) 784-1960

Eastman Kodak Company, Rochester, NY 14650. (800) 225-5352

E. Lietz, Incorporated, Rockleigh, NJ 07647. (201) 767-1100

Nikon, Instrument Division, 623 Stewart Avenue, Garden City, NY 11530 (516)222-0200

Nuclide Corporation, AGV Divsion, 916 Main St., Acton, MA 01720. (617) 263-2936

Miller-Stephenson Chemical Company, Incorporated, George Washington Highway, Danbury, CO 06810. (203) 743-4447

Technosyn Limited, Coldhams, Cambridge CBI-3EW, England

Carl Ziess, Incorporated, One Zeiss Dr., Thornwood, NY 10594. (914) 747-1800

PART II

BIBLIOGRAPHY OF APPLIED CATHODOLUMINESCENCE

GENERAL REFERENCES

ADIROWITSCH, E. I., 1953, Einige fragen der lumineszenz der kristalle. Berlin Akademie. unknown pages.

AMIEUX, P., 1981, La cathodoluminescence dans les roches sedimentaires. Applications sedimentologiques et diagenetiques. Ph.D. Thesis, University of Lyon, 224 p.

AMIEUX, P., 1982, Cathodoluminescence: method of sedimentological study in carbonates. Bulletin des Centres de Recherches Exploration-Production Elf-Aquitaine, v. 6, p. 437-483. [Includes 6 color plates.]

BROECKER, W., and PFEFFERKORN, G., 1976, Bibliography on cathodoluminescence. Scanning Electron Microscopy, v. 9, p. 725-737.

CROOKES, W., 1880, Magnetic deflection of molecular trajectory -- Laws of magnetic rotation in high and low vacua -- Phosphorgenic properties of molecular discharge. Philosophical Transactions of the Royal Society of London, v. 170, part II, p. 641-662. [First description of CL phenomena.]

GARLICK, G. F. J., 1955, Absorption, emission, and storage of energy in phosphors. Journal Applied Physics, supplement no. 4, p. 85-90.

GARLICK, G. F. J., 1966, Cathodo- and radioluminescence. In Goldbert, P., (ed.), Luminescence of Inorganic Solids, Academic Press, New York, p. 685-731.

GOBEL, V. W., and PATZELT, W. J., 1976, Moglichkieten der untersuchung von festkorpern mit hilfe der KathodoLuminenzenz. Leitz Mitt. Wiss. Tech. v. 6, p. 263-277.

GRANT, P., 1978, The role of the scanning electron microscope in cathodoluminescence petrology. In Whalley, W. B., ed., Scanning electron Microscopy in the Study of Sediments, Geo-abstracts, Norwich, p. 1-11.

HARWOOD, G. M., 1982, The geological applications of cathodoluminescence. Colloquium Manchester (poster, in press). [as cited by Amieux, 1982]

HERZOG, L. F., MARSHALL, D. J., and BABIONE, R. F., 1970, The luminoscope - a new instrument for studying the electron-stimulated luminescence of terrestrial, extra-terrestrial and synthetic materials under the microscope. Pennsylvania State University, Materials Research Laboratory, Special Publication no. 70-101, p. 79-98.

HOLT, D. B., MUIR, M. D., GRANT, P. R., and BOSWARVA, I. M., 1974, Quantitative Scanning Electron Microscopy. New York, Academic Press, 507 p.

KOPP, O. C., ed., 1973, Geological Applications of Cathodoluminescence. Short course notes. University of Tennessee, Koxville.

KOPP, O. C., 1982, Cathodoluminescence petrography: a valuable tool for teaching and research. Journal of Geological Education, v. 29, p. 108-113.

KRINSLEY, D. H., and DOORNKAMP, J. C., 1973, Atlas of quartz sand surface textures. Cambridge, Cambridge University press. 93 p.

KROGER, F. A., 1948, Some aspects of the luminescence of solids. New York, Elsevier.

LEVERENZ, H. W., 1950, An introduction to luminescence of solids. Wiley, New

York, 569 p. (republished by Dover, New York in 1968).
LONG, J. V. P., 1963, Application of the electron microanalyser to metallurgy and mineralogy. In Pattee, H. H., ed., X-ray Optics and X-ray Microanalysis. [no publisher given.], p. 279-295.
LONG, J. V. P., and AGRELL, S. O., 1965, The cathodo-luminescence of minerals in thin section. Mineralogical Magazine, v. 34, p. 318-326.
MARFUNIN, A. S., 1980, Spectroscopy, luminescence and radiation centers in minerals. Springer-Verlag, Berlin, 325 p.
MARSHALL, D. J., 1976, Cathodoluminescence references. Nuclide Corporation, publication no. 1627-0476. 5 p. Updated version, 1981, publication number 1019-0281.
MARSHALL, D. J., 1981, The influence of microscope performance on cathodoluminescence observations. Nuclide Corporation, publication no. 1019-0281.
MUIR, M. D., and GRANT, P. R., 1974, Cathodoluminescence. In Holt, D. B., Muir, M. D., Grant, P. R., and Boswarva, I. M., eds., Quantitative Scanning Electron Microscopy, chapter 9. Academic Press, London.
NICKEL, E., 1979, The present status of cathode luminescence as a tool in sedimentology. Mineral Science Engineering (Johannesburg), v. 10, p. 73-100.
POTOSKY, R. A., 1967, Application of cathodoluminescence in the field of petrology. M.S. thesis, University of Tennessee, 50 p.
POTOSKY, R. A., and KOPP, O. C., 1970, Application of cathodoluminescence to petrographic studies. Compass, v. 47, p. 63-69.
PRINGSHEIM, P., and VOGEL, M., 1946, Luminescence of liquids and solids. Wiley Interscience Publishers, New York, 201 p.
REMOND, G., 1977, Applications of cathodoluminescence in mineralogy. Journal of Luminescence, v. 15, p. 121-155.
SIPPEL, R. F., 1966, Geologic applications of cathodoluminescence. Proceedings, International Conference on Luminescence, Budapest, 1966. Akademiai Kiado, Budapest, p. 2079-2084.
SMITH, J. V., and STENSTROM, R. C., 1965, Electron-excited luminescence as a petrologic tool. Journal of Geology, v. 73, p. 627-635.
SPIVAK, G. V., SAPARIN, G. V., ANTOSHIN, M. K., BOCHKO, R. A., and LADYGIN, V. M., 1973, Observations of rocks by scanning electron microscopy with the aid of color cathode luminescence. Moscow University, Vestn., Ser. Geol., v. 28, p. 44-47. [in Russian].
WEIBLEN, P., 1965, Investigation of cathodoluminescence with the petrographic microscope. In Davis, E. N., ed., Developments in Applied Spectroscopy, v. 4, Plenum Press, New York, p. 245-251.
WETZEL, W., 1939, Lumineszenzanalyse und sedimentpetrographie. Zent Bl. Mineral. Geol. Palaont., Abt. A, no. 8, p. 225-247.
WETZEL, W., 1959, Das lumineszenzmikroskopische Verhalten von sedimenten. Neus Jahrbuch fuer Geologie und Palaeontologie Abh., v. 107, p. 261-277.
WETZEL, W., 1962, Lumineszenzmikroskopische studien an chilenischen sedimenten. Neus Jahrbuch fuer Geologie und Palaontologie, Mh. 6, p. 303-308.
WHALLEY, W. B., ED., 1978, Scanning electron microscopy in the study of sediments. Norwich Geo-abstracts, 414 p.

SEDIMENTARY ROCKS

Carbonates

ADAMS, A. E., and SCHOFIELD, K. 1983, Recent submarine aragonite, magnesian calcite, and hematite cements in a gravel from Islay, Scotland. Journal of Sedimentary Petrology, v. 53, p. 417-421.

ALLEN, S. H., BECHER, J. W., FOLK, R. L., MOORE, C. H., and SMITHERMAN, J. M., 1979, Porosity in carbonate rock sequences. American Association of Petroleum Geologists, Course Notes Series no. 11, part A, 125 p.

BARKER, C. E. and HALLEY, R. B., 1984, Fluid inclusion and stable isotope evidence for the burial history of the Bone Spring Limestone, Southern Guadalupe Mountains, Texas [abst.]. Abstracts, Society of Economic Paleontologists and Mineralogists, First Annual Midyear Meeting, San Jose, California, p. 10.

BARKER, C.E. and HALLEY, R.B., in press, Fluid inclusion, stable isotope, and vitrinite reflectance evidence for the burial history of the Bone Spring Limestone, southern Guadalupe Mountains, Texas: In Gautier, D. L., ed., Society of Economic Paleontologists and Mineralogists, Special Publication. 25 manuscript pages.

BATHURST, R. G. C., 1983, Neomorphic spar versus cement in some Jurassic grainstones: Significance for evaluation of porosity evolution and compaction. Journal of the Geological Society, v. 140, p. 229-237.

BEARDALL, G. B., JR., and AL-SHIEB, Z., 1984, Dolomitization stages in a regressive sequence of Hunton Group, Anadarko Basin, Oklahoma [abst.]. American Association of Petroleum Geologists, v. 68, p. 452.

BOROKOWSKI, R., and MAZZULLO, J., 1985, Petrography of the sandy dolosparite (unit 7) in (DSDP leg 80) hole 549. Initial Reports of the deep sea drilling project, U. S. Government Printing Office, Washington, D.C., v. 80, p. 899-903.

BREINING, K. A., and LOHMANN. K. C., 1984, Diagenetic evolution of a Silurian limestone reef: Geochemical documentation of mixed-water dolomitization [abst.]. American Association of Petroleum Geologists, v. 68, p. 457.

BUDAI, J. M., LOHMANN, K. C., and OWEN, R. M., 1984, Burial dedolomite in the Mississippian Madison Limestone, Wyoming and Utah thrust Belt. Journal of Sedimentary Petrology, v. 54, p. 276-288.

BUYCE, R. M., and FRIEDMAN, B. M., 1975, Significance of authigenic K-feldspar in Cambrian-Ordovician carbonate rocks of the Proto-Atlantic Shelf in North America. Journal of Sedimentary Petrology, v. 45, p. 808-821.

CARPENTER, A. B., 1975, Effect of ferrous iron on the stability and nucleation of dolomite [abst.]. Geological Society of America, Abstracts with Programs, v. 7, p. 1019.

CARPENTER, A. B., and OGLESBY, T. W., 1976, Hydrologic significance of manganese, iron, and magnesium in calcite and dolomite cements of the Smackover Formation, eastern Mississippi. Nuclide Spectra, v. 4, no. 3, p. 1.

CARRASCO, V. B., 1973, Cathode luminescence and diagenesis of dolomitized rudists and its relation to the development of porosity. Revista del Instituto Mexicano del Petroleo, v. 5, p. 5-14. [in Spanish]

CZERNIAKOWSKI, L. A., LOHMANN, K. C., and WILSON, J. L., 1984, Closed system marine burial diagenesis: isotopic data from the Austin Chalk and its components. Sedimentology, v. 31, p. 863-877.

CHURNET, H. G., and MISRA, K. C., 1980, Zoning in dolomites as indicator of a diagenetic environment involving mixing of fresh and saline waters [abst.].

Abstracts and Programs, The Geological Society of America, v. 12, no. 4, p. 173-174.
COWAN, P. E., and MEYERS, W. J., 1982, Diagenesis of lime mud, Mississippian-age bioherms, Sacramento Mountains, New Mexico. American Association of Petroleum Geologists, v. 66, p. 559-560.
DE REENA, RAO, C. M., and KAUL, I. K., 1981. Diagenesis and thermoluminescence characteristics of the deep sea carbonate oozes from the Indian Ocean. Modern Geology, v. 7, p. 231-241.
DICKSON, J. A. D., 1983, Graphical modelling of crystal aggregates and its relevance to cement diagnosis. London Royal Philosphical Society, Transactions, Series A, v. 309, p. 465-502.
DICKSON, J. A. D., 1985, Diagenesis of shallow-marine carbonates. In Brenchley, P. J. and Williams, B. P. J., eds., Sedimentology; recent developments and applied aspects. Blackwell, London. p. 173-184.
DOROBEK, S. L., 1984, Stratigraphy, sedimentology, and diagenetic histroy of the Siluro-Devonian Helderburg Group, Central Applalachians. Ph.D. thesis, Virgina Polytechnic Institute. 252 p.
DRIESE, S. G., 1982, Sedimentology, Conodont Distribution, and Carbonate Diagenesis of the Upper Morgan Formation (Middle Pennsylvanian), Northern Utah and Colorado. Ph.D. thesis, University of Wisconsin, Madison, 289 p.
DRIESE, S. G., 1983, Diagenetic Aspects of Morgan Formation (Pennsylvanian) Shelf Carbonates, Northern Utah and Colorado. Bringham Young University Geology Studies, v. 30, p. 1-18.
FAIRCHILD, I. J., 1978, Sedimentation and post-depositional history of the Dalradian Bonahaven Formation of Islay. Ph.D. thesis, University of Nottingham. Unknown pages.
FAIRCHILD, I. J., 1980, Stages in Precambrian dolomitization, Scotland: cementing versus replacement textures. Sedimentology, v. 27, p. 631-650.
FAIRCHILD, I. J., 1983, Chemical controls of cathodoluminescence of natural dolomites and calcites: new data and review. Sedimentology, v. 30, p. 579-583.
FAUPL, P., and BERAN, A., 1983, Diagenetic alterations of radiolaria and sponge spicule-bearing rocks of the Strubberg Formation (Jurrassic, northern Calcareous Alps, Austria). Neues Jahrbuch Geologie und Palaeontologie, v. 5, p. 129-140.
FEAZEL, C. T., and SCHATZINGER, R. A., 1985, Prevention of carbonate cementation in petroleum reservoirs. In Schneidermann, N., and Harris, P. M., eds., Carbonate Cements, Society of Economic Paleontologists and Mineralogists, Special Publication 36, p. 97-106.
FERRIGNO, K. F., 1973, Paleoecology of the reef of the Holston Limestone. PhD thesis, University of Tennessee, Knoxville. unkown pages.
FERRIGNO, K. F., 1978, The use of cathodoluminescence for the interpretation of limestone environments and the identification of bryozoans. In Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 2 p.
FOX, L. A., 1979, Porosity and permeability reduction in the Nugget Sandstone, southwestern Wyoming. M. S. Thesis, University of Missouri, Columbia. 117 p.
FRANK, J. R., 1978, vug-filling calcite of the Taum Sauk Marble (Bonneterre FormaIn Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 2 p. tion) Upper Cambrian, southeast Missouri: Preliminary report. In Babcock, J., Marshall, D., and Thomas J.

B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 2 p.
FRANK, J. R., 1979, Dedolomitization in the Taum Sauk Limestone. M.A. thesis, University of Missouri, Columbia. 92 p.
FRANK, J. R., 1981, Dedolomitization in the Taum Sauk Limestone (Upper Cambrian), Southeast Missouri. Journal of Sedimentary Petrology, v. 51, p. 7-18.
FRANK, J. R., CARPENTER, A. B. and OGLESBY, T. W., 1982, Cathodoluminescence and composition of calcite cement in the Taum Sauk Limestone (Upper Cambrian), southeast Missouri. Journal of Sedimentary Petrology, v. 52, p. 631-638.
FRANK, M. H., and LOHMANN, K. C., 1982, Cathodoluminescent and isotopic analysis of diagenetically altered dolomite, Bonneterre Formation, southeast Missouri [abst.]. Abstracts and Programs, Geological Society of America, v. 14, no. 7, p. 491.
FRANKE, M. R., 1981, Natural porosity, diagenetic evolution, and experimental porosity development in Macae carbonates (Albian-Cenomanian), Campos Basin, offshore Brazil. Ph.D. thesis, University of Illinois, Urbana. 141 p.
FREEMAN, T., 1971, Morphology and composition of an Ordovician vadose cement. Nature, v. 233, p. 133-134.
FREIDMAN, G. M., 1985, The problem of submarine cement in classifying reefrock: an experience in frustration. In Schneidermann, N., and Harris, P. M., eds., Carbonate Cements, Society of Economic Paleontologists and Mineralogists, Special Publication 36, p. 117-121.
GARBER, R. A., 1976, Diagenetic patterns of Oligocene reefs in Indonesia. M.S. thesis, Rennsseler Polytechical Institute. unknown pages.
GEORGE, M., 1977, Carbonate equilibrium in the Hosston Formation, central Mississippi. M. S. thesis, University of Missouri, Columbia. 83 p.
GIVEN, R. K., and LOHMANN, K. C., 1985, Derivation of the original isotopic composition of Permian marine cements. Journal of Sedimentary Petrology, v. 55, p. 430-439.
GLOVER, E. D., 1977, Cathodoluminescence, iron and manganese content, and the early diagenesis of carbonates. Ph.D. thesis, University of Wisconsin, Madison, 465 p.
GORODY, A. W., 1980, Dolomitization and paleohydraulic history of the Lower Ordovician Mascot Formation, Upper Knox Gruop, in north central Tennessee [abst.]. Geological Society of America, Abstracts with Programs, v. 12, no. 7, p. 435.
GRAMMER, M. G., 1985, Diagenetic destruction of promary reservoir porosity in Viola Limestone, south-central Oklahoma [abst.]. Amercian Association of Petroleum Geologists, v. 69, p. 258-259.
GREGG, J. M., 1985, Regional epigenetic dolomitization in the Bonneterre Dolomite (Cambrian), southeastern Missouri. Geology, v. 13, p. 503-506.
GROVER, G. A., JR., 1981, Cement types and cementation patterns of Middle Ordovician ramp-to-basin carbonates, Virginia. Ph.D. thesis, Virginia Polytechnic Institute, 229 p.
GROVER, G. A., JR., 1984, Burial cementation of carbonates. West Texas Geological Society Bulletin, v. 23, p. 17.
GROVER, G. A., JR., and READ, J. F., 1983, Paleoaquifer and deep burial related cements defined by regional cathodoluminescent patterns, Middle Ordovician carbonates, Virginia. American Association of Petroleum Geologists, v. 67, p. 1275-1303.
GROVER, G. A., JR., and READ, J. F., 1983, Sedimentology and diagenesis of Middle Ordovician carbonate buildups, Virginia. Society of Economic

Paleontologists and Mineralogists, Core Workshop no. 4, p. 2-25.
HARRIS, D. C., and MEYERS, W. J., 1985, Carbonate cement stratigraphy of Burlington Limestone (Osagean) of Iowa: Evidence for Eh gradients in a regional Mississippian paleogroundwater system [abst.]. American Association of Petroleum Geologists, v. 69, p. 263.
HARWOOD, G., 1983, The application of cathodoluminescence in relative dating of barite mineralization in the Lower Magnesian Limestone (Upper Permian), United Kingdom. Economic Geology, v. 78, p. 1022-1027.
HEARN, P. P. jr., and SUTTER, J. F., 1985, Authigenic potassium feldspar in Cambrian carbonates: Evidence of Alleghanian brine migration. Science, v., 228, p. 1529-1531.
HILL, C. M., 1979, A diagenetic study of carbonate sediments from the Red Sea utilizing cathodoluminescence. M.S. thesis, Rennseller Polytechnic Institute. unknown pages.
JAMES, N. P., and KLAPPA, C. F., 1983, Petrogenesis of Early Cambrian reef limestones, Labrador, Canada. Journal of Sedimentary Petrology, v. 53, p. 1051-1096.
JAMES, N. P. and CHOQUETTE, P. W., 1984, Diagenesis. Part 9. Limestones - the meteoric environment. Geoscience Canada, v. 11, 161-194.
KABLANONOW, R. I., SURDAM, R. C., and PREZBINDOWSKI, D., 1984, Origin of dolomites in the Monterey Formation: Pismo and Huasna Basins, California. Society of Economic Paleontologists and Mineralogists, annual meeting, Guidebook no. 2, p. 38-49.
KASTNER, M., 1971, Authigenic feldspars in carbonate rocks. American Mineralogist, v. 56, p. 1403.
KAUFMAN, J., CANDER, H. S., and MEYERS, W. J., 1985, Near-surface and burial diagenesis of Mississippian Burlington and Keokuk Formations [abst.]. Amercian Association of Petroleum Geologists, v. 69, p. 272.
KOEPNICK, R. B., 1976, Luminescent zonation of carbonate cements in the Upper Cambrian Straight Canyon and Fera Formations of the Dugway Range, Utah. Nuclide Spectra, v. 9, no. 2, p.1.
LAMIRAUX, C., 1977, Contribution a l'etude du phemomene de cathodoluminescence appliquee a des echantillons de roche en lame mince. Rapport Elf Aquitaine, 22 p. (in press). [as cited by Amieux, 1982].
LOHMANN, K. C., and MEYERS, W. J., 1977, Microdolomite inclusions in cloudy prismatic calcites: a proposed criterion for former high-magnesium calcites. Journal of Sedimentary Petrolgy, v. 47, p. 1078-1088.
LAKE, J. H., 1981, Sedimentology and paleoecology of Upper Ordovican mounds of Anticosti Island, Quebec Lake. Canadian Journal of Earth Science, v. 18, p. 1562-1571.
MACHEL, H. G., 1982, Cathodoluminescence of calcites: activator concentrations and environmental interpretations [abst.]. 11th International Association of Sedimentologists, International Congress, Hamilton, Ontario, Canada, August 22-27, 1982, Abstracts, p. 157.
MACHEL, H. G., 1983, Cathodoluminescence in carbonate petrography; some aspects of geochemical interpretation [abst.]. American Association of Petroleum Geologists, v. 67, p. 507-508.
MANGER, W. L., RICE, W. R., HOGUE, J. I., and HOKETT, S. L., 1985, Depositonal and postdepositonal history of Stuart City Member, Edwarrds Limestone (Lower Cretaceous), Washburn Ranch Field, Lasalle County, Texas [abst.]. American Association of Petroleum Geologists, v. 69, p. 283.
MARSHALL, D. J., 1975, The status of the cathodoluminescence technique in the study of carbonates [abst.]. Abstracts, 9th International Congress of Sedimentology, Nice, France. p. 6.

MARTIN, H., and ZEEGERS, H., 1969, Cathode luminescence and distribution of manganese in upper Tournaisian limestones and dolomites, southern Ninant, Belgium. Academy of Science, C.R., series D, v. 269, p. 1922-1924. [in French].

MEYERS, W. J., 1974, Carbonate cement stratigraphy of the Lake Valley Formation (Mississippian) Sacramento Mountains, New Mexico. Journal Sedimentary Petrology, v. 44, p. 837-861.

MEYERS, W. J., 1977, Chertification in the Mississippian Lake Valley Formation, Sacramento Mountains, New Mexico. Sedimentology, v. 24, p. 75-105.

MEYERS, W. J., 1978, Carbonate cements: their regional distribution and interpretation in Mississippian limestones of southwestern New Mexico. Sedimentology, v. 25, p. 371-400.

MEYERS, W. J., and LOHMAN, K. C., 1978, Microdolomite-rich syntaxial cements: Proposed meteoric-marine mixing zone preatic cements from Mississippian limestones, New Mexico. Journal of Sedimentary Petrology, v. 48, p. 475-488.

MEYERS, W. J., and LOHMAN, K. C., 1985, Isotope geochemistry of regionally extensive calcite cement zones and marine components in Mississippian limestones, New Mexico. In Schneidermann, N., and Harris, P. M., eds., Carbonate Cements, Society of Economic Paleontologists and Mineralogists, Special Publication 36, p. 223-239.

MIDDLETON, J. A., 1979, Diagenesis of reef materials as seen through cathodoluminescence. M.S. thesis, Rennsselaer Polytechnical Institute. unknown pages.

MILINKOVICH, T., 1984, Dolomitization and luminescence stratigraphy of the Irondequoit Formation, Ontario and New York. B.S. thesis, Brock University, 88 p.

MOORE, N. K., and WALKER, K. R., 1974, Porosity occlusion in ancient reefal carbonates, with an example from the Holston Formation (Middle Ordivician) of east Tennesee [abst.]. Geological Society of America, Abstracts with Programs, v. 6, p. 1049.

MRUK, D. H., 1984, Carbonate cementation, and dolomitization of the Capitan Limestone, McKittrick Canyon, west Texas. M. S. thesis, University of Colorado, Boulder. Unknown pages.

MUKHERJEE, B., 1948, Cathodoluminescence spectra of Indian calcites, limestones, dolomites and aragonites. Indian Journal of Physics, v. 22, 305-310.

MUGRIDGE, S.-J., 1981, Cathodoluminescent zoning in Mississippian carbonate cements, southwestern Manitoba. B.S. thesis, Brandon University. unknown pages.

NEWTON, M. R., 1985, Porosity evolution in Salem Limestone (Mississippian) of south-central Indiana [abst.]. American Association of Petroleum Geologists Bulletin, v. 69, p. 292.

NIEMAN, J. C., and READ, J. F., 1985, Recognition of unconformity-sourced aquifer cements and later burial cements [abst.]. American Association of Petroleum Geologists Bulletin, v. 69, p. 293.

NORTHRUP, A., 1972, The luminescence of calcite. Rocks and Minerals, V. 47, p. 659-669.

OGIDAN, R. D., 1976, Petrography of caliche. M.S Thesis, Rensselaer Polytechnical Institute. unknown pages.

OGLESBY, T. W., 1976, A model for the distribution of manganese, iron, and magnesium in authigenic calcite and dolomite cements in the upper Smackover Formation in eastern Mississippi. M.S. thesis, University of Missouri, 122 p.

OLDERSHAW, A. E., and SCOFFIN, T. P., 1967, The source of ferroan and non-ferroan calcite cements in the Halkin and Wenlock Limestones. Geological Journal, v. 5, p. 309-320.
PACEY, N. R., in press, Luminescent properties of calcite in the English Chalk. Modern Geology.
PEDLEY, H. M., 1983, The petrology and palaeoenvironment of the Sortino Group (Miocene) of southeast Sicily. Evidence for periodic emergence. Journal of the Geological Society, v. 140, p. 335-350.
PERYT, T. M., 1981, Cathodoluminescence in studies of carbonate rocks. Przeglad Geologiczny, v. 29, p. 119-125. [in polish].
PIERSON, B. J., 1977, The control of cathodoluminescence in dolomite by iron and maganese. M. S. thesis, University of Kentucky, 85 p.
PIERSON, B. J., 1981, The control of cathodoluminescence in dolomite by iron and manganese. Sedimentology, v. 28, p. 601-610.
PIERSON, B. J., 1981, Late Cenozoic geology of the southeastern Bahama banks. Ph.D. thesis, University of Miami. Unknown pages.
POSEY, H. H., 1978, Luminescent cements of the Butterly Formation, Arbuckle Mountains, Olkahoma. In Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 2 p.
RADKE, B. M., and MATHIS, R. L., 1980, On the formation and occurrence of saddle dolomite. Journal of Sedimentary Petrology, v. 50, p. 1149-1168.
REES, M. N., BRADY, M. J., and ROWELL, A. J., 1976, Depositional environment of the Upper Cambrian Johns Wash Limestone (House Range, Utah). Journal of Sedimentary Petrology, v. 46, p. 38-47.
RENFREW, C., and PEACEY, J. S., 1968, Aegean marble: a petrological study. The Annual of the British School at Athens, p. 45-66.
RICHTER, D. K., and ZINKERNAGEL, U., 1981, Use of cathodoluminescence in carbonate petrography. Geology Rundschdau, v. 70, p. 1276-1302. (in german).
SATHYANARAYAN, S., and MULLER, G., 1982, Origin of microstructures and textures in the carbonate rocks of the Kaladgi (younger Precambrian) Group, Karnataka, India [abst.]. Congres International de Sedimentologie, v. 11, p. 158.
SCHATZINGER, R. A., 1983, Phylloid algal and sponge-bryozoan mount-to-basin transition: A Late Paleozoic facies tract from the Kelly-Snyer field, west Texas. Society of Economic Paleontologists and Mineralogists, Core Workshop no. 4, p. 244-303.
SCHOLLE, P. A., and HALLEY, R. B., 1985, Burial diagenesis, out of sight, out of mind! In Schneidermann, N., and Harris, P. M., eds., Carbonate Cements, Society of Economic Paleontologists and Mineralogists, Special Publication 36, p. 309-334.
SEITZ, J. N., 1975, A diagenetic study of Miocene carbonates from Indonesia utilizing cathodoluminescence. M.S. thesis, Rensselaer Polytechnical Institute. Unknown pages.
SHRANK, J. A., 1975, Formation of red Sea lithified layers as studied by Cathodoluminescence; Deep Sea Drilling Project Leg 23B. M.S. thesis, Rensselaer. unknown pages.
SHRANK, J. A., and FRIEDMAN, G. M., 1975, Lithified layers from sub-bottom carbonate sediments of the Red Sea: Deep Sea Drilling Project, Leg 23B [abst.]. 9th International Congress of Sedimentology, Nice, France. Abstracts, p. 4.
SIPPEL, R. F., and GLOVER, E. D., 1965, Structures in carbonate rocks made visible by luminescence petrography. Science, v. 150, p. 1283-1287.

SMITH, F. D., REEDER, R. J., and MEYERS, W. J., 1984, Fluid inclusions in Burlington Limestone (Middle Mississippian) - evidence for multiple dewatering events from Illinois Basin [abst.]. American Association of Petroleum Geologists, v. 68, p. 528-529.

SOMMER, S. E., 1972, Cathodoluminescence of carbonates; 2, Geological applications. Chemical Geology, v. 9, p. 275-284.

SUCHECKI. R. K., and HUBERT, J. F., 1984, Stable isotopic and elemental relationships of ancient shallow-marine and slope carbonates, Cambro-Ordovician Cow Head Group, Newfoundland: implications for fluid flux. Journal of Sedimentary Petrology, v. 54, p. 1062-1080.

TEN HAVE, L. E., 1979, Relationship of dolomite/limestone ratios to the structure and producing zones of the West Branch oil field, Ogemaw County, Michigan. M.S. thesis, Michigan State University, 106 p.

TUCKER, M. E., 1982, Precambrian dolomites: Petrographic and isotopic evidence that they differ from Phanerozoic dolomites. Geology, v. 10, p. 7-12.

TUCKER, M. E., 1983, Diagenesis, geochemistry, and origin of a Precambrian dolomite: The Beck Spring Dolomite of eastern California. Journal of Sedimentary Petrology, v. 53, p. 1097-1119.

TUCKER, M. E., 1985, Calcitized aragonite ooids and cements from the Late PreCambrian Biri Formation of southern Norway. Sedimentary Geology, v. 43, p. 67-84.

ULMER, D. S., 1984, Dedolomitization and calcitization of gypsum in Mississippian Arroyo Penasico Group, north-central New Mexico [abst.]. American Association of Petroleum Geologists, v. 68, p. 536.

WAGNER, P. D., and MATTHEWS, R. K., 1982, Porosity preservation in the upper Smackover (Jurassic) carbonate grainstone, Waler Creek field, Arkansas: Response of paleophreatic lenses to burial processes. Journal of Sedimentary Petrology, v. 52, p. 3-18.

WALKDEN, G., and DAVIES, J., 1983, Polyphase erosion of subaerial omission surfaces in the Late Dinantian of Anglesey, North Wales. Sedimentology, v. 30, p. 861-878.

WALKDEN, G. M., and BERRY, J. R., 1984, Syntaxial overgrowths in muddy crinoidal limestones: cathodoluminescence sheds new light on an old problem. Sedimentology, v. 31, p. 251-267.

WALKDEN, G. M., and BERRY, J. R., 1984, Natural calcite in cathodoluminecence; crystal growth during diagenesis. Nature, v. 308, p. 525-527.

WALLS, R. A., MOUNTJOY, E. W., and FRITZ, P., 1979, Isotopic composition and diagenetic history of carbonate cements in Devonian Golden Spike Reef, Alberta, Canada. Geological Society of America Bulletin, v. 90, p. 963-982.

WALLS, R. A., and BURROWES, G., 1985, The role of diagenetic history of Devonian reefs, western Canada. In Schneidermann, N., and Harris, P. M., eds., Carbonate Cements, Society of Economic Paleontologists and Mineralogists, Special Publication 36, p. 185-220.

WARD, W. C., and HALLEY, R. B., 1985, Dolomitization in a mixing zone of near-seawater composition, Late Pleistocene, northeastern Yucatan Peninsula. Journal of Sedimentary Petrology, v. 55, p. 407-420.

WIGGINS, W. D., and HARRIS, P. M., 1985, Burial diagenesis in deep-water allochtnonous dolomites, Permian Bone Spring Limestone, southeast New Mexico. Society of Economic Paleontologists and Mineralogists, Core Workshop no. 6, p. 140-173.

WILKINSON, B. H., JANECKE, S. U., and BRETT, C. E., 1982, Low-magnesian calcite marine cement in Middle Ordovician hardgrounds from Kirkfield, Ontario. Journal of Sedimentary Petrology, v. 52, p. 47-57.

WILKINSON, B. H., SMITH, A. L., and LOHMAN, K. C., 1985, Sparry calcite cement

in Upper Jurassic limestones of southeastern Wyoming. In Schneidermann, N., and Harris, P. M., eds., Carbonate Cements, Society of Economic Paleontologists and Mineralogists, Special Publication 36, p. 169-184.
YOUNG, L. M., 1985, Dolomites and early Mississippian bioherms, Leadville Formation, Molas Lake, Colorado [abst.]. American Association of Petroleum Geologists Bulletin, v. 69, p. 318.
ZIMMERIE, W., and ZINKERNAGEL, U., 1982, Petrography and diagenesis of a choice of cores from the Middle Devonian of Schwarzbachtal-1; Contribution to the petrographic studies using cathodoluminescence. Geologie Landesamt Nordrhein-Westfalen, v. 63, p. 115-139. [In German].

Siliciclastic rocks

ALLEN, P. A., MANGE-RJETZKY, M. and MATTER, A., 1985, Dynamic paleaogeography of the open Burdigalian Seaway, Swiss Molasse Basin. Eclogae Geol. Helv., v. 78, p. 351-381.
BARKER, C. E., 1978, Patterns of cementation in hydrothermally altered sediments, Cerro Prieto geothermal field, Baja California, Mexico. In Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 4 p.
BLANCHE, J. B., and WHITAKER, J. H. M., 1978, Diagenesis of part of the Brent Sand Formation (Middle Jurassic) of northern North Sea Basin. Journal of the Geological Society, v. 135, p. 73-82.
BODARD, J. M., WALL, V. J., and CAS, R. A. F., 1984, Diagenesis and the evolution of Gippsland Basin reservoirs. Australian Petroleum Exploration Association (APEA) journal, v. 24, p. 314-335.
BRENNER, R. L., MOU, D. C., and MOUSSAVI-HARAMI, R., 1980, Diagenetic studies of Pennsylvanian sandstones in Kansas and Wyoming using cathodoluminescence [abst.]. Geological Society of America, Abstracts with Programs, v. 12, no. 5, p. 220.
BUYCE, R. M., 1974, Semiquantitative analysis of detrital versus authigenic potassium-feldspar contents using cathodoluminescence. Nuclide Spectra, v. 7 no. 5., p. 1.
DENGLER, L. A., and SPRUNT, E. S., 1977, Cathodoluminescence of some quartzites from the Bergell Alps [abst.]. EOS, v. 58, p. 1239.
DUDLEY, R. J., 1976, The use of cathodoluminescence in the identification of soil minerals. Journal of Soil Science, v. 27, p. 487-494.
FUCHTBAUER, H., and MULLLER, G., 1970, Sediment petrologie: Teil II, Sedimente und sedimentgesteine. Stuttgart. E. Schweizerbartsche.
FUCHTBAUER, H., LEGGEWIE, R., GOCKELN, C., HEINEMANN, C.,, and SCHROEDER, P., 1982, Methods of quartz investigations applied to Mesozoic and Pleistocene sandstone and sands. Neus Jahrbuch Geoligie und Palaeontologie, v. 4, p. 193-210.
GARBARINI, J. M. and CARPENTER, A. B., 1978, Albitization of plagioclase by oil-field brines [abst.]. Geological Society of America, Abstracts and Programs, v. 10, no. 7, p. 406.
GRANT, P. R., and WHITE, S. H., 1978, Cathodoluminescence and microstructure of quartz overgrowths on quartz. In O'hare, ed., Scanning Electron Microscopy, 1978, p. 789-793.
HOUSEKNECHT, D. W., 1984, Influence of grain size and temperature on intergranular pressure solution, quartz cementation, and porosity in a quartzose sandstone. Journal of Sedimentary Petrology, v. 54, p. 348-361.

JANECKE, S. U., WILKINSON, B. H., and BRETT, C. E., 1980, Fabric and composition of marine phreatic cements in Middle Ordovician hardgrounds from Kirkfield, Ontario. Geological Society of America, Abstracts with progams, v. 12, no. 7, p. 455.

KASTNER, M., and SIEVER, R., 1979, Low temperature feldspars in sedimentary rocks. American Journal of Science, v. 279, p. 435-479.

KRINSLEY, D. H., 1978, The present state and future prospects of environmental discrimination by scanning electron microscopy. In Whalley, W. B., ed., Symposium on Scanning Electron Microscopy in the Study of Sediments. Geoabstracts, Norwich, p. 169-179.

KRINSELY, D. H., and HYDE, P. W., 1971, Cathodoluminescence studies of sediments. Scanning Electron Microscopy, v. 4, p. 409-416.

KRINSELY, D. H., and TOVEY, N. K., 1978, Cathodoluminescence in quartz sand grains. Scanning Electron Microscopy: International Reviews of Advanced Technical Applications of Scanning Electron Microscopy, part 1, p. 887-892.

MARIANO, A. N., 1977, The use of cathodoluminescence in evaluation of heavy minerals in beach sand. Nuclide Spectra, v. 10, no. 2, 2p.

MATTER, A., BURLEY, S. D., and MULLIS, J., 1985, Quantitative constraints on the timing of reservoir diagenesis: Application of combined cathodoluminescence microscopy and fluid inclusion thermometry. Program and Abstracts, Sixth Annual Research Conference, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists. p. 19-20

MOU, D. C., and BRENNER, R. L., 1982, Control of reservoir properties of Tensleep Sandstone by depositional and diagenetic facies: Lost Soldier Field, Wyoming. Journal of Sedimentary Petrology, v. 52, p. 367-381.

OGUNYOMI, O., MARTIN, R. F., and HESSE, R., 1981, Albite of secondary origin in Charny Sandstones, Quebec: A re-evaluation. Journal of Sedimentary Petrology, v. 51, p. 597-606.

OWEN, M. R., 1984, Sedimentary petrology and provenance of the upper Jackfork Sandstone (Morrowan), Ouachita Mountains, Arkansas, U.S.A.. Ph.D. thesis, University of Illinois, 167 p.

PAGAN, M. T., and TWEEDIE, J. A., 1980, The importance of rock characterization in North Sea reservoir description. Society of Underwater Technology and Oceanography International Symposium, Brighton, England, July 3, 1980, Proceedings Technical Session B, p. 25-32.

PAGAN, M. T., and TWEEDIE, J. A., 1981, The importance of rock characterization in North Sea reservoir description. Ocean Manage., v. 7, p. 167-187.

PITMAN, J. K., and SPRUNT, E. S., 1984, Origin and occurrence of fracture-filling cements in the Upper Cretaceous Mesaverde Formation at MWX (Multiwell experiment), Piceance Creek Basin, Colorado. U. S. Geological Survey, Open File Report no. 84-757, p. 87-101.

PITTMAN, E. D., 1979, Recent advances in sandstone diagenesis. Review of Earth and Planetary Science, v. 7, p. 39-62.

RAMSEYER, K., 1982, A new cathodoluminescence microscope and its application to sandstone diagenesis [abst.]. Abstracts, 11th International Association of Sedimentologists, International Sedimentology Congress, Hamilton, Ontario, Canada, August 22-27, 1982, p. 120.

RANGANATHAN, V., 1983, The significance of abundant K-feldspar in potassium-rich, Cambrian shales of the Appalachian Basin. Southeast Geology, v. 24, p. 139-146.

RICHTER, D. K., and ZINKERNAGEL, U., 1975, Petrography of the "Permo-Scythian" of the Jaggl-Plawen unit (southern Tyrol, Italy) and a discussion of the provenance of the detritus with aid from cathode luminescence. Geologie Rundschdau, v. 64, p. 783-807. [in German].

RUPPERT, L. F., CECIL, C. B., STANTON, R. W., and CHRISTIAN, R. P., 1985, Authigenic quartz in the Upper Freeport coal bed, west-central Pensylvannia. Journal of Sedimentary Petrology, v. 55, p. 334-339.
SANDERSON, I. D., 1984, Recognition and significance of inherited quartz overgrowths in quartz arenites. Journal of Sedimentary Petrology, v. 54, p. 473-486.
SCHLUGER, P. R., 1976, Petrology and origin of the red beds of the Perry Formation, New Brunswick, Canada, and Maine, USA. Journal of Sedimentary Petrology, v. 46, p. 22-37.
SCHOLLE, P. A., 1979, A color illustrated guide to constituents, textures, cements, and porosites of sandstones and associated rocks. American Association of Petroleum Geologists, Memoir 28, 211 p.
SIBLEY, D. F., 1975, Extension microfractures in the Tuscarora Orthoquartzite, evidence from luminescence petrography. Nuclide Spectra, v. 8, no. 1, 2 p.
SIBLEY, D. F., and BLATT, H., 1976, Intergranular pressure solution and cementation of the Tuscarora Orthoquartzite. Journal of Sedimentary Petrology, v. 46, p. 881-896.
SIPPEL, R. F., 1968, Sandstone petrology, evidence from luminscence petrography. Journal of Sedimentary Petrology, v. 38, p. 530-554,
SPIVAK, G. V., BOCHKO, R. A., SAPARIN, G. V., and ANTOSHIN, M. K., 1973, The possibility of determining the mineral composition of clay with spectral analysis of cathode luminescence and scanning electron microscopy. Moscow University, Vestn., Ser. Geol., v. 28, p. 48-51.
SPRUNT, E. S., 1977, Pressure solution, cementation, and cathodoluminescence with emphasis on quartz. Ph.D. thesis, Stanford University, 135p.
SPRUNT, E. S., 1981, Causes of quartz cathodoluminescence colors. Scanning Electron Microscopy, pt. 1, p. 525-536.
SPRUNT, E. S., and NUR, A., 1977, Destruction of porosity through pressure solution. Geophysics, v. 42, p. 726-741.
SPRUNT, E. S., and NUR, A., 1980, Another look at pore structures; cathodoluminescence petrography. SPWLA logging Symposium, Transactions, v. 21, p. B1-B16.
STALDER, P. J., 1975, Cementation of Pliocene-Quaternary fluviatile clastic deposits in and along the Oman Mountains. Geologie en Mijnb., v. 54, p. 148-156.
STOW, D. A. V., and MILLER, J., 1984, Mineralogy, petrology, and diagenesis of sediments at (DSDP Leg 75) site 530, southeast Angola Basin. In Initial Reports of the Deep Sea Drilling Project, U.S. Government Printing Office, Washington, v. 75, p. 859-873.
TAYLOR, J. M., 1950, Pore space reduction in sandstones. American Association of Petroleum Geologists Bulletin, v. 34, p. 701-716.
THOMAS, J. B., 1974, Cathodoluminescence as applied to sandstone petrology: sediment-source rock relationships. Nuclide Spectra, v. 7, no. 6., 2 p.
TOVEY, N. K., and KRINSLEY, D. H., 1980, A cathodoluminescent study of quartz sand grains. Journal of Microscopy, v. 120, p. 279-289.
WALLEM, D. B., STEIDTMANN, J. R., and SURDAM, R. C., 1981, Depositional environments and diagenesis of the Bear River Formation, western Wyoming. Wyoming Geology Association, guidebook, Energy Resources of Wyoming. p. 23-39.
WAUGH, B., 1970, Formation of quartz overgrowths in the Penrith sandstone (Lower Permian) of northwest England as revealed by scanning electron microscopy. Sedimentology, v. 14, p. 309-320.
WHITAKER, J. H. M., 1979, Diagenesis of the Brent Sand Formation: A scanning electron microscope study. In Whalley, W. B., ed., Symposium on Scanning

Electron Microscopy in the Study of Sediments. Geoabstracts, Norwich. p. 363-382.
ZINKERNAGEL, U., 1978, Cathodoluminescence of quartz and its application to sandstone petrology. E. Schweizerhartsche Verlagsbuchhandlung, Contributions to Sedimentology, no. 8, 69p.
ZINKERNAGEL, U., 1980, Framework alterations in sandstones in the course of diagenesis (cathodoluminescence studies) [abst.]. Abstracts, First European meeting, International Association of Sedimentologists, Bochum, Germany. p. 21-22.

Fossils

CARRASCO, B. V., 1973, Cathodoluminescence as an auxiliary in studying diagenesis of dolomitized rudistid shells and its relationship to the development of porosity. Revista del Instituto Mexicano del Petroleo, v. 5, p. 5-14. [in Spanish].
FERRIGNO, K. F., 1973, The use of cathodoluminescence in the study of limestone and fossils in thin section. In Kopp, O. C., ed., Geological Applications of Cathodoluminescence. Short Course Notes, University of Tennessee, Knoxville.
LOW, B. M., 1974, Analysis and interpretation of fossils in the Onondaga Formation using cathodoluminescence as compared with petrogrpahic technique of examination. B.S. thesis, McMaster University. unpaginated.
MUIR, M. D., HAMILTON, L. H., GRANT, P. R., and SPICER, R. A., 1974, A comparitive study of modern and fossil microbes, using X-ray microanalysis and cathodoluminescence. In Hall, Echlin, and Kaufmann, eds., Microprobe Analysis as Applied to Cells and Tissues. Academic Press, London, p. 33-58.
RICHTER, D. K., and ZINKERNAGEL, U., 1980, Mn-activated cathodoluminescence of echnoid tests. Proceedings, First European Regional Meeting, International Association of Sedimentologists. p. 172-176.
SMITH, M. M., BOYDE, A., and REID, S. A., 1984, Cathodoluminescence as an indicator of growth increments in the dentine in tooth plates of Triassic lungfish. Neues Jahrbuch fuer Geoligie und Palaeontologie, v. 1, p. 39-45.

IGNEOUS - METAMORPHIC ROCKS

BARNES, V. E., and MARGOLIS, S. V., 1976, Cathode luminescence and microprobe studies of Libyan desert glass and australites [abst.]. 25th International Geological Congress, Abstracts, Resumes 25, v. 2, section 15, plantetology, p. 611.
BERKLEY, J. L., BROWN, H. G., KEIL, K., CARTER, N. L., MERCIER, J.-C. C., and HUSS, G., 1976, The Kenn Ureilite: an ultramafic rock with evidence for igneous, metamorphic, and shock origin. Geochimica et Cosmochimica Acta, v. 40, p. 1429-1437.
DERHAM, C. J., GEAKE, J. E., and WALKER, G., 1964, Luminescence of enstatite achondrite meteorites. Nature, v. 203, p. 134-136.
DIETRICH, D., and GRANT, P. R., 1985, Cathodoluminescence petrography of syntectonic quartz fibres. Journal of Structural Geology, v. 5, p. 541-553.
DONAHUE, J. , 1969, Volcanic ash correlation by cathodoluminescence [abst.]. Geological Society of America, Special Paper 121, p. 78.
FRIBERG, L. V. M., and WYMER, R. E., 1978, Cathodoluminescence of metamorphic and igneous rocks from a complex Precambrian terrain, Wyoming [abst.].

Geological Society of America, Abstracts with Program, v. 10, no. 7, p. 404.
GEAKE, J. E., DOLLFUS, A., GARLICK, G. F. J., LAMB, W., WALKER, G., STEIGMANN G. A., and TITULAER, C., 1970, Luminescence, electron paramagnetic resonance and optical properties of lunar material from Apollo II. Apollo II Lunar Science Conference, v. 3, p. 2127-2147.
GEAKE, J. E., WALKER, G., MILLS, A. A., and GARLICK, G. F. J., 1971, Luminescence of Apollo lunar samples. Second Lunar Science Conference, Proceedings, v. 3, p. 2265-2275.
GEAKE, J. E., WALKER, G. and MILLS, A. A., 1972, Luminescence excitation by protons and electrons applied to Apollo lunar samples. In Urey, H. C. and Runcorn, S. K., eds., The Moon, Proceedings, Symposium of the International Astronomy Union, v. 47, p. 270-297.
GREEN, G. R., 1981, Spectroscopic studies of transition-metal luminescence centres in silicates. Ph.D. thesis, University of Manchester. Unknown pages.
GREEN, G. R., and WALKER, G., 1985, Luminescence excitation spectra of Mn^{2+} in synthetic foresterite. Phys. Chem. Minerals, v. 12, p. 271-278.
GREENMAN, N. N., and MILTON, W. B., 1968, Silicate luminescence and remote compositional mapping: Proceedings of the 6th annual meeting of the working group on extraterrestrial resources, NASA SP-177, p. 55-63.
GREENMAN, N. N., and GROSS, H. G., 1971, Luminescence of Apollo II and Apollo 12 lunar samples. Second Lunar Science Conference, v. 3, p. 2223-2233.
GREER, T. R., VAND, V., and WEBER, J. N., 1968, Applications of luminescence techniques to the study of the lunar surface. In Symposium on the Interpretation of Lunar Probe Data, Huntington Beach, California. p. 57-58.
GROEGLER, N. and LIENER, A., 1968, Cathodoluminescence and thermoluminescence observations of aubrites. In McDougall, D.J., ed., Thermoluminescence of Geological Materials, Academic Press, London, p. 569-578.
HUTCHEON, E. D., STEELE, I. M., SMITH, J. V., and CLAYTON, R. N., 1978, Ion microprobe, electron microprobe and cathodoluminescence data for Allende inclusions with emphasis on plagioclase chemistry. Geochimica Cosmochimica Acta, Supplement, V. 10, p. 1345-1368.
IMBUSCH, G. F., 1978, Inorganic Luminescence. In Lumb, M. D., ed., Luminescence Spectroscopy. Academic press, London. p. 1-92.
LEITCH, C. A., and SMITH, J. V., 1979, Striking cathodoluminescence in the Indarch enstatite chondrite. Meteorics, v. 14, p. 469-472.
LEITCH, C. A., and SMITH, J. V., 1980, Two types of clinoenstatite in Indarch enstatite chondrite. Nature, v. 283, p. 60-61.
LOEPPERT, R. H., and HOSSNER, L.R., 1984, Reactions of Fe^{2+} and Fe^{3+} with calcite. Clays and Clay Minerals, v. 32, p. 213-222.
MARIANO, A. N., 1978, Cathodoluminescence of feldspars from granite plutons of southeastern New England [abst.]. Geological Society of America, Abstracts with Programs, v. 10, no. 2, p. 74.
MARIANO, A. N., 1979, Enhancement and classification of fenitization by cathode luminescence [abst.]. Geological Society of Canada-Mineralogical Association of Canada, Program Abstracts, v. 4, p. 65.
MCKEEVER, S. W. S., and SEARS, D. W., 1980, Meteorites that glow. Sky and Telescope, v. 60, p. 14-15.
NASH, D. B., 1966, Proton-excited luminescence of silicates: Experimental results and lunar implications. Journal of Geophysical Research, v. 71, p. 2517-2534.
NASH, D. B., 1973, Experimental results on combined ultraviolet-proton excitation of moon-rock luminescence. Journal of Geophysical Research, v.

78, p. 3513-3514.
PAGE, L. E., CHAN, M. A., and TEWHEY, J. D., 1979, Cathodoluminescent zonation of anhydrite veins from the Salton Sea geothermal field, California [abst.]. Geological Society of America, Abstracts with Programs, v. 11, no. 3, p. 121.
PARK, S. L., ERWIN, J. W., NOBLE, D. C., AND MCKEE, E. H., 1983, Paleomagnetic stratigraphy, geochemistry, and source areas of Miocene ash-flow tuffs and lavas of the Badger Mountain area [abst.]. Geological Society of America, Abstracts with Programs, v. 15, no. 5, p. 281.
REID, A. M., and COHEN, A. J., 1967, Some characteristics of enstatite from enstatite achondrites. Geochimicha Cosmochimica Acta, v. 31, p. 661-672.
SIPPEL, R. F., 1971, Luminescence petrography of the Apollo 12 rocks and comparative features in terrestrial rocks and meteorites. Second Lunar Science Conference, v. 1, p. 246-263.
SIPPEL, R. F., and SPENCER, A. B., 1971, Luminescence petrography and properties of lunar crystalline rocks and breccias. Apollo II Science Conference, v. 3, p. 2413-2426.
SIPPEL, R. F., and SPENCER, A. B., 1970, Cathodoluminescence properties of lunar rocks. Science, v. 167, p. 677-679.
SPRUNT, E. S., 1981, Causes of quartz luminescence colours. Scanning Electron Microscopy, v. 1, p. 525-535.
SPRUNT, E. S., DENGLER, L. A., and SLOAN, D., 1978, Effects of metamorphism on quartz cathodoluminescence. Geology, v. 6, p. 305-308.
SPRUNT, E. S., and NUR, A., 1979, Microcracking and healing in granites; new evidence from cathodoluminescence. Science, v. 205, p. 495-497.
STEELE, I. M., and HUTCHEON, I. D., 1982, Cathodoluminescence of carbonaceous chondrites; another petrographic dimension [abst.]. Meteorics, v. 17, p. 281-282.
STEELE, I. M., SMITH, J. V., and SKIRIUS, C., 1985, Cathodoluminescence zoning and minor elements in forsterites from the Murchinson (C2) and Allende (C3V) carbonaceous chondrites. Nature, v. 313, p. 294-297.
THOMPSON, W. F., and FRIBERG, L. M., 1982, Cathodoluminescence colors and textures of Pre-Cambrian metasedimentary rocks from the Black Hills, South Dakota [abst.]. Geological Society of America, Abstracts With Programs, v. 14, no. 6, p. 352.
WEBER, J. N., GREER, R. T., and VAND, V., 1967, Electron-excited fluorescence of serpentines. Planetary and Space Science, v. 15, p. 633-642.

ORE DEPOSITS

ARMSTRONG, A. K., 1982, Petrography and cathode luminescence of carbonate rocks at Bornite, Alaska. U.S. Geological Survey Circular 844, p. 38-40.
BARKER, C. E., and BARKER, J. M., 1985, A re-evaluation of the origin and diagenesis of borate deposits, Death Valley Region, California: In Barker, J. M., and Lefond, S. J., eds., Borates--Economic Geology and Production, American Institute of Mining, Metallurgical, and Petroleum Engineers, Special Publication, p. 101-135.
COBB, L. B., 1974, A study of the distribution of trace elements (iron and manganese) and cathodoluminescent zonation in mineralized fracture fillings. M.S. thesis, University of Tennesee, 39 p.
DANSART, W. J., 1982, A petrographic study of the Josephine Breccia in the Metaline District of northeastern Washington using cathodoluminescence. M.S. thesis, University of Idaho, unknown pages.

EBERS, M. L., 1973, Cathodoluminescence study of Mississippi Valley type ore deposits [abst.]. Geological Society of America, Abstracts and Programs, v. 5, no. 5, p. 395.
EBERS, M. L., 1976, A study of gangue dolomite mineralization in the Mascot-Jefferson City zinc district, Tennessee, using cathodoluminescence. M.S. thesis, University of Tennessee, 82 p.
EBERS, M. L., 1977, Cathodoluminescent zonation microstratigraphy in gangue dolomite in the Mascot-Jefferson City District and its exploration application [abst.]. Geological Society of America, Abstracts and Programs, v. 9, no. 2, p. 136.
EBERS, M. L., and KOPP, O. C., 1979, Cathodoluminescent microstratigraphy in gangue dolomite, the Mascot-Jefferson City District, Tennessee. Economic Geology, v. 74, p. 908-918.
HAGNI, R. D., and COOPER, M., 1982, The nature of phosphorous-bearing mineral grains in the Birmingham, Alabama sedimentary iron ores and an assessment of their potential liberation by beneficiation. In Hagni, R. D., ed., Process Mineralogy II, American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 95-117.
HAGNI, R. D., 1985, Cathodoluminescence microscopy applied to mineral exploration and beneficiation. In Park, W. C., Hausen, D. M., and Hagni, R. D., eds., Applied Mineralogy, American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 41-66.
HARWOOD, G., 1983, The application of cathodoluminescence in relative dating of barite mineralization in the Lower Magnesian Limestone (Upper Permian), United Kingdom. Economic Geology, v. 78, p. 1022-1027.
ISTAS, L. S., 1983, Trace elements in veins of the Bohemia mining district, Oregon. Ph.D. Thesis, University of Washington, 150 p.
JANIK, M. G., 1982, Cathodoluminescence of gangue dolomite near lead-zinc occurrences in Stevens County, northeastern Washington. M.S. thesis, University of Idaho, unknown pages.
KOPP, O. C., LARSEN, R. M., and FERGUSON, T. L., 1983, A study of zoned dolomite and calcite gangue in the central Tennessee zinc district using cathodoluminescence microscopy and X-ray fluorescence analysis [abst.]. Geological Society of America, Abstracts with Programs, v. , p. 108.
LINDBLOM, S., 1983, A preliminary study of cathodoluminescence of calcite and sphalerite at Laisvall. ORG 83, Annual Report Ore Research Corporation, Stockholm University. p. 61-73. [Abstracted in Fluid Inclusion Reasearch, 1983, v. 16, p. 154]
MARIANO, A. N., 1978, The application of cathodoluminescence for carbonatite exploration and characterization. In de Andrade Ramos, J. R., ed., Proceedings of the First Interantional Symposium on Carbonatites, June, 1976, Pocos de Caldas, Brazil. Published by the Brazil Ministry of Minas Y Energia, p. 39-57.
MORTON, R. D., 1978, Cathodoluminescence applied to uranium exploration. Nuclide Spectra, v. 11, no. 1, 2 p.
SHEA, M., 1984, Uranium migration at some hydrothermal veins near Marysvale, Utah; a natural analog for waste isolation. Materials Research Society Symposia Proceedings, v. 26, p. 227-23?.

MINERALOGY/CHEMISTRY

ADAM, R. C. G., BIELICKI, T. A., and LANG, A. R., 1981, Correlation of electrostatic charging patterns with internal structure in diamonds.

Journal of Matelals Science, v. 16, no. 9, p. 2369-2380.
BALBERG, I., and PANKOVE, J. I., 1971, Cathodoluminescence of magnetite: Phys. Rev. Getl., v. 27, p. 1371-1374.
BARSANOV, G. P., and SARSEMBAEVA, Kh. K., 1962, Luminescence of Iceland spar. Tr. Mineralog. Muzeya. Akad. Nauk., v. 13, p. 147-152. [in Russian].
BARSANOV, G. P., SERGEEVA, N. E., YUSHKIN, N. P., SPIVAK, G. V., SAPARIN, G. V., and ANTOSHIN, M. K., 1974, Study of the composition and inner structure of sphalerite by the use of the cathode luminescence method with scanning electron microscope. Moscow University Geology Bulletin, v. 29, p. 63-66.
BHALLA, R. J. R. S. B., 1974, Electron beam damage in cathodochronic sodalite. Journal of Applied Physics, v. 45, p. 3703-3709.
BHALLA, R. J. R. S. B., 1970, Intrinsic cathodoluminescence emission from willemite single crystals. In Weber, J. W. and White, E, eds., Space Applications of Solid State Luminescence Phenomena. Pennsylvania State University, Materials Research Laboratory, Special Publication 70-101. p. 71-78.
BHALLA, R. J. R. S. B., and WHITE, E. W., 1970, Polarized cathodoluminescence emission from Willemite (Zn_2SiO_4(Mn)) Single Crystals. Journal of Applied Physics, v. 41, p. 2268-2269.
BHALLA, R. J. R. S. B., and WHITE, E. W., 1971, Intrinsic cathodoluminescence emission from willemite single crystals. Journal of Luminescence, v. 4, p. 194-200.
BLAZHEVISCH, A. I., LAVRON, A. V., and PANASYNK, E. I., 1969, Effects of acceptor-donor impurities on the cathdoluminescence of ZnS single crystals. Bulletin Acad. Sci., v. 33, p. 906-909.
BUCHANAN, R. A., WICKERSHEIM, K. A., WEAVER, J. L. and ANDERSON E. E., 1968, Cathodoluminescence properties of the rare earths in yttrium oxide. Journal of Applied Physics, v. 39, p. 4342-4347.
BURNS, R. G., 1970, Mineralogical application of crystal field theory. Cambridge University press, Cambridge. 224 p.
BURNS, R. G., and VAUGHAN, D. J., 1975, Polarized electronic spectra. In Karr, C., jr., ed., Infrared and Raman Spectroscopy of Lunar and Terrestrial materals, Academic Press, London. p. 39-72.
CASEY, M., and WILKS, J., 1972, Cathodoluminescence in deformed diamond. Nature, v. 239, p. 393-394.
CLAFFY, E. W., and GINTHER, R. J., 1959, Red-luminescencing quartz. American Mineralogist, v. 44, p. 987-994.
CHINNER, G. A., SMITH, J. V., and KNOWLES, C. R., 1969, Transition metal contents of Al_2SiO_5 polymorphs. American Journal of Science, v. 267-a, p. 96-113.
COLLINS, A. T., 1974 Visible luminescence from diamond. Industrial Diamond Review, April, p. 131-137.
COY-YLL, R., 1970, Quelques aspects de la cathodoluminescence des mineraus. Chemical Geology, v. 5, p. 243-254.
DAVIES, G., 1975, Cathodoluminescence of diamond: a short review. Diamond Research 1975, Industrial Diamond Information Bureau. p. 13-17.
DAVIES, G., 1979, Cathodoluminescence. In Field, J. E., ed., The Properties of Diamond. Academic Press, London, p. 165-181.
DE MENT, J. A., 1945, Grading gems by cathodoluminescence. Mineralogist, v. 13, p. 112-115.
DENG, HUA-XIN, 1980, Cathodoluminescence study of apatite. Geochimica, v. 4, p. 368-374.
DENNEN, W. H., 1964, Impurities in quartz. Geological Society of America Bulletin, v. 75, p. 241-246.

FONDA, G. R., 1957, Influence of activator environment on the spectral emmission of phosphors. Journal of the Optical Society of America, v. 47, p. 877-880.
GAAL, R. A. P., 1977, Cathodoluminescence of gem materials. Gems and Gemology, v. 15, p. 238-244.
GARICK, G. F. J., 1962, The kinetics and efficiency of cathodoluminescence. British Journal of Applied Physics, v. 13, p. 541-547.
GEAKE, J. G., and WALKER, G., 1975, Luminescence of minerals in the near infrared. In Karr, C., jr., ed., Infrared and Raman Spectroscopy of Lunar and Terrestrial materals, Academic Press, London. p. 73-89.
GIRAUD, R., GONI, J., and REMOND, G., 1968, Possibilites de la microanalyse par sonde electronique dan la detection des elements en traces, applications de la cathodoluminescence a letude de la localisation des elements en traces dans les mineraux. In Dosage des elements a l'etat de traces dans les roches et autres substances minerales naturelles, p. 413-432. Coll. Centre Nat. Rech. sci., v. 923. [as cited by Amieux, 1982].
GURILENKO, T. B., and KARAPETYAN, G. O., 1970, Cathodoluminescence of multicomponent silicate glasses activated with Ce. Zh. Prik Spectrosk., v. 13, p. 85-88. [in Russian].
GOLDSMITH, J. R., and LAVES, F., 1954, Potassium feldspars structurally intermediate between microcline and sanidine. Geochimica Cosmochimica Acta, v. 6, p. 100-118.
GONI, J. C., and REMOND, G., 1969, Localization and distribution of impurites in blende by cathodoluminescence. Mineralogical Magazine, v. 37, p. 153-155.
GORZ, H., BHALLA, R. J. R. S. B., and WHITE, E. W., 1970, Detailed cathodoluminescence characterization of common silicates. Pennsylvania State University, Materials Research Laboratory, Special Publication 70-101, p. 62-70.
GRITSAYENKO, G. S., and IL'IN, M. I., 1975, Solution electron microscopy of minerals; main trends and possibilities. Akad. Nauk. SSSR, Izv., ser. Geol., v. 7, p. 21-34. [in Russian].
GROGLER, N. and LIENER, A., 1968, Cathodoluminescence and thermoluminescence of aubrites. In McDougall, D. J., Thermoluminescence of Geologic Materials. Academic Press, London. p. 569-578.
HALL, A. J., 1978, Post-growth readjustment of a cassiterite twin-boundary revealed by cathodoluminescence. Mineralogical Magazine, v. 42, p. 288-290.
HALL, M. R., and RIBBE, P. H., 1971, An electron microprobe study of luminescence centers in cassiterite. American Mineralogist, v. 56, p. 31-45.
HANLEY, P. L., KIFLAWI, I., and LANG, A. R., 1977, On topographically identifiable sources of cathodoluminescence in natural diamonds. Royal Philosophical Society of London, Transactions, Series A, v. 284, p. 329-368.
HOLT, D. B., CHASE, B. D., and STEYN, J. B., 1970, Scanning electron microscopy studies of striations in ZnS. Journal of Materials Science, v. 5, p. 546-556.
HUMMEL, F. A., 1961, Cordierite-indialite: A new manganese-activated phosphor. Journal of the Electrochemistry Society, v. 108, p. unkown.
HUMMEL, F. A., and SARVER, J. F., 1964, The cathodoluminescence of Mn^{2+} - and Fe^{3+} - activated magnesium aluminate spinel. Journal of the Electrochemistry Society, v. 111, p. 252-253.
JEANROT, P., and REMOND, G., 1978, Application of electron microscopy to

mineralogy; II. Scanning electron microscopy and associated microanalysis by dispersive X-ray spectroscopy. Bulletin de Mineralogie, v. 101, p. 287-304.
KLICK, C. C., 1955, Divalent Manganese as a luminescent centre. British Journal of Applied Physics, supplement no. 4, p. 74-78.
KIFLAWI, I., and LANG, A. R., 1977, Polarised infrared cathodoluminescence from platelet defects in natural diamonds. Nature, v. 267, p. 36-37.
KITANO, Y., and FUJIYOSHI, R., 1980, Selective chemical leaching of cadmium, copper, manganese and iron in marine sediments. Geoch. J., v. 14, p. 113-122.
LELL, E., KREIDL, N. J., and HENSLER, J. R., 1966, Radiation effects in quartz, silica, and glasses. In Progress in Ceramic Science, v. 4. Pergamon, London. p. 1-93.
LANG, A. R., 1979, Internal structure. In Field, J. E., ed., The properties of diamond. Academic Press, London. p. 425-469.
LARACH, S., 1968, Cathode-ray-exctied emission spectroscopy analysis of trace rare earths. Part 1: Qualitative studies. Analyt. Chim. acta, v. 47, p. 189-195.
LAUD, K. R., GIBBONS, E. F., TIEN, T. Y., and STADLER, H. L., 1971, Cathodoluminscence of Ce^{3+} and Eu^{2+} activated alkaline earth feldspars. Journal of Electrochemistry Society, v. 118, p. 918-923.
LEHMANN, G., and BAMBAUER, H. U., 1973, Quartz crystals and their colors. Agnew. Chem. International Edition, v. 12, p. 283-291.
LOEFFLER, B. M., and BURNS, R. G., 1976, Shedding light on the colors of gems and minerals. American scientist, v. 64, p. 636-647.
MARFUNIN, A. S., 1979, Spectroscopy, luminescence, and radiation centers in minerals. Springer Verlag, Berlin. 352 p.
MARIANO, A. N., ITO, J., and RING, R. J., 1973, Catholuminescence of plagioclase feldspar [abst.]. Geological Society of America, Abstracts and programs, v. 5, no. 7, p. 726.
MARIANO, A. N., and RING, P. J., 1975, Europium-activated cathodoluminescence in minerals. Geochimica Cosmochimica Acta, v. 39, p. 649-660.
MASSE, G., ALCARDI, J. P., and LEYRIS, J. P., 1978, Study of the yellow emission of natural alpha-hgs. Journal of Luminescence, V. 17, P. 29-48.
MAZZASCHI, J., BARRAU, J., BRABANT, J. C., BROUSSEAU, M., and VOILLOT, F., 1980, Cathodoluminescence studies of defects in natural diamonds. Rev. Phys. Appl., v. 15, p. 9-14.
MCCAULEY, R. A., and HUMMEL, F. A., 1973, Luminescence as an indication of distortion in A_2^{3+} B_4^{2+} O_7 type phyrochlores. Journal of Luminescence, v. 6, p. 105-115.
MEDLIN, W. L., 1959, Thermoluminescence properties of calcite. Journal of Chem. Phys., v. 30, p. 451-458.
MEDLIN, W. L., 1961, Thermoluminescence in dolomite. Journal of Chem. Phys., v. 32, p. 672-677.
MEDLIN, W. L., 1963, Thermoluminescence in quartz. Journal of Chem. Phys., v. 38, p. 1132-1143.
MENDELSSOHN, M. J., MILLEDGE, H. J., VANCE, E. R., NAVE, E., and WOODS, P. A., 1979, Internal radioactive haloes in diamond. Diamond Research, p. 31-36.
MILLEDGE, H. J., and others, 1984, Isotopic variations in diamond in relation to cathodoluminescence. Acta Crystallographica, v. 40, supplement, p. 255.
MOHAMMED, K. M., DAVIES, G., and COLLINS A. T., 1982, Uniaxial stress measurements on optical transitions in yellow luminescencing brown diamonds. Journal of Physics, Solid State Physics, v. 15, p. 2789-?
MOORE, A. M., 1979, Optical studies of diamonds and their surfaces; a review of

the late professor tolansky's work. In Field, J. E., ed., The Properties of Diamond. Academic Press, London. p. 245-277.
NASSAU, K., 1978, The origins of color in minerals. American Mineralogist, v. 63, p. 219-229.
NASSAU, K., and PRECOTT, B. E., 1977, Smoky, blue, greenish yellow, and other irradiation-related colors in quartz. Mineralogical Magazine, v. 41, p. 301-312.
OSIKO, V. V., and MAKSIMOVA, G. V., 1960, Valence of the manganese activator in crystallophosphors. Optical Spectroscopy, v. 9, p. 478-481.
PORTNOW, A. M., and GOROBETS, B. S., 1969, Luminescence of apatite from different rock types. Doklady Akademiya Nauk SSSR, v. 184, p. 110-113. [in Russian].
REID, A. M., BUNCH, T. E., and COHEN, A. J., 1964, Luminescence of orthopyroxenes. Nature, v. 204, p. 1292-1293.
REMOND, G., and PERROT, P., 1969, Distribution of impurities in minerals made visible through cathodoluminescence [abst.]. Dan. Geol. Foren. Medd., v. 19, part 3, p. 332-333.
REMOND, G., 1973, Exemples d'indification et de localisation des elements en traces dans des mineraux luminescents (cassiterites) a l'aide de l'analseur ionique. Bull. Soc. Fr. Mineral. Cristallogr., v. 96, p. 183-198.
REMOND, G., KIMOTO, S., and OKUZUMI, H., 1970, Use of the SEM in cathodoluminescence of natural samples. Scanning Electron Microscopy, 1970, p. 33-40.
REMOND, G., KOMOTO, S., and OKUZUMI, H., 1972, Applications of scanning electron microscope to the study of cathodoluminescence of some minerals. limits of resolution and sensitivity. In Shinoda, G. ed., Proceedings of the International Conference X-ray Microanalysis, p. 611-617.
REMOND, G., LE GRESSUS, C., and OKUZUMI, H., 1979, Electron beam effects observed in cathodoluminescence and Auger electron spectroscopy in natural materials: evidence for ionic diffusion. Scanning Electron Microscopy, International Review of Advances in Technology and Application of Scanning Electron Microscopy, part 1, p. 237-242.
RIBBE, P. H., and HALL, M. R., 1966, Microprobe cathodoluminescence and X-ray emmission studies of cassiterities [abst.]. Geological Society of America, Special Paper 87, p. 135-136.
ROSS, M., PAPIKE, J. J., and WEIBLEN, P. W., 1968, Exsolution in clinoamphiboles. Science, v. 159, p. 1099-1102.
SAKSENA, D. D., and PANT, L. M., 1951, Cathodoluminescence of crystalline quartz. J. Chem. Phys., v. 19, p. 363-372.
SCHULMAN, J. E., EVANS, L. W., GINTHER, R. J., and MURATA, K. J., 1974, The sensitized luminescence of manganese-activated calcite. Journal of Applied Physics, v. 18, p. 732-739.
SPIVAK, G. V., SAPARIN, G. V., ANTOSHIN, M. K., NESTEROV, I. V., and BARSANOV, G. P., 1973, Observation of molybdoscheelite with cathode luminescence and scanning electron microscopy. Moscow University, Vestn. Ser. Geol., v. 28, p. 40-43.
SPRUNT, E. S., 1978, Effects of impurities on quartz cathodoluminescence [abst.]. EOS, v. 59, p. 1216.
SOMMER, S. E., 1969, Characterization and application of cathodoluminescence from Mn activated carbonate minerals. Ph.D. thesis, Pennslyvannia State University. 124 p.
SOMMER, S. E., 1972, Cathodoluminescence of carbonates; 1. characterization of cathodoluminescence from carbonate solid solutions. Chemical Geology, v. 9, p. 257-273.

SUMIDA, N., and LANG, A. R., 1981, Cathodoluminscence evidence of dislocation interactions in diamond. Philosophical Magazine, a, v. 43, p. 1277-1287.
TELFER, D. J., and WALKER, G., 1975, Optical detection of Fe^{3+} in lunar plagioclase. Nature, v. 258, p. 694-695.
TELFER, D. J., and WALKER, G., 1978, Ligand field bands of Mn^{2+} and Fe^{3+} luminescence centres and their site occupancy in plagioclase feldspars. Modern Geology, v. 6, p. 199-210.
WALKER, G., 1983, Luminescence centres in minerals. Chem. Britian, v. 19, p. 824-831.
WALKER, G., 1985, Mineralogical applications of luminescence techniques. In Berry, F. J., and Vaughan, D. J., eds., Chemical Bonding and Spectroscopy in Mineral Chemistry. Chapman and Hall, London. p. 103-140.
WEBER, B. C., 1963, Luminescent phenomena and zirconia research. Interceram, no. 2, p. 90-96.
WEST, S., 1978, Luminescent lithology. Science News, v. 114, p. 316-319.
WEST, S., 1980, Luminescent lithology. Journal of the Fluorescent Mineral Society, v. 9, p. 9-22.
WICKERSHEIM, K. A., BUCHANAN, R. A., and SOBON, L. E., 1968, Cathode luminescence as an analytical technique in the determination of rare earths in yttria. Analytical Chemistry, v. 40, p. 807-809.
WILDEMAN, T. R., 1970, The distribution of Mn $^{2+}$ in some carbonates by eletron spin resonance. Chemical Geology, v. 5, p. 167-177.
WILLIAMS, F. E., 1955, Theory of activator systems in luminescent solids. British Journal of Applied Physics, supplement no. 4, p. 97-102.
WOODS, G. S., and LANG, A. R., 1975, Cathodoluminescence, optical absorption and X-ray topographic studies of synthetic diamonds. Journal of Crystal Growth, v. 28, p. 215-226.
WOODS, G. S., 1976, Electron microscopy of 'giant' platelets on cube planes in diamonds. Philosophical Magazine, v. 34, p. 993-1012.

Methods

ALLEN, D., 1984, A one-stage precision polishing technique for geological specimens: Mineralogical Magazine, v. 48, p. 298-300.
AMSTUTZ, G. C., 1960, The preparation and use of polished thin sections. American Mineralogy, v. 45, p. 1114-1116.
BABCOCK, J., and MARSHALL, D., 1978, Introduction to cathodoluminescence. In Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 5 p.
BARKER, C. E., and REYNOLDS, T. J., 1984, Preparing doubly polished sections of temperature sensitive rocks. Journal of Sedimentary Petrology, v. 54, p. 635-636.
BARKER, C. E., and WOOD, T., 1986, Notes on cathodoluminescence microscopy using the Technosyn stage, and a bibliography of Applied Cathodoluminescence. U.S. Geological Survey Open File Report 86-85, 25 p.
BELL, R. T., SMYTH, J. R., and HEGE, E. K., 1966, A device for the study of cathodoluminescence [abst.]. Virginia Journal of Science, v. 17, p. 260.
BOND, E. F., BERESFORD, D., and HAGGIS, G. H., 1974, Improved cathodoluminescence microscopy. Journal of Microscopy, v. 100, p. 271-282.
BRENNER, M., 1983, Computer enhancement of low light microscopic images. American Laboratory, v. 15, p. 30-35.
BROECKER, W., HOEHLING, H. J., NICHOLSON, W. A. P., KREFTING, E. R., SCHREIBER,

J., SCHLACKE, and DRUEEN, B., 1978, Comparison of the methods of cathodoluminescence, electron probe microanalysis, and calcium staining, applied to human aorta with isthmus stenosis. Pathol., Res. Pract., v. 163, p. 310-322.
BRUMBY, G. R., and SHEPERD, T. J., 1978, Improved sample preparation for fluid inclusion studies. Mineralogical Magazine, v. 42, p. 297-298.
DELLY, J. G., and WILLS, W. F., jr., 1985, How to buy a compound microscope: an update. American Laboratory, v. 17, p. 66-115.
DICKSON, J. A. D., 1966, Carbonate identification and genesis as revealed by staining. Journal of Sedimentary Petrology, v. 36, p. 491-505.
FURBISH, W. J., 1974, Polished thin sections for cathode-luminescent study. Nuclide Corporation, Publication no. 1488-1174.
GAAL, R., 1976, Cathodoluminescence by the luminoscope. Guilds -- Conclave Issue, Boston, Massachusetts, p. 13-15.
GOBEL, V., 1978, Rapid examination and petrography of bulk samples by cathodoluminescence. In Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 1 p.
GRITSAENKO, G. S., SONYUSHKIN, V. E., ILIN, M. I., ERMILOV, V. V., and LUNEVA, O. I., 1977, Certain problems of electron petrography (the state-of-art and methodology). Lithology and Mineral Resources (USSR), v. 12, p.443-456.
GREER, R. T., and WHITE, E. W., 1967, Microprobe attachment for quantitative studies of cathodoluminescence. Transactions of the Second National Conference on Electron Microprobe Analysis, paper no. 51.
HAMILTON, T. D. S., MUNRO. I. H., and WALKER, G., 1978, Luminescence instrumentation. In Lumb, M. D., ed., Luminescence Spectroscopy. Academic Press, London. p. p. 149-238.
HANUSIAK, W. M., 1975, Low temperature cathodoluminescence of crystalline silica for use in the characterization of respirable dusts. Pennsylvania State University, Ph.D. Thesis. Unknown pages.
HANUSIAK, W. M., 1975, SEM cathodoluminescence for characterization of damaged and undamaged alpha quartz in respirable dusts. In Johari, O. M., ed., Scanning Electron Microscopy, 1975, p. 125-131.
HOLT, D. B., and DATTA, S., 1980, The cathodoluminescence mode as an analytical technique: its development and prospects. Scanning Electron Microscopy, 1980, v. 1 p. 259-278.
HURLEY, R. G., 1973, Innovations in soft x-ray spectroscopy and cathodoluminescence for quantitative phase analysis and chemical bonding characterization of materials. Ph.D. thesis, Pennsylvania State University. Unknown pages.
GOEBEL, V. W., and PATZELT, W. J., 1976, Cathodoluminescence -- investigations of solids with the Leitz contrasting device. Scientific and Technical Information, Leitz Wetzlar, v. 6, no. 7, p. 263-267.
KNISELEY, R. N., LAABS, F. C., and FASSEL, V. A., 1969, Analysis of rare earth materials by cathodoluminescence spectra excited in an electron microprobe. Analytical Chemistry, v. 41, p. 50-53.
KNISELEY, R. N. and LAABS, F. C., 1973, Applications of cathodoluminscence in electron microprobe analysis. In Anderson, C. A., ed., Microprobe Analysis, New York, John Wiley. p. 371-382.
KOPP, O. C., 1981, An inexpensive means for increasing the magnification range of a luminoscope. Journal of Sedimentary Petrology, v. 51, p. 667-668.
MARIANO, A. N., 1983, Macro-photography of CL. Nuclide Corporation, publication number 1080-1083.
MARSHALL, D. J., 1978, Suggested standards for the reporting of

cathodoluminescence results. Journal of Sedimentary Petrology, v. 48, p. 651-653.
MAZZUCOTELLI, A. and VANNUCCI, R., 1979, Determination of traces of cerium in silicates by cathodoluminescence on a $CaO-CaSO_4$ matrix after separation by ion exchange chromatography. Soc. Ital. Mineral. Petrol., Rend., v. 35, no. 2, p. 609-618.
MORAN, W., 1978, Radiation safty considerations in Cathodoluminescence observation. In Babcock, J., Marshall, D., and Thomas J. B., eds., Course Notes, Workshop on Cathodoluminescence, Geology Department, University of Tulsa, Tulsa, Oklahoma, March 8, 1978. 1 p.
MUGRIDGE, S. J., and YOUNG, H. R., 1984, Rapid preparation of polished thin sections for cathodoluminescence study of carbonate rocks. Canadian Mineralogy, v. 22, p. 513-515.
PYE, K., and KRINSLEY, D. H., 1984, Petrographic examination of sedimentary rocks in the SEM (scanning electron microscope). Journal of Sedimentary Petrology, v. 54, p. 877-888.
RYAN, D. E., and SZABO, J. P., 1981, Cathodoluminescence of detrital sands; a technique for rapid determination of the light minerals of detrital sands. Journal of Sedimentary Petrology, v. 51, p. 669-670.
SIPPEL, R. F., 1965, Simple device for luminescence petrography. Review of Scientific Instruments, v. 36, p. 1556-1558.
SOMMER, S. C., 1972, Selected area X-ray luminescence spectroscopy with the X-ray milliprobe. Applied Spectrography, v. 26, p. 557-558.
SPRAY, K. J., 1970, How to prepare relief-free polished surfaces of geological or refractory specimens. Industrial Diamond Review, v. 30, p. 182-186.
STEYN, J. B., GILES, P. and HOLT, D. B., 1976, An efficient spectroscopic detection system for cathodoluminescence mode scanning electron microscopy (SEM). Journal of Microscopy, v. 107, p. 107-128.
SZABO, J. P., and RYAN, D. E., 1980, Determination of quartz/feldspar ratios in the fine sand fraction of tills using cathodoluminescence [abst.]. Geological Society of America, Abstracts with Programs, v. 12, p. 258.
TAGGART, J. E., jr., 1977, Polishing technique for geologic samples. American Mineralogist, v. 62, p. 824-827.
WOODBURY, J. L., and VOGEL, T. A., 1970, A rapid, economical method for polishing thin sections for microprobe and petrographic analyses. American Mineralogist, v. 55, p. 2095-2102.

Fluorescence Petrography

DRAVIS, J. J. and YUREWICZ, D. A., 1985, Enhanced carboante petrography using fluorescence microscopy. Journal of Sedimentary Petrology, v. 55, p. 795-805.
LINWOOD, S. H., and WEYL, W. A., 1942, The fluorescence of manganese in glasses and crystals. Journal of the Optical Society of America, v. 32, p. 443-445.
MAIER, D., and WETZEL, W., 1958, Fluoreszenzmikroskopie geolischer und palaontologisher objevte. Zeiss Mitt., v. 1, p. 127-131.