Michel-Lévy Color Chart

Identification of minerals in polarized light



Information on Polarization Microscopy



We make it visible.

Polarization in transmitted light



Determination of birefringence by means of the Michel-Lévy Color Chart

When a ray of light enters an anisotropic medium, it is almost always split into two linearly polarized waves; the ordinary and the extraordinary ray. Both partial rays are characterized by different propagation rates due to different refraction indices. This characteristic is called birefringence. The oscillation planes of these two partial rays are perpendicular to each other.

The superposition of the two partial waves (constructive or destructive) is called interference; the colors which appear under crossed (90°) polarizers are called interference colors.



Rotating the mineral into the position of extinction

Total extinction (darkest position of mineral)





Rotating the mineral into a diagonal position

- (45° from position of extinction)
- Maximum brightness
- Identification of interference color: blue

This amounts to two distinct possibilities:

- second order blue (path difference ca 655 nm)
- third order blue (path difference ca 1150 nm)

3



Inserting the lambda compensator (Addition of a path difference of 551 nm) Assumption: second order blue (path difference ca 655 nm)

Effect: In subtraction position the mineral appears lavender- to bluegrey (655 nm - 551 nm = 104 nm)



Rotating the mineral by a further 90° Effect: In this position (addition position) the mineral appears greenish blue (655 nm + 551 nm = 1206 nm)

Result: The interference color has been identified as a second order blue.



Determining the birefringence with the Michel-Lévy Color Chart

Follow the 655 nm line of the path difference across to find the intersection with the corresponding thickness line (usually $25-30 \,\mu$ m). From this intersection, follow the "sun line" downwards towards the bottom right to pinpoint

the respective birefringence magnitude on the scale on the right. In this case this leads to a birefringence value of 0.024; the mineral has been identified as an **augite**.

		Cryolite Melilite Saponite	Halloysite β-Cristobalite α-Tricalciumphosphate	Vesuvianite Tridymite Serendibite Coesite	Orthoclase Microcline Åkermanite Kaolinite	Silicocarnotite Anorthoclase	Quartz Rankinite Tricalciumsilicate Gypsum Boracite	Gehlenite Scolecite ?-Dicalciumsilicate	Brushite Perlaite Anorthite Rhodonite Trona Wollastonite	Bustamite Boehmite	P-Dicalciumsilicate Mullite Gedrite	Thomsonite	Polyhalite Amesite	Spodumene Amblygonite Brucite Gibbsite	Sillimanite Orthoferrosilite	Larnite Gadolinite Kaersutite	Borax Montmorillonite ie	Cancrinite Stishovite	Glauconite	Calciumhydroxide	Sucrose	Dumortierite Lamprophyllite Clinoferrosilite	Stilpnomelane	Pectolite	Muscovite				hel-L or Cl		
		Analcite Leucite Apophyllite	Marialite Apatite Chabazite	Eudialyte Vanthoffite Nepheline Sanidine	Beryl Zoisite Harmotome Antigorite	C orundum Plagioclase An 20-60	Albite Celestite Struvite Bronzite Chrvsobervl	Andalusite Bytownite Natrolite	Barite Kornerupine Hypersthene Thenardite Margarite Thuringite	Jadeite Crossite	Monticellite Richterite Kyanite		Pargasite	Alunite Vermiculite Katophorite Comm. Hornbl. Glauberite	Tremolite Hastingsite	Pigeonite Omphacite Augite	Tourmaline Wavellite Hydromagnesi	Wöhlerite Fassaite Titanaugite	Phlogopite Epsomite	Paragonite Salite Hedenbergite Johannsenite	Zinnwaldite	Chondrodite Humite	Forsterite Variscite	Bischofite Olivine	Fe-Epidote Grandidierite						
		Pennine Ripidolite	Phillipsite Kämmererite	Riebeckite Chamosite Clinozoisite Arfvedsonite	T NO A	오늘	Topaz Enstatite Cordierite Axinite Epistilbite Mg-Riebeckite	Clinochlore Chloritoid Laumontite	to gr m	Epidote Picromerite	Phenakite Merwinite Syngenite	Hiortdahlite	52	Melinophan Actinolite Barkevikite Prehnite	: UE	Kainite Cookeite	Anthophyllite Glaucophane	Rosenbuschite Mizzonite Carnallite	Colemanite		Diopside	Clinonumite Allanite Rhönite	Prehnite	Kernite Lazulite	Catapleiite						
	Birefringence $(n_{\gamma} - n_{\alpha})$	-0.001	-0.003	-0.004	-0.006	-0.008	-0.009 -0.010	-0.011 -0.012	-0.013 -0.014	-0.015	-0.016 -0.017	-0.018	-0.019	-0.020 -0.021	-0.022	-0.023 -0.024	-0.025	-0.026	-0.028	-0.029	0.031	-0.032	-0.033	-0.034 -0.035	-0.036						
	αίμmj																														
Thickness	50											X														-	-0.040	Tephroite Meionite	Tilleyite Spurrite	Låvenite Nontronite	0,038 0,039
	40			+	AA	\mid						X													_	_	-0.045	Aegerine- augite Grunerite Datolite	Biotite Carborundum	Phengite Titanbiotite Anhydrite	0,041 0,043 0,044 0,045
																											-0.050 -0.055	Talc Monazite Zircon Aegirine Astrophyllite	Diaspore Cholesterole	Pyrophyllite Fayalite Ilvaite	0,041 0,043 0,044 0,045 0,047 0,048 0,049 0,050 0,052
	30																						-			_	-0.060		Silk	Piemontite	0,055
																										=	-0.065 -0.070		lende e Cellulose	Kieserite	0,060 0,063 0,065 0,070
	20																								_		-0.080 -0.090	Ascharite Anatase Siderophyllite	Maltose	Stilpno mela	0,073
	20																					-			=	—	0.050		Bicalciumferrit Brownmillerite Glucose		0,090 0,096
												-	-				-								_	_	-0.120	Baddeleyite Sphene	Carbamide	Xenotime	0,107 0,120
	10																						_	-			-0.180	Brookite Columbite Aragonite Calcite	Monocalciumf	Goethite errite Whewellite	0,140 0,150 0,156 0,172
ion													_															Magnesite Siderite			0,180 0,195 0,241 0,270
Reading direction	0																											Pyrophanite Hematite Rutile Geikielite Lepidocrocite			0,140 0,150 0,156 0,172 0,180 0,195 0,241 0,270 0,280 0,286 0,36 0,57
Readin								•							•								• •					Lepidociocite			0,57
$\overline{1}$																															
		0 40 97	158	218 234 259 267	275 281 306 332	430	505	5555 8755 8955 8955		728 747	826 843	910 910	948	666	1101 1128		1258	1334		1426	1534		1652 1682	1711 1744		→ Pa	ath differer 000nm = 1	nce [nm] 1μm = 10 ⁻³ mm)			
				200		400		600			800			1000		1200			1400			1600									
		gray	d)	y white ure white	v yellow low ow llow	wolle	ge	_		blue	nter green owish green	yellow ow		ange-red	et-red ish violet		blue	c	green	yellow	red		ole ay	e green	5				ZEI		
4		Black Iron gray Lavender	Gray blu	Clear gra Greenish Nearly pt Yellowish	Pale stra Straw ye Light yell Bright ye	Brown-y	Red-orar Red	Deep rec Purple Violet Indigo	Sky blue	Greenish Green	Lighter g Yellowish	Greenish y Pure yellov	Orange	Bright or	Dark viol Light blu	Indigo	Greenish	Sea gree	Lustrous	Greenish	Carmine r		Dull purple Violet-gray	Gray-blue Dull sea gre				١	We make i	t visihle	
т				First	Order			I		S	Second O	rder						Thi	rd Ord	ler											



Linearly and circularly polarized light



In contrast to linear polarization, circularly polarized light allows minerals to display their interference colors devoid of extinction. For that reason, circular polarization is the preferred method for image analytical procedures.

Behavior of optically anisotropic crystals in linearly and circularly polarized light, orthoscopy and conoscopy.

Determination of the optical character

	State of polarization of the light										
uniaxial	line	ar	circular								
unuxiu	compensator λ										
	without	with	without	with							
positive quartz	\Rightarrow										
negative calcite			0								

Determination of the optical character of uniaxial and biaxial minerals in linearly

and circularly polarized light. The reference direction ny of the λ -compensator is aligned in NE-SW.

	State of polarization of the light													
		lin	ear		circular									
biaxial	compensator λ													
	without	with	without	with	without	with	without	with						
	normal	position	diagonal	position	normal	position	diagonal position							
positive barite			$\langle \rangle$											
negative muskovite							P							

Highlights of minerals analysis

Auguste Michel-Lévy (1844-1911)

French geologist, Inspector General of Mining and director of the Geological Survey in France, made a name for himself by his research into extrusive rocks, their microscopic structure and origin.

Until this day, the interference color chart proposed by him in 1888 remains an important tool in the identification of thin sections of minerals with polarization microscopy.

Then as now, Carl Zeiss sets benchmarks with their polarized light microscopes, in mineralogy and petrography as well as materialography and other application fields.



Mineralogical microscope stand of 1906.



Plagioclase (feldspar) Twin lamination



Pyroxene Cleavage angle ca. 87°



Amphibole Cleavage angle ca. 124°



Kindly supported by TU Bergakademie Freiberg

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70-2-0100/e – printed 02.2011 Information subject to change. Printed on environmentally friendly paper bleached without cholorine.