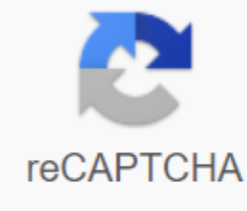




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1. 1 EARTH SCIENCES FACULTY OF SCIENCES AND TECHNOLOGY UNIVERSITY OF COIMBRA SEBENTA DE MINERALOGIA (degree in geology, geological engineering and mining engineering) Elsa Maria Carvalho Gomez 2004 - c 2. 2.1. INTRODUCTION 1.1. The definition of mineralogy is a science dedicated to the study of minerals. 1.2. History - the Greek philosopher Theophrastus (372-287 BC) - he is credited with the first written work on minerals and stones; Pliny, 400 years later (1 century AD) - author of the encyclopedic journal of mineralogy; In 1556, the physicist and mining engineer George Bauer (known by the Latin name Georgius Agricola) published a work called De Re Metallica detailing the practice of mining at that time and determining the physical properties of minerals; Nils Stenson, in Latin Nicolas Steno (1669) - demonstrated the law of permanence of interfacial corners; Abraham G. Werner (1750-1817) - standardized the item to describe minerals; Rene-Just Haüy (1743-1822) - showed that the crystals were built by laying identical blocks, which we designate as habit cells; is considered the Father of Mathematical Crystallography; - J. J. Berzelius (1779-1848) - recognized that minerals are chemical compounds and laid the foundation for chemical classification of minerals; William Nicol (1768-1851) - invented the prism of Nicholas in 1828, which allowed to study the behavior of light in crystalline substances and laid the foundations of optical mineralogy; James D. Dana (1813-1895) - published the 1st edition of the Mineralogy System in 1837; in the 4th edition (1854) a chemical classification of minerals was introduced, which is still in use today; Max von Laue (1912) - demonstrated that crystals diffract X-rays; William Henry Bragg, William Lawrence Bragg (1914) - used X-rays to determine the crystalline structure of minerals. 20th century - Electronic micro-tests; TEM - Transmission electron microscope. 3. 3.1.3. The mineral definition is a homogeneous solid, natural, with a specific chemical composition (but not necessarily fixed) and a highly ordered atomic location. It is usually shaped by inorganic processes. 1. It is a homogeneous solid, that is, consists of one solid, which cannot be physically divided into simpler chemical compounds. Gases and liquids are excluded. 2. Industrial and research laboratories produce synthetic equivalents of many natural materials, including gemstones. The chemical composition, which will be determined in the near future, can be expressed by a specific chemical formula. 4. Atomic Agreement indicates the internal structure of atoms or ions that define the usual geometric pattern. 5. According to the traditional definition, the mineral is formed as a result of inorganic processes. If we add the word normally, we can include organically produced compounds in the mineralogy area that meet all other requirements necessary. 1.4. The definition of mineraloids are mineral-like materials, but without a crystalline structure. Examples include opal (SiO<sub>2</sub> amorphous), Minerals you and Th, such as zircon (ZrSiO<sub>4</sub>), where the original crystalline is destroyed by radiation from radioactive elements present in the original structure (metamorphic minerals) and volcanic glass. 1.5. Crystalline definition When conditions are favorable, minerals can be limited to flat, smooth surfaces and take the usual geometric shapes known as crystals. Thus, in the traditional sense, the term crystal denotes the usual geometric solid, limited by flat and smooth surfaces, which are the outer expression of the regular internal arrangement of ions or composite atoms; this definition implies a sense of perfection in development. Today, many scientists use the term crystal to describe any solid body with an orderly internal structure, neglecting whether it has an external face. This definition is reasonable because the person is essentially the height of the accident and its 4. 4. Absence does not change the fundamental properties of the crystal. The broader definition of a crystal can be: homogeneous solid with three-dimensional internal order. Microcrystal matter If crystalline substances are found in fine-grained aggregates visible only under a microscope, they are called a microcrystalline substance. Cryptocrystalline matter If the aggregates are so thin that grains can only be identified by X-rays, the designation cryptocrystalline (crypto-hidden) is used. Euhedrine Crystalline is solid with well-defined faces (from Greek hedron means face - Greek prefix eu meaning anything or something) (Figure 1b). Anecdotal Solid without a face (from the Greek hedron means face - Greek prefix an meaning sem) (Figure 1c). 2. CRYSTALLOGRAPHY 2.1. Crystallography definition crystallography describes the shape, symmetry and crystalline structure of minerals. Crystallography connects the crystalline structure of minerals with their outer form. 2.2. Rene-Juste Haüy's reticular theory has introduced the concept of integral molecules (appropriate to the modern concept of cell unit) that, regularly stacked, develop different forms (Figure 2). A unit cell is the smallest unit of a structure or pattern that can be endlessly repeated to generate the entire structure. The crystalline structure or internal order in crystals is the result of the repetition of the motif (chemical units - atoms or ions) in regular three-dimensional translations. Orderly patterns represent a lower energy state than random patterns (Figure 3). 5. 5 Figure 1. Feature of the shape of the crystal in the hand sample: (a) euhedral crystals, (b) subhedral crystals, (c) anhydrous crystals (BORGES, 1996). 6. 6 Figure 2. Various external forms produced by laying cubic unit cells: (a) ideal cube, (b) distorted cubes, (c) octahedron and (d) dodecahedron (KLEIN and HURLBUT, 1999). Octahedron and dodecahedron forms are the result of systematic additions of units along accelerated growth lines. Figure 3. The wall, built of identical bricks, is arranged in an orderly manner, providing a more stable configuration and less energy than a wall built of bricks, arranged in a random way (KLEIN and HURLBUT, 1999). 7. 7 2.2.1. One-dimensional order (queues) Consider point O (Figure 4), which is a chemical block that is repeated by translation, according to direction y and distance b. Points generated in this way are marked by homologous dots or nodes, and the constant distance separated by two consecutive homologous points is the queue parameter (vector b). The sequence of homologous dots, equally distributed in this direction, is a reticular queue. 2.2.2. Two-dimensional order (flat grids) Two-dimensional order is the result of regular translations in two different directions, called x and y. Figure 4 shows the usual two-dimensional pattern, produced at two different intervals a and b and an angle between directions x and y, except 90 and 60 and 120 degrees. The two-dimensional network created in this way is called a flat grid. Regularly marked dots, or nodes, represent the location of atoms, ions, molecules or ion complexes. The smallest piece of structure in a two-dimensional pattern is a parallelogram shaded in Figure 4 (cell unit). If this cell unit is repeated indefinitely by a and b, x and y, the result is the grid represented in Figure 4. The primary grid of the grid is defined by bursts, the parameters of which are equal to the shortest distances separating which separate homologous dots (Figure 5). Secondary mesh mesh, the sides of which do not correspond to the shortest distances, which are seam homologous points (Figure 5). Conjugated queues When there is no place in the queue outside the nodes, the queue is considered to be conjugated (Figure 5). Undeveloped queues When there are points outside the nodes in the queue unconjugated (Figure 5). There are only 5 types of possible flat grids that depend on the angle between x and y and measurements relative to b (Figure 6). These 5 grids are illustrated in Figure 6 and are called: - Square mesh; - Primitive rectangular mesh (P) - only with nodes on the vertices of the block cells; 8. 8 Figure 4. A flat grid defined by queue parameters A and B and the angle between x and y. Parallelogram is the smallest unit of the template (KLEIN and HURLBUT, 1999). Figure 5. Primary grid (Ob1a1c1) and secondary grid (Oc1b1d1). Conjugated queues (Oa2 and Ob4) and nerveless queue (Oc2). About A1 b1 c1 d1 y x c2 d2 b2 b3 b4 a2 9. 9 Figure 6. Types of flat nets (a) and unit cells (b) (NESSE, 2000). Square a-b-90o Rectangular P a-b 90o Rectangular C a-b cos'a/2b Hexagonal a'b 120o Coslick a-b-90o Parallelogram Losangole C Rectangle P Square 10. 10 - Central rectangular mesh (C) - has nodes in the vertices and center of the cell block; Hexagonal mesh; - Oblique mesh. There are no grids with a pentagonal or crevice base, because with a successive repetition of a cell unit it would be impossible to cover the entire reticular plane without leaving empty spaces (Figure 7). Figure 7. Pentagon and octagonal grids are not possible, because when a cell repeats, it is impossible to cover the entire reticular plane without leaving empty spaces. 2.2.3. Three-dimensional order (space grids) 3D grids can be built by adding a vector direction to flat grids in Figure 6. This third vector does not belong to the two-dimensional grid plane. Cell unit edges are marked A, B and C and angles between the axes of coordinates, x, y and z, y and q, y, - angle between b and c - the angle between a and c and th angle between A and B. Cell size is expressed in angstrom (1 x 10<sup>-8</sup> cm) 11. Identified 11 14 different types of spatial grids (including one and several grids) known as bravais meshes (Figure 8): Cubic or isometric mesh (P, F and I); Tetragonal mesh (P and I); Orthorhombic grid (P, C, F and I); Monoclinic mesh (P and I); Triclinic mesh (P); hexagonal mesh (P or C); Rombohedric or Trigonal Grid (R). According to Figure 8, Bravais grids have six types: Primitive or simple, P only homologous dots or nodes near vertices; There are 7 primitive nets. In the center or center of the body, I have homologous dots on the vertical and center of the cell; In the center of the face, F has homologous dots on the vertical and center of all persons; Centered bases, C Have homologous dots on the vertical and in the center of the face perpendicular to c; T has can be A or B if a pair of persons with homologous dots in its center is perpendicular to A or b, respectively (Side-centered); Multiplicity - Multiple corresponds to the number of nodes contained in multiple grids (table 1). Each knot in the mesh top is common for 8 grids; Each node at the end of the grid is common for 4 grids; Each knot on the face mesh is common for 2 grids; Each node inside the grid belongs only to him. The volume of multiple grids is greater than the volume of any single grid, which is determined in a single distribution of nodes. The multiplicity of the network is given by the ratio between these volumes. For example, a centered hub has a four-fold volume of any single grid, which is determined in the same distribution of nodes. 12. 12 Figure 8. 14 Bravais nets (KLEIN and HURLBUT, 1999). Triclinic a-b-c 90o Tetragonal orthorhombic a-b-s-; 90o hexagonal axagonal a-b-s-; 90o; 120o Rombohedrica a'bus; F-90o Cubic a'b'k 90o Monoclinic a-b-c 90o (or C) 13. 13 Table 1. Cell diversity. Grid Symbol Primitive Versatility P 8x1/8'1 Side Center (100) A 8x1/8'2x1/2'2 Side Center (010) B 8x1/8'2x1/2'2 Centered Persons F 8x1/8'6x1/2'4 Centered I 8x1/8'1'1'2 Romboheric R 1 1 Also in three-dimensional mechanisms the number of possible block cells is limited. Restrictions on cell unit selection are as follows: 1. Cell unit edges must correspond to grid symmetry (item 2.3) if possible; 2. The edges must be linked to each other by grid symmetry (paragraph 2.3); 3. The cell is usually the smallest possible, meeting the requirements 1 and 2, i.e. it must have full symmetry; 4. Cell unit must have a fundamental possibility of repetition in three directions to build a crystal without leaving empty spaces. 2.3. Operations and elements of symmetry The concept of symmetry implies repetition, which examines two fundamental entities: motive (which is repeated) and period or rhythm (the law of repetition). The rhythm is constant and is the result of symmetry operations that can be identified through so-called repetition operators, symmetry operators or symmetry elements. Symmetry elements or operators are geometric objects (points - symmetry centers, lines - axis of rotation or plane - mirror planes), for which symmetrical operations (translations, rotations, reflections, inversions, etc.) are processed. Translation is a repetitive operation consisting of shifting the subject in parallel with itself. The snooze statement is vector (T) 9. 14. 14 2.3.2. Rotation is an operation that consists of repeating an object by angular frequency; being a periodic repetition in which each piece comes from the previous and generates the following, after a certain number of repetitions of the operation necessarily coincides with the original figure. The corresponding symmetry statement, right around which you can imagine the rotation of the object, is indicated by the rotation axis (Figure 10). The rotation angle is 360o alicite. Depending on their class, the axes are designated as: n'1 a mona axis; axis of torque n'2; n-3 thorn shafts; n-4 quarter-axis; axis n'5 kinaria; Axis trap n'6; n Class 7 axis; n'n axis class n. In crystals axes can be: 1 class (monoristic, No 360o), 2nd class (binary, No 180o), 3rd class (ternar, No 120o), 4 class (quaternary, 90o) and class 6 (old, No 60o), depending on the number of times when the object is visible in rotation (Ris1). In the descriptive crystallography of the rotation axis are represented by the letter E, accompanied by an index relative to the degree of the axis or, to put it simply, the



due to the fact that some fluorites (CaF<sub>2</sub>) represent this property. Some examples: Autunite (Ca(UO<sub>2</sub>)<sub>2</sub>(PO<sub>4</sub>)<sub>2</sub>·10-12H<sub>2</sub>O), yellow, turns green fluorescence; - scheelite (CaWO<sub>4</sub>) emits bluish light when illuminated by ultraviolet light, in connection with the replacement of W Mo; Fluorite represents fluorescence in shades of blue due to the presence of organic matter or rare earth; Calcite fluorescence due to the presence of Mn. If luminescence persists after removing a source of radiation called phosphorescence. These as a result of the absorption of radiant energy by electrons from the most external layers (valence electrons) or electrons associated with mesh defects. Thermoluminescence Thermoluminescence is called the emanation of visible light due to heating below the glowing point. Calcite, apatite, esoolith, fluorite and some feldspars are thermoluminescent. Thermoluminescence is usually stronger between 50 and 100oC and stops above 475oC. 59. 59 Triboluminescence Triboluminescence is caused by pressure, crushing or friction. Many minerals that own this property are non-metallic and have perfect cleavage: fluorite, mixture and lepidolyth. 3.12. Electrical properties Electrical conductivity The ability of minerals to conduct electricity depends on the nature of chemical compounds. Minerals with metal compounds, such as local metals (e.g. copper from electrical cables), are excellent conductors because electrons can migrate freely through a crystalline structure. Minerals with covalent or ion bonds are non-wires or insulators. Crystal substances with intermediate conductivity between conductors and insulators are called semiconductors. Because electrical conductivity depends on chemical bonds, it varies depending on the direction in non-isometric minerals. In graphite (hexagonal system), for example, electrical conduction is more parallel to the blades, i.e. perpendicular to the C axis, than parallel c. Piezoelectricity In 1880, brothers Pierre and Jack Curie demonstrated that when crystals are subjected to pressure in certain directions, they acquire an electric field, leaving the surface of the crystal positively charged and negatively charged. This property is called a direct piezoelectric effect. Common piezoelectric minerals: quartz (SiO<sub>2</sub>), topaz (Al<sub>2</sub>SiO<sub>4</sub>(F,OH) and tourmaline NaFe<sub>3</sub>Al<sub>6</sub>(BO<sub>3</sub>)<sub>3</sub>Si<sub>6</sub>O<sub>18</sub>(OH)<sub>4</sub>. Although not of great importance from a geological point of view, it is extremely important for industry and high technology. what happens to silica tetraedre. If the tetraedre is deformed, pushing down the anion O<sub>2</sub>- identified by the letter p, Cation Si<sub>4</sub>, in the middle of the tetraedra, also shifts down according to the distance d, and the three O<sub>2</sub> anion- at the base stretch, so that the lengths of four Si-O remain the same. These changes cause the load to move. Compared to the original configuration, 60. 60 tetraedre becomes positively charged at the base and negatively charged at the top. Since the quartz lacks a center of symmetry, the voltage produced by this silica tetraedron is not compensated by reverse voltage in another tetraedra. Thus, the whole crystal becomes positive on the one hand and negative on the other. Figure 54..Diaphanous levels between opaque (1) and transparent (4). Figure 55..Piezoelectricity. (a) Silica tetraedre consisting of Si<sub>4</sub> cation in the middle of 4 O<sub>2</sub>-anions. (b) Pressure-deformed silica tetraedre. 61. 61 Just as the deformation of the piezoelectric crystal produces tension, the use of voltage can lead to deformation. This phenomenon is called reverse piezoelectric effect. Piezoelectricity is a vector property that occurs only in species without a center of symmetry. The only exceptions are 432 (3E<sub>4</sub> 4E<sub>3</sub> 6E<sub>2</sub>) crystals, which have no symmetry center, but whose symmetry elements prevent this property from manifesting. The absence of a center of symmetry allows the manifestation of piezoelectric effect in 20 of the 32 symmetry classes. Pyroelectricity Pyroelectricity is an electrical property manifested by the shift of positive and negative charges and the development of voltage effect of temperature change. Heat causes distortions in the crystal mesh, such as piezoelectric deformation. This property occurs only in crystals with one polar axis belonging to 10 of the 20 classes of symmetry considered for piezoelectric crystals. Tourmaline is an example of pyroelectric mineral. Turmalin has only one polar axis c, while quartz has three (a axis) and does not belong to a group of 10 symmetry classes. When heated and exposed to sulphuric and lead powder, the sulfur attracts the face of a positively charged crystal, while the lead powder attracts a negatively charged face. 3.13. The magnetic properties of minerals, as to their behavior in the magnetic field, are classified as: Diamagnetic; Paramagnet; Ferromagnet; Antiferromagnetic and ferrimagnetic. The magnetic properties of minerals are the result of magnetic fields produced by the movement of electrons around the nucleus and the rotational motion of electrons around themselves (spin). When the crystal is under the influence of an external magnetic field, a force is generated that tends to align the magnetic fields of atoms to produce a magnetic moment for the entire crystal. Magnetic susceptibility (K) is the relationship between the magnetic moment (M) received and the intensity of the outer field To M/H. 62. 62 Diamagnetic minerals have small negative K values and are slightly repelled by the field (examples: calcite, plagioclase, quartz). Paramagnetic minerals have a slight positive K value and slightly attract the magnetic field, although magnetization is not permanent (examples: minerals consisting of Fe, Ti, Mn and Cr, such as olivine and pyroxen). Diamagnetic and paramagnetic minerals do not retain a magnetic moment after the removal of the external magnetic field. Ferromagnetic minerals are strongly attracted to the magnetic field, even weak, and constantly magnetized. The ferromagnetic substance has domains containing a large number of paramagnetic atoms with aligned dipoles. These domains are randomly oriented and as a result the magnetic moment is zero (Figure 56a). When placed under the influence of an external field, domains are aligned according to the orientation imposed by that field (Figure 56b). Ferromagnetic minerals lose only magnetization above the Curie point (770oC for metal iron), becoming paramagnetic. Antiferromagnetism is the result of the interaction of adjacent atoms, which leads to the alignment of spins in parallel, but in opposite directions, called anti-parallel spins. Two magnetic moments are canceled, and there is no permanent magnetic moment. In ferrimagnetel minerals, the moments of anti-parallel spin are not equal and, as a result, there is constant magnetization. Substances with this behavior are said to be ferrimagnetic. Magnetite (Fe<sub>3</sub>O<sub>4</sub>) and pyrrhotite (Fe<sub>1-x</sub>S) are ferrimagnetic minerals. The magnetite formula can be written by Fe<sub>3</sub>(Fe<sup>2+</sup> Fe<sup>3+</sup>)O<sub>4</sub> taking into account the overall shape of the XY<sub>2</sub>O<sub>4</sub> spinel group. Knowing that in magnetite 8, we have 8 X cations in tetra-etrал positions and 16 Y cations in octageeetrал positions per unit of formula. Fe<sup>3+</sup>'s ions are distributed in two different mesh positions, but with opposite magnetic spin directions. Fe<sup>2+</sup> ions (with a lower magnetic pulse) are responsible for permanent magnetic domains in magnetite (Figure 57). 63. 63 Figure 56. Magnetic domains in ferromagnetic solid (KLEIN and HURLBUT, 2000). (a) Random domains in demagoguery. (b) Parallel domain alignment under the influence of an external magnetic field. Figure 57. (a) In ferrimagnetic solids, the backs are anti-parallel and have different sizes. In ferromagnetic solids the backs are parallel and aligned in one direction (KLEIN and HURLBUT, 2000). (b) A schematic representation of spin directions in tetraedral and octaeadal magnetite positions Fe<sup>3+</sup> (Fe<sup>2+</sup> Fe<sup>3+</sup>) (KLEIN and HURLBUT, 2000). Ferrimagneism 8 tetraetral positions 16 octageeetrал positions 64. 64 4. OPTICAL PROPERTIES OF MINERALS 4.1. Light Radiant energy has electrical and magnetic properties and is therefore called electromagnetic radiation. Electrical and magnetic components vibrate, making the right angles with the direction of distribution (Figure 58a). The interaction between electric waves and crystals is usually much stronger than the interaction between magnetic waves and crystals, so we will only consider the electrical properties of light. Thus, light is characterized by wavelength (l, nm), frequency (me, cycles/sec or Hz) and speed (V, nm/sec), according to the ratio of V and q. Wavelength represents the distance between the two nearest points in the same vibration phase (Figure 58b). Frequency is the number of vibrations or cycles per second (Figure 58b). Visible light has wavelengths ranging from 390 nm to 770 nm (3900 to 7700 euros). Different wavelengths correspond to different colors (Figure 52). Lower wavelengths correspond to purple light, and the highest - red. White light consists of all wavelengths of primary colors. This is called polychromatic white light because it contains interval, or spectrum, wavelengths. In addition to V, and, light is characterized by amplitude (A) and phase. Amplitude refers to the intensity of waves (Figure 58b). The phase refers to the movement of the wave up or down at a certain point. If two waves move up and down at the same time, they are said to be in phase. That is, if the moment of the electric field of one of the emitter is maximum in a certain sense or the other also, the two fields add up and the intensity increases (constructive intervention). If the fields corresponding to the two radiations are simultaneously maximum, but in opposite directions, the resulting field is zero, and the intensity of light is also zero (destructive intervention). The nature of the intervention depends on the relationship between wavelengths and phases. Light waves that pass through crystals can have different wavelengths, amplitudes and phases, depending on the atomic structure. Interference phenomena give minerals a variety of optical properties. 65. 65 Figure 58. Electromagnetic radiation (NESSE, 2000). (a) Periodic change in the electrical and magnetic fields of radiation (b) The wave moves at V speed; Wavelength is the distance between two successive ridges; Frequency (k) is the number of ridges that pass at point per second; Amplitude (A) is the maximum distance from the equilibrium position; brightness is proportional to the square of the amplitude. Figure Reflected and refracted light (KLEIN and HURLBUT, 1999). Figure 60. Beams of light moved from glass into the air. Critical Angle (CA) and Full Reflection (Radius D) (KLEIN and HURLBUT, 1999). Electric Field Magnetic Field Direction Glass Distribution Glass n-1.52 AC 66. 66 4.2. Reflection and refraction When light passes from a rarefied environment, such as air, to a denser environment, such as glass, part is reflected by the surface and the other part crosses the glass (Figure 59). Reflected rays are subject to the laws of reflection: (a) the angle of frequency (i) is equal to the angle of reflection (r'), measured in relation to a normal surface, which between two means; (b) The radius of the incident and the reflected radius belong to the same plane. The light that penetrates through the glass moves at a slower speed than in the air, and does not follow the trajectory of the beam accident, being refracted. The tilt of the refracted radius depends on the oblique zone of the incident and the relative speed of light in the two media. The higher the angle of morbidity and the greater the difference in speed, the greater the refraction. The refraction index (n) of the substance is expressed in the relationship between the speed of light in the air (Va) and the speed of light in the substance (Vs). As a comparison, the speed of light in a vacuum is considered to be 1. In the air, the speed of light is 0.9997 and is therefore also considered unitary. Thus, the refraction index is the reverse speed index n No. 1 / v Under normal conditions, the air refraction index is 1.00029. Because the speed of light in a denser environment than air is always lower, n is always more than 1. High n values correspond to materials that slowly transmit light. When light passes from air to most opaque minerals, their speed drops by 1/3 or 1/2. Since the frequency remains constant the wavelength should decrease a similar proportion. Most minerals have a refraction index between 1.5 and 2.0. The relationship between the angle of morbidity and the angle of refraction is given by Snell's law, which states that for two means Sen i/sen r is a permanent hay i/ sen r n Total reflection and the critical angle of light can always be refracted when it goes from an environment with a lower refraction index to a medium with a higher refraction index, because the refraction angle is smaller than the angle of frequency, that is, the angle of the refraction is smaller than the angle of the frequency. When conditions change and light moves from a higher refraction index to an environment with a lower refraction index, it is refracted, moving from normal to the dividing surface of the two environments (Figure 60). The higher the oblation of the incident radius, the greater the refraction angle. The critical angle (CA) is the angle which results in a 90-degree refraction angle. Rays with disease angles of more than 67. The 67 critical angles are fully reflected within the environment of the higher index. If refraction rates are known the critical angle can be calculated from the law of Snell, making i equal to accom xi and r equals 90 . Sep AC No Va / Vs 4.3. Isotropic and anisotropic crystals In isotropic materials light moves in all directions at the same speed and, therefore, isotropic substances have a single refraction index. Isotropic substances are gases, liquids, glass and crystals of the cubic system. In anisotropic materials, the speed of light varies depending on the crystallographic direction and therefore has more than one refraction index. All crystals, except cubic systems, are anisotropic. As a rule, the light passing through the anisotropic crystal decomposes into two polarized beams, which vibrate in mutually perpendicular planes. Thus, for this orientation, the crystal has two refractive indexes associated with each of the polarized rays. 4.4. Polarized sunlight or a normal lamp vibrates in all directions, making the right angles with the spread side (Figure 61a). When vibration is limited to one plane, light is said to be polarized (Figure 61b). Three main ways to get polarized light: double refraction, absorption and reflection. Light polarized by double refraction It was reported that when light passes through an anisotropic crystal, it is divided into two polarized beams. The principle on which the first polarizer was based is to eliminate one of these rays. The crystalline material used was a transparent variety of calcite, island's slot, and the polarizer was named Nicholas's prism, according to its inventor William Nicola. Calcite has a double refraction so strong that each beam produces a separate image when the object is observed through the surface of the fission. In the construction of the Nikolna prism (Figure 62), the cleavage gap of calcite is cut at a certain angle, and the two halves are glued to balm from Canada. The faces are then chopped at the ends of the prism to make 90 corners with a cemented surface. When entering the prism, the light decomposes into two O and E beams. Radius E, with a refraction index similar to a balm, is virtually unsalted and appears as a polarized light. 68. 68 Figure 61. (a) Non-polarized light vibrating in all directions is perpendicular to the direction of propagation. (b) Polarized light; electric vector vibrates in one plane (NESSE, 2000). Figure 62. Nicole (KLEIN and HURLBUT, 1999). Optical axis 69. 69 Light, polarized by absorption In some anisotropic crystals, light is divided into two beams, one of which is completely absorbed. The resulting light is polarized, and the direction of vibration depends on the orientation of the crystal. This is the principle underlying polarizing filters. In modern microscopes polarizers are plastic, but the first models use natural crystals. Minerals that strongly absorb one beam and allow the passage of another are called diricos and have a different color depending on the direction in which light passes through them. Some varieties of tourmaline diholita. The reflection of polarized light reflected by a soft non-metallic surface is partially polarized with the direction of vibration parallel to the reflective surface. The degree of polarization depends on the angle of morbidity (Figure 63) and the reflective surface refraction index. It is almost completely polarized when the angle between the reflected and refracted radius is 90 (Brewster's Law). 4.5. The polarizing microscope Polarizing Microscope (Figure 64), also called the petrographic microscope, is a fundamental tool in the study of minerals and rocks. At the base of the lamp provides a white light source. Light passes through the filters and diaphragm before reaching platinum and the blade is slender. One of the most important filters is the polarizer, which curbs the vibration of light on one plane. In modern polarizing microscopes, the polarizer only allows the passage of light, which vibrates in the east-west direction. In old microscopes, the polarizer is oriented north-south. A fixed capacitor and a subplatinum aperture help the center of light in the sample. We can insert a special lens (converged lens) between the polarizer and the platinum that produces converged light. This lens, also called a capacitor, comes off a beam of light rays at the point of the sample. The microscope platinum can rotate to change the orientation of the sample relative to polarized light. The interference of light with anisotropic crystals varies when we run platinum. The calibrated angular scale allows you to accurately measure the orientation of the crystal. The scale is also used to measure angles between splits, crystal faces, macula planes and some optical properties. Above the platinum rotating lat contains several lenses, usually with an increase of 4x, 10x and 40x. Oculars additional lenses that provide an 8x or 10x increase. Binocular microscopes have two oculars. One of the eyepieces may be 70. 70 two perpendicular wires (styk wire) needed to measure With platinum. We can insert other filters and lenses between lenses and eyepieces when necessary. The upper polarizer, called the analyzer, can be inserted or removed from the trajectory of the light beam and is oriented to 90 degrees of the lower polarizer. Without a sample in platinum, and with the analyzer stuck, the light polarized by the lower polarizer does not reach the eye because it is absorbed by the analyzer and the field turns black. However, most minerals, when placed in platinum, change the polarization of light, so that some of them can pass through the analyzer. Two accessory plates, plaster and mica, are called compensators and can be inserted over the analyzer. After the compensator, many polarizing microscopes have (Amici-)Bertrand lens and diaphragm. They are used with a special subplatin capacitor to observe minerals in converged polarized light. We can observe minerals under a microscope with or without an analyzer. When the analyzer is not inserted, it is said that we work in parallel with nicois or with polarized flat light (PP light). When the analyzer is inserted, we work in crossed nicos (XP light). Granulometry, shape, color, cleavage are physical properties observed in parallel nicknames. The refraction index and pleochroism are optical properties also defined in parallel niction. In the crossed niem we identified an elongated signal, a interference figure, an optical signal and an angle of 2V. 4.6. Uniaxial and biaxiaal crystals As mentioned above, in most polarizing microscopes, polarized light refuses to polarize vibrate from east to west. If you find an isotropic crystal in platinum, the speed of light decreases as you cross the crystal, but it continues to vibrate from east to west. If we introduce an analyzer, the crystal will turn black. When polarized light passes through an anisotropic crystal, it is divided into two polarized beams vibrating perpendicular directions (double refraction), and each crosses the crystal on different trajectories, with different speed and refraction index. The fastest radius has a lower refraction rate, and the slower radius has a higher refraction rate. All anisotropic minerals have one or two directions, called optical axes, along which light is not divided into two beams. Minerals of tetragonal, hexagonal and trigon system have only one optical axis (axis c) and are called single-axis. Minerals of the orthorrocheobic, monoclinic and triclinic system have two optical axis and livro mineralogia pdf. livro manual de mineralogia pdf. livro mineralogia dana. livro mineralogia óptica. livro dana mineralogia pdf. mineralogia óptica livro pdf. livro sobre mineralogia

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