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Chapter 1 : Yardley, Mackenzie & Guilford, Atlas of Metamorphic Rocks and Their Textures | Pearson

Section Two deals with textures characteristic of metamorphic rocks. In all it contains over colour pictures, accompanied by short descriptions and discussion, making this the most visually attractive of all the companion volumes.

About Gneiss Gneiss is a very widespread rock type , especially in the lower parts of the continental crust , but it is also a common rock on the surface in some places Scandinavia, Canada, and other shield areas where crystalline rocks are not covered by a layer of sedimentary rocks. A sample from Karelia, Russia. This specimen has a composition of an ordinary granite: Width of sample 11 cm. It was originally a mining term, meaning a country rock in the Ore Mountains Erzgebirge which contained metalliferous veins. The term gneist was first recorded in print by Agricola Georg Bauer in his famous posthumously published book De Re Metallica which remained the most important mineralogy and mining textbook for the next two centuries. The book was published in 1. Most of the mineral grains of gneissose rocks are visible to the naked eye. Banding in this rock is a result of mineral segregation into separate, typically light- and dark-colored layers. Light-colored layer is usually composed of feldspars and quartz. Most important dark minerals are hornblende and biotite. Individual bands are usually mm in thickness. Layers larger than that imply that partial melting or the introduction of new material have probably taken place. Such rocks are called migmatites. It is often difficult to distinguish it from migmatite because there is a gradational transition from one to another. It is not well understood how the segregation takes place, but it must be the result of extreme pressure and shear stress deep in the crust. The protolith of gneiss may be an igneous rock , in this case it is called an orthogneiss. It forms probably because of shear in vicous granitic magma. Paragneiss is a variety with a sedimentary protolith. Even in the latter case, gneissic banding has nothing to do with original layering of sedimentary rocks. These original features are completely obliterated by the metamorphic processes involved in the formation of this rock type. Paragneiss in most cases is thought to be the end product of metamorphism of a pelitic clay-rich sedimentary rock shale , argillite, claystone, etc. Still deeper burial or more intense heating may result in migmatization and finally complete melting of gneiss. Despite being clearly oriented, this rock is not considered to be foliated because it is not fissile along the layering. So, when hammered, gneiss behaves like a uniform homogenous rock. In this sense it is similar to igneous rocks like granite and gabbro and not similar to related metamorphic rocks like schist and phyllite which are foliated. It is important to note that gneiss is a rock type that is defined by its oriented texture, rather by its mineralogy or chemical composition. Hence, qualifying terms are often added to the rock name: Gneiss is a product of regional metamorphism. This is a type of metamorphism which is associated with mountain building. Gneisses form deep below the forming mountain ranges and are exhumed many millions of years later when the mountains get carried away by the erosion. The cores of the continental landmasses are typically composed of such grayish gneisses. This very old from the Archaean sample is from Karelia, Russia. Width of sample 16 cm. An augen gneiss from Estonia glacial erratic from the Finnish Bedrock. Width of sample 30 cm. A sample from an unknown location, possibly from Karelia. A contact between gneiss and pegmatite. A contact between gneiss and granitic pegmatite. A sample of migmatitic gneiss. Width of sample 14 cm. It would be logical to assume that dark biotite-rich bands represent metamorphosed muddy layer in a sandy sediment but this is not necessarily the case. In lower grade metamorphic rocks the original fabric of the protolith is indeed often recognizably preserved, but higher grade rocks like gneiss show compositional banding which does not need to represent the original banding of the protolith. Furthermore, metamorphic differentiation can create compositional layers where none previously existed 2. Gneiss is widely used as a dimension stone. It has a nice combination of hardness and durability with beautiful texture. Wall made of gneiss blocks in Sweden. Even the rocks that do not seem to have a banded appearance do have it when looked from a different direction. Igneous and Metamorphic Petrology , 2nd Edition.

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Chapter 2 : Atlas of Metamorphic Rocks and Their Textures - PDF Free Download

Tremolite Talc forms the fine-grained matrix between the prismatic crystals of tremolite in this rock. Andalusite This is an andalusite porphyroblast with poikiloblastic texture. Also note how the foliation oriented roughly N-S in this view is wrapped around the left and right corners of this grain, suggesting synkinematic growth of the andalusite porphyroblast. Augite Clinopyroxene Note the pigeonite twin lamellae in this grain. Pigeonite is a Ca-poor clinopyroxene. Biotite Note the anomalous red interference color. Calcite Note the rhombohedral cleavage and very high order interference colors. Chlorite Chlorite defines the foliation in this rock, which also shows some crenulation cleavage. Chlorite replacing biotite In this photo, a large "book" of red-brown biotite is partially replaced by green chlorite. When replacing biotite brown , chlorite green typically appears to "spread apart" the sheets of the biotite structure. Chloritoid These stubby crystals are chloritoid porphyroblasts. You can just barely see the anomalous green interference color at the edge of some of the grains. Ellenbergerite The dark reddish-purple grain in the center of this photomicrograph is ellenbergerite, an extremely rare, high-pressure Mg-Al-Ti-silicate, which here forms an inclusion in nearly pure endmember pyrope garnet from the famous Dora Maira massif of Italy. Epidote Note the high-order interference colors of epidote. Contrast this with polysynthetic twinning in plagioclase feldspar. Contrast this with twinning in microcline K-feldspar. This plagioclase is a xenocryst in a vitrophric volcanic rock. Note the compositional zoning and the fractured portion of the crystal. Garnet Note the zonal distribution of quartz inclusions in this garnet porphyroblast Hypersthene Orthopyroxenes are noted for having low, first-order interference colors. Also note the cleavages that intersect at about 90 degrees. A fairly uninteresting photo here. Kyanite Note the first-order interference colors and prismatic habit of kyanite. Leucite Note the nearly isotropic nature of these leucite grains Muscovite This grain is shown at maximum birefringnence. Nepheline Many of the phenocrysts in this basalt are nepheline Olivine Almost all of the grains in this rock are olivine. Note the high order interference colors and the minor secondary calcite. Piemontite Piemontite has beautiful, high-order interference colors Piemontite has beautiful rose to yellow pleochroism. Quartz This slide shows quartz in a range of crystal orientations, all having low-first order interference colors. Sub-grains in quartz The crystal structure of this quartz grain has been deformed probably by low-grade metamorphism to produce sub-grains Quartz after coesite The region of coarser-grained quartz in the upper center portion of this photomicrograph was probably originally occopied by coesite, the high-pressure polymorph of quartz. Sericite a fine-grained variety of muscovite The feldspars in this alaskite from the Boulder Batholith have been largely replaced by fine-grained muscovite sericite. In this rock, sericite is a product of hydrothermal alteration. Staurolite The "swiss cheese" look i. Also note the strong banana yellow pleochroism. The "swiss cheese" look i. Actually, the stilpnomelane in this slide has a more acicular habit than most biotite. Titanite Titanite typically forms wedge-shaped crystals like this one. Also notice the extremely high interference colors. Titanite typically forms wedge-shaped crystals like this one. Also notice the extremely high relief. Tourmaline This slide shows extinct trigonal cross-sections and elongate sections displaying maximum birefringence. The matrix is quartz. This slide shows zoned trigonal cross-sections and elongate sections. Note green to brown pleochroism. Tourmaline may also display bluish pleochroism.

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Chapter 3 : Atlas of metamorphic rocks and their textures (edition) | Open Library

Atlas of Igneous Rocks and Their Textures - W.S. MacKenzie, www.nxgvision.comson and Guilford W. S. MacKenzie, C. Guilford-Atlas of Rock-Forming Minerals in Thin Section-Ad Wes Lon Higher Ed() Atlas of Sedimentary Rocks.

Rock-forming minerals of metamorphic rocks, in thin section a work in progress 1 Olivine: Plane-polarised light, width of view 2. Polars crossed, width of view 2. Plane-polarised light, width of view 0. Polars crossed, width of view 0. Plane-polarised light, width of view 1 mm. Polars crossed, width of view 1 mm. Plane-polarised light, width of view 6 mm. Plane-polarised light, field of view 5 mm 12 Garnet: Plane-polarised light, field of view 4 mm 13 Garnet: Polars crossed, field of view 4 mm 14 Garnet: Plane-polarised light, field of view 3. Plane-polarised light, field of view 2. Polars crossed, field of view 2. Plane-polarised light, field of view 5 mm 18 Sillimanite Sillimanite fibrolite , intergrown with biotite in schist. Polars crossed, field of view 5 mm 19 Sillimanite Sillimanite, nodules of fibrolite in schist. Plane-polarised light, field of view 5 mm 20 Sillimanite Sillimanite, nodules of fibrolite in schist. Polars crossed, field of view 5 mm 21 Sillimanite Sillimanite, prismatic, in aluminous granulite. Plane-polarised light, field of view 8 mm 24 Andalusite Andalusite chiastolite with pink core zone, in graphitic hornfels. Ordinary light, field of view 10 mm 26 Kyanite Kyanite, in schist. Plane-polarised light, field of view 1 mm 33 Staurolite Staurolite poikiloblast, in hornfels. Plane-polarised light, field of view 2 mm 34 Staurolite Staurolite poikiloblast, in hornfels. Polars crossed, field of view 2 mm 35 Chloritoid Chloritoid, in schist. Plane-polarised light, field of view 2 mm 36 Chloritoid Chloritoid, in schist. Clinozoisite, showing anomalous interference colours. Polars crossed, field of view 1 mm 40 Clinozoisite Epidote group: Clinozoisite, poikiloblast in eclogite. Clinozoisite, poikiloblast in eclogite, showing zoned birefringence core more Fe-rich. Zoisite, in high-pressure gneiss. Plane-polarised light, field of view 1. Zoisite, showing anomalous blue interference colours and narrow rim of clinozoisite. Polars crossed, field of view 1. Piemontite, in manganiferous metachert. Plane-polarised light, field of view 1 mm 47 Piemontite Epidote group: Polars crossed, field of view 1 mm 48 Lawsonite Lawsonite, pale brownish, with glaucophane, chlorite and white mica, in blueschist. Plane-polarised light, field of view 1 mm 49 Lawsonite Lawsonite, in blueschist. Polars crossed, field of view 1 mm 50 Cordierite Cordierite, granoblastic-polygonal texture, granulite facies. Polars crossed, field of view 5 mm 51 Cordierite Cordierite, poikiloblastic, in low-P spotted schist Buchan type. Plane-polarised light, field of view 5 mm 52 Cordierite Cordierite, poikiloblastic, in low-P spotted schist Buchan type. Polars crossed, field of view 5 mm 53 Cordierite Cordierite, showing complex sector twinning, in spotted hornfels. Plane-polarised light, field of view 5 mm 57 Cordierite Cordierite, with sillimanite inclusions, in granulite-facies metapelitic gneiss. Polars crossed, field of view 5 mm 58 Osumilite Osumilite double-ring silicate resembling cordierite, diagnostic of ultrahigh-T metamorphism , with feldspar and orthopyroxene. Plane-polarised light, field of view 5 mm 61 Clino- and Orthopyroxene Pyroxene: Polars crossed, field of view 5 mm 62 Clinopyroxene Pyroxene: Polars crossed, field of view 5 mm 63 Diopside Pyroxene: Plane-polarised light, field of view 1 mm 64 Diopside Pyroxene: Polars crossed, field of view 1 mm 65 Enstatite Pyroxene: Plane-polarised light, field of view 5 mm 66 Enstatite Pyroxene: Polars crossed, field of view 5 mm 67 Enstatite Pyroxene: Plane-polarised light, width of view 19 mm 68 Jadeite Pyroxene: Plane-polarised light, field of view 4 mm 81 Hornblende Amphibole: Note low-order interference colours, partly masked by body colour. Polars crossed, field of view 4 mm 82 Hornblende Amphibole: Plane-polarised light, field of view 2 mm 83 Hornblende Amphibole: Plane-polarised light, field of view 2 mm 84 Hornblende Amphibole: Note greenish rims resulting from retrograde change. Plane-polarised light, field of view 4 mm 85 Anthophyllite Amphibole: Plane-polarised light, field of view 2 mm 86 Anthophyllite Amphibole: Polars crossed, field of view 2 mm 87 Gedrite Amphibole: Plane-polarised light, field of view 6 mm 88 Gedrite Amphibole: Polars crossed, field of view 6 mm 89 Glaucophane Amphibole: Plane-polarised light, prisms parallel to polariser. Plane-polarised light, prisms normal to polariser. Plane-polarised light, field of view 6 mm 95 Muscovite Muscovite bright colours , with biotite, garnet and kyanite in schist. Polars crossed, field of view 6 mm 96 Muscovite Muscovite, in phyllite. Plane-polarised light, field of view 1 mm 99 Muscovite phengite Muscovite var. Central grain will give a uniaxial figure 3T polytype. Polars crossed, field of view 1 mm Biotite Biotite, poikiloblast in biotite-grade schist greenschist facies. Plane-polarised light, field of view 2 mm Biotite Biotite, in high-grade gneiss with cordierite and quartz. Plane-polarised light, field of view 1 mm Stilpnomelane Stilpnomelane brown, high birefringence , in metabasic greenschist. Polars crossed, field of view 1 mm Talc Talc, in metasomatised peridotite. Polars crossed, field of view 3. Note purplish-brown anomalous interference colour. Plane-polarised light, field of view 2 mm Chlorite Chlorite, Mg-chlorite with spinel, in forsterite marble. Note bright first-order white interference colour. Polars crossed, field of view 2 mm.

Chapter 4 : Atlas Of Igneous And Metamorphic Rocks Minerals And Textures | Download eBook PDF/EPUB

Description. Metamorphic rocks, those altered by temperature and pressure, display a wide range of textural features under the microscope. They are notoriously difficult to photograph and the collection gathered here represents the finest ever assembled.

These minerals, known as index minerals , include sillimanite , kyanite , staurolite , andalusite , and some garnet. Other minerals, such as olivines , pyroxenes , amphiboles , micas , feldspars , and quartz , may be found in metamorphic rocks, but are not necessarily the result of the process of metamorphism. These minerals formed during the crystallization of igneous rocks. They are stable at high temperatures and pressures and may remain chemically unchanged during the metamorphic process. However, all minerals are stable only within certain limits, and the presence of some minerals in metamorphic rocks indicates the approximate temperatures and pressures at which they formed. The change in the particle size of the rock during the process of metamorphism is called recrystallization. For instance, the small calcite crystals in the sedimentary rock limestone and chalk change into larger crystals in the metamorphic rock marble ; in metamorphosed sandstone, recrystallization of the original quartz sand grains results in very compact quartzite, also known as metaquartzite, in which the often larger quartz crystals are interlocked. Both high temperatures and pressures contribute to recrystallization. High temperatures allow the atoms and ions in solid crystals to migrate, thus reorganizing the crystals, while high pressures cause solution of the crystals within the rock at their point of contact. Foliation geology The layering within metamorphic rocks is called foliation derived from the Latin word folia, meaning "leaves" , and it occurs when a rock is being shortened along one axis during recrystallization. This causes the platy or elongated crystals of minerals, such as mica and chlorite , to become rotated such that their long axes are perpendicular to the orientation of shortening. This results in a banded, or foliated rock, with the bands showing the colors of the minerals that formed them. Textures are separated into foliated and non-foliated categories. Foliated rock is a product of differential stress that deforms the rock in one plane, sometimes creating a plane of cleavage. For example, slate is a foliated metamorphic rock, originating from shale. Non-foliated rock does not have planar patterns of strain. Rocks that were subjected to uniform pressure from all sides, or those that lack minerals with distinctive growth habits, will not be foliated. Where a rock has been subject to differential stress, the type of foliation that develops depends on the metamorphic grade. For instance, starting with a mudstone , the following sequence develops with increasing temperature: Another important mechanism of metamorphism is that of chemical reactions that occur between minerals without them melting. In the process atoms are exchanged between the minerals, and thus new minerals are formed. Many complex high-temperature reactions may take place, and each mineral assemblage produced provides us with a clue as to the temperatures and pressures at the time of metamorphism. Metasomatism is the drastic change in the bulk chemical composition of a rock that often occurs during the processes of metamorphism. It is due to the introduction of chemicals from other surrounding rocks. Water may transport these chemicals rapidly over great distances. Because of the role played by water, metamorphic rocks generally contain many elements absent from the original rock, and lack some that originally were present. Still, the introduction of new chemicals is not necessary for recrystallization to occur. Types of metamorphism Contact metamorphism A contact metamorphic rock made of interlayered calcite and serpentine from the Precambrian of Canada. Contact metamorphism is the name given to the changes that take place when magma is injected into the surrounding solid rock country rock. The changes that occur are greatest wherever the magma comes into contact with the rock because the temperatures are highest at this boundary and decrease with distance from it. Around the igneous rock that forms from the cooling magma is a metamorphosed zone called a contact metamorphism aureole. Aureoles may show all degrees of metamorphism from the contact area to unmetamorphosed unchanged country rock some distance away. The formation of important ore minerals may occur by the process of metasomatism at or near the contact zone.

When a rock is contact altered by an igneous intrusion it very frequently becomes more indurated, and more coarsely crystalline. Many altered rocks of this type were formerly called hornstones, and the term hornfels is often used by geologists to signify those fine grained, compact, non-foliated products of contact metamorphism. A shale may become a dark argillaceous hornfels, full of tiny plates of brownish biotite ; a marl or impure limestone may change to a grey, yellow or greenish lime-silicate-hornfels or siliceous marble , tough and splintery, with abundant augite , garnet , wollastonite and other minerals in which calcite is an important component. A diabase or andesite may become a diabase hornfels or andesite hornfels with development of new hornblende and biotite and a partial recrystallization of the original feldspar. Chert or flint may become a finely crystalline quartz rock; sandstones lose their clastic structure and are converted into a mosaic of small close-fitting grains of quartz in a metamorphic rock called quartzite. If the rock was originally banded or foliated as, for example, a laminated sandstone or a foliated calc- schist this character may not be obliterated, and a banded hornfels is the product; fossils even may have their shapes preserved, though entirely recrystallized, and in many contact-altered lavas the vesicles are still visible, though their contents have usually entered into new combinations to form minerals that were not originally present. The minute structures, however, disappear, often completely, if the thermal alteration is very profound. Thus small grains of quartz in a shale are lost or blend with the surrounding particles of clay, and the fine ground-mass of lavas is entirely reconstructed. By recrystallization in this manner peculiar rocks of very distinct types are often produced. Thus shales may pass into cordierite rocks, or may show large crystals of andalusite and chiastolite , staurolite , garnet , kyanite and sillimanite , all derived from the aluminous content of the original shale. A considerable amount of mica both muscovite and biotite is often simultaneously formed, and the resulting product has a close resemblance to many kinds of schist. Limestones, if pure, are often turned into coarsely crystalline marbles; but if there was an admixture of clay or sand in the original rock such minerals as garnet, epidote , idocrase , wollastonite, will be present. Sandstones when greatly heated may change into coarse quartzites composed of large clear grains of quartz. These more intense stages of alteration are not so commonly seen in igneous rocks, because their minerals, being formed at high temperatures, are not so easily transformed or recrystallized. In a few cases rocks are fused and in the dark glassy product minute crystals of spinel , sillimanite and cordierite may separate out. Shales are occasionally thus altered by basalt dikes , and feldspathic sandstones may be completely vitrified. Similar changes may be induced in shales by the burning of coal seams or even by an ordinary furnace. There is also a tendency for metasomatism between the igneous magma and sedimentary country rock, whereby the chemicals in each are exchanged or introduced into the other. Granites may absorb fragments of shale or pieces of basalt. Sometimes an invading granite magma permeates the rocks around, filling their joints and planes of bedding, etc. This is very exceptional but instances of it are known and it may take place on a large scale. Dynamic metamorphism Regional metamorphism, also known as dynamic metamorphism, is the name given to changes in great masses of rock over a wide area. Much of the lower continental crust is metamorphic, except for recent igneous intrusions. Horizontal tectonic movements such as the collision of continents create orogenic belts , and cause high temperatures, pressures and deformation in the rocks along these belts. If the metamorphosed rocks are later uplifted and exposed by erosion , they may occur in long belts or other large areas at the surface. Recrystallization of the rock will destroy the textures and fossils present in sedimentary rocks. Metasomatism will change the original composition. Regional metamorphism tends to make the rock more indurated and at the same time to give it a foliated, shistose or gneissic texture, consisting of a planar arrangement of the minerals, so that platy or prismatic minerals like mica and hornblende have their longest axes arranged parallel to one another. For that reason many of these rocks split readily in one direction along mica-bearing zones schists. In gneisses , minerals also tend to be segregated into bands; thus there are seams of quartz and of mica in a mica schist, very thin, but consisting essentially of one mineral. Along the mineral layers composed of soft or fissile minerals the rocks will split most readily, and the freshly split specimens will appear to be faced or coated with this mineral; for example, a piece of mica schist looked at facewise might be supposed to consist entirely of shining scales of mica. On the edge of the specimens, however, the white folia of granular quartz will be visible. In gneisses these alternating folia are sometimes thicker and less regular than in schists, but most importantly less micaceous; they may be lenticular, dying out rapidly. Gneisses also, as a rule, contain more feldspar than schists do, and are tougher and less fissile. Contortion or crumbling of the foliation is by no means uncommon; splitting faces are undulose or puckered. Schistosity and gneissic banding the two main types of foliation are formed by directed pressure at elevated temperature, and to interstitial movement, or internal flow arranging the mineral particles while they are crystallizing in that directed pressure field. Rocks that were originally sedimentary and rocks that were undoubtedly igneous may be metamorphosed into schists and gneisses. If originally of similar composition they may be very difficult to distinguish from one another if the metamorphism has been great. A quartz-porphyry , for example, and a fine feldspathic sandstone, may both be metamorphosed into a grey or pink mica-schist.

Chapter 5 : Atlas of Igneous and Metamorphic Rocks - PDF Free Download

This rock is a low-grade metamorphic rock, which retains relics of pre-existing igneous and sedimentary minerals and textures, with metamorphic chlorite, quartz, albite, epidote and primary.

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Chapter 9 : Gneiss - Metamorphic rocks

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