Granite

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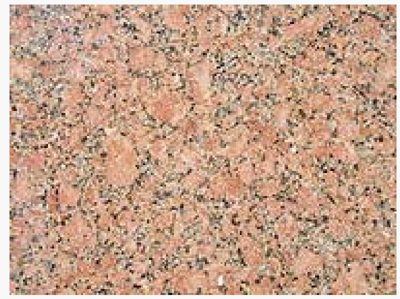
Granite

— Igneous Rock —



Granite containing potassium feldspar, plagioclase feldspar, quartz, and biotite and/or amphibole

Composition

Potassium feldspar, plagioclase feldspar, and quartz; differing amounts of muscovite, biotite, and hornblende-type amphiboles.

Granite (pronounced /ˈɡrænɨt/) is a common and widely occurring type of intrusive, felsic, igneous rock. Granites usually have a medium to coarse grained texture. Occasionally some individual crystals (phenocrysts) are larger than the groundmass in which case the texture is known as porphyritic. A granitic rock with a porphyritic texture is sometimes known as a porphyry. Granites can be pink to gray in color, depending on their chemistry and mineralogy. By definition, granite has a color index (i.e. the percentage of the rock made up of dark minerals) of less than 25%. Outcrops of granite tend to form tors, and rounded massifs. Granites sometimes occur in circular depressions surrounded by a range of hills, formed by the metamorphic aureole or hornfels.

Granite is nearly always massive (lacking internal structures), hard and tough, and therefore it has gained widespread use as a construction stone. The average density of granite is located between 2.65[1] and 2.75 g/cm^3, its compressive strength usually lies above 200 MPa and its viscosity at standard temperature and pressure is 3-6 • 10^{19} Pa·s.[2]

The word granite comes from the Latin *granum*, a grain, in reference to the coarse-grained structure of such a crystalline rock.

Granitoid is used as a descriptive field term for general, light colored, coarse-grained igneous rocks for which a more specific name requires petrographic examination.[3]

Contents[hide]

Mineralogy

[edit]

Orbicular granite near the town of Caldera, northern Chile

Granite is classified according to the QAPF diagram for coarse grained plutonic rocks and is named according to the percentage of quartz, alkali feldspar (orthoclase, sanidine, or microcline) and plagioclase feldspar on the A-Q-P half of the diagram. True granite according to modern petrologic convention contains both plagioclase and alkali feldspars. When a granitoid is devoid or nearly devoid of plagioclase the rock is referred to as alkali granite. When a granitoid contains <10% orthoclase it is called tonalite; pyroxene and amphibole are common in tonalite. A granite containing both muscovite and biotite micas is called a binary or *two-mica* granite. Two-mica granites are typically high in potassium and low in plagioclase, and are usually S-type granites or A-type granites. The volcanic equivalent of plutonic granite is rhyolite. Granite has poor primary permeability but strong secondary permeability.

Chemical composition [edit]

A worldwide average of the chemical composition of granite, by weight percent:[4]

The Stawamus Chief is a granite monolith in British Columbia

- SiO_2 — 72.04%
- Al_2O_3 — 14.42%
- K_2O — 4.12%
- Na_2O — 3.69%
- CaO — 1.82%
- FeO — 1.68%
- Fe_2O_3 — 1.22%
- MgO — 0.71%
- TiO_2 — 0.30%
- P_2O_5 — 0.12%
- MnO — 0.05%

Based on 2485 analyses

Occurrence [edit]

Granite is currently known only on Earth where it forms a major part of continental crust. Granite often occurs as relatively small, less than 100 km² stock masses (stocks) and in batholiths that are often associated with orogenic mountain ranges. Small dikes of granitic composition called aplites are often associated with the margins of granitic intrusions. In some locations very coarse-grained pegmatite masses occur with granite.

Granite has been intruded into the crust of the Earth during all geologic periods, although much of it is of Precambrian age. Granitic rock is widely distributed throughout the continental crust of the Earth and is the most abundant basement rock that underlies the relatively thin sedimentary veneer of the continents.

Origin [edit]

Granite is an igneous rock and is formed from magma. Granitic magma has many potential origins but it must intrude other rocks. Most granite intrusions are emplaced at depth within the crust, usually greater than 1.5 kilometres and up to 50 km depth within thick continental crust. The origin of granite is contentious and has led to varied schemes of classification. Classification schemes are regional and include French, British,

Close-up of granite exposed in Chennai, India.

and American systems.

Geochemical origins [edit]

Granitoids are a ubiquitous component of the crust. They have crystallized from magmas that have compositions at or near a eutectic point (or a temperature minimum on a cotectic curve). Magmas will evolve to the eutectic because of igneous differentiation, or because they represent low degrees of partial melting. Fractional crystallisation serves to reduce a melt in iron, magnesium, titanium, calcium and sodium, and enrich the melt in potassium and silicon - alkali feldspar (rich in potassium) and quartz (SiO_2), are two of the defining constituents of granite.

Close-up of granite from Yosemite National Park, valley of the Merced River

This process operates regardless of the origin of the parental magma to the granite, and regardless of its chemistry. However, the composition and origin of the magma which differentiates into granite, leaves certain geochemical and mineral evidence as to what the granite's parental rock was. The final mineralogy, texture and chemical composition of a granite is often distinctive as to its origin. For instance, a granite which is formed from melted sediments may have more alkali feldspar, whereas a granite derived from melted basalt may be richer in plagioclase feldspar. It is on this basis that the modern "alphabet" classification schemes are based.

Chappell & White classification system [edit]

The letter-based Chappell & White classification system was proposed initially to divide granites into *I-type* granite (or igneous protolith) granite and *S-type* or sedimentary protolith granite.[5] Both of these types of granite are formed by melting of high grade metamorphic rocks, either other granite or intrusive mafic rocks, or buried sediment, respectively.

M-type or mantle derived granite was proposed later, to cover those granites which were clearly sourced from crystallized mafic magmas, generally sourced from the mantle. These are rare, because it is difficult to turn basalt into granite via fractional crystallisation.

A-type or *anorogenic* granites are formed above volcanic "hot spot" activity and have peculiar mineralogy and geochemistry. These granites are formed by melting of the lower crust under conditions that are usually extremely dry. The rhyolites of the Yellowstone caldera are examples of volcanic equivalents of A-type granite.[6][7]

Granitization [edit]

An old, and largely discounted theory, ***granitization*** states that granite is formed in place by extreme metasomatism by fluids bringing in elements e.g. potassium and removing others e.g. calcium to transform the metamorphic rock into a granite. This was supposed to occur across a migrating front. The production of granite by metamorphic heat is difficult, but is observed to occur in certain amphibolite and granulite terrains. In-situ granitisation or melting by metamorphism is difficult to recognise except where leucosome and melanosome textures are present in gneisses. Once a metamorphic rock is melted it is no longer a metamorphic rock and is a magma, so these rocks are seen as a transitional between the two, but are not technically granite as they do not actually intrude into other rocks. In all cases, melting of solid rock requires high temperature, and also water or other volatiles which act as a catalyst by lowering the solidus temperature of the rock.

Ascent and emplacement

[edit]

Roche Rock, Cornwall

The ascent and emplacement of large volumes of granite within the upper continental crust is a source of much debate amongst geologists. There is a lack of field evidence for any proposed mechanisms, so hypotheses are predominantly based upon experimental data. There are two major hypotheses for the ascent of magma through the crust:

- Stokes Diapir
- Fracture Propagation

The Cheesewring, a granite tor on the southern edge of Bodmin Moor, Cornwall

Of these two mechanisms, Stokes diapir was favoured for many years in the absence of a reasonable alternative. The basic idea is that magma will rise through the crust as a single mass through buoyancy. As it rises it heats the wall rocks, causing them to behave as a power-law fluid and thus flow around the pluton allowing it to pass rapidly and without major heat loss.[8] This is entirely feasible in the warm, ductile lower crust where rocks are easily deformed, but runs into problems in the upper crust which is far colder and more brittle. Rocks there do not deform so easily: for magma to rise as a pluton it would expend far too much energy in heating wall rocks, thus cooling and solidifying before reaching higher levels within the crust.

Nowadays fracture propagation is the mechanism preferred by many geologists as it largely eliminates the major problems of moving a huge mass of magma through cold brittle crust. Magma rises instead in small channels along self-propagating dykes which form along new or pre-existing fault systems and networks of active shear zones (Clemens, 1998).[9] As these narrow conduits open, the first magma to enter solidifies and provides a form of insulation for later magma.

Granitic magma must make room for itself or be intruded into other rocks in order to form an intrusion, and several mechanisms have been proposed to explain how large batholiths have been emplaced:

- Stoping, where the granite cracks the wall rocks and pushes upwards as it removes blocks of the overlying crust
- Assimilation, where the granite melts its way up into the crust and removes overlying material in this way
- Inflation, where the granite body inflates under pressure and is injected into position

Most geologists today accept that a combination of these phenomena can be used to explain granite intrusions, and that not all granites can be explained entirely by one or another mechanism.

Natural radiation

[edit]

Granite is a natural source of radiation, like most natural stones. However, some granites have been reported to have higher radioactivity thereby raising some concerns about their safety.

Some granites contain around 10 to 20 parts per million of uranium. By contrast, more mafic rocks such as tonalite, gabbro or diorite have 1 to 5 ppm uranium, and limestones and sedimentary rocks usually have equally low amounts. Many large granite plutons are the sources for palaeochannel-hosted or roll front uranium ore deposits, where the uranium washes into the sediments from the granite uplands and associated, often highly radioactive, pegmatites. Granite could be considered a potential natural radiological hazard as, for instance, villages located over granite may be susceptible to higher doses of radiation than other communities.[10] Cellars and basements sunk into soils over granite can become a trap for radon gas, which is formed by the decay of uranium.[11] Radon can also be introduced into houses by wells drilled into granite.[12] Radon gas poses significant health concerns, and is the #2 cause of lung cancer in the US behind smoking.[12]

There is some concern that materials sold as granite countertops or as building material may be hazardous to health. One expert, Dr. Dan Steck of St. Johns University, has stated[13] that approximately 5% of all granites will be of concern, with the caveat that only a tiny percentage of the tens of thousands of granite slabs have been actually tested. Various resources from national geological survey organizations are accessible online to assist in assessing the risk factors in granite country and design rules relating, in particular, to preventing accumulation of radon gas in enclosed basements and dwellings.

A study of granite countertops was done (initiated and paid for by the Marble Institute of America) in November 2008 by National Health and Engineering Inc of USA, and found that all of the 39 full size granite slabs that were measured for the study showed radiation levels well below the European Union safety standards (section 4.1.1.1 of the National Health and Engineering study) and radon emission levels well below the average outdoor radon concentrations in the US.[14]

Other researchers and organizations do not agree with the Marble Institute's stated position on granite safety, including AARST (American Association of Radon Scientists and Technicians) and the CRCPD (Conference of Radiation Control Program Directors, an organization of state radiation protection officials).[*citation needed*] Both organizations have committees currently setting maximum allowed levels of radiation/radon as well as protocols for measuring radiation/radon from granite countertops. The European Union regulations will likely serve as the basis for new EPA based regulations for granite building materials in the U.S.[*citation needed*]

Uses [edit]

Antiquity [edit]

The Red Pyramid of Egypt (c.26th century BC), named for the light crimson hue of its exposed granite surfaces, is the third largest of Egyptian pyramids. Menkaure's Pyramid, likely dating to the same era, was constructed of limestone and granite blocks. The Great Pyramid of Giza (c.2580 BC) contains a huge granite sarcophagus fashioned of "Red Aswan Granite." The mostly ruined Black Pyramid dating from the reign of Amenemhat III once had a polished granite pyramidion or capstone, now on display in the main hall of the Egyptian Museum in Cairo (see Dahshur). Other uses in Ancient Egypt include columns, door lintels, sills, jambs, and wall and floor veneer.[15] How the Egyptians worked the solid granite is still a matter of debate. Dr. Patrick Hunt[16] has postulated that the Egyptians used emery shown to have higher hardness on the Mohs scale.

Life-size elephant and other creatures carved in granite; Mahabalipuram, India.

Many large Hindu temples in southern India, particularly those built by the 11th century king Rajaraja Chola I, were made of granite. There is a large amount of granite in these structures. They are comparable to the Great Pyramid of Giza.[17]

Modern [edit]

Building [edit]

Granite has been extensively used as a dimension stone and as flooring tiles in public and commercial buildings and monuments. Aberdeen in Scotland, which is contructed principally from local granite, is know as "The Granite City". Because of its abundance, granite was commonly used to build foundations for homes in New England. The Granite Railway, America's first railroad, was built to haul granite from the quarries in Quincy, Massachusetts, to the Neponset River in the 1820s. With increasing amounts of acid rain in parts of the world, granite has begun to supplant marble as a monument material, since it is much more durable. Polished granite is also a popular choice for kitchen countertops due to its high durability and aesthetic qualities. In building and for countertops, the term "granite" is often applied to all igneous rocks with large crystals, and not specifically to those with a granitic composition.

Quarrying granite for the Mormon Temple, Utah Territory, in Little Cottonwood Canyon

Other uses

Curling stones are traditionally fashioned of Ailsa Craig granite. The first stones were made in the 1750s, the original source being Ailsa Craig in Scotland. Because of the particular rarity of the granite, the best stones can cost as much as US$1,500. Between 60–70 percent of the stones used today are made from Ailsa Craig granite, although the island is now a wildlife reserve and is no longer used for quarrying.[18]

In some areas granite is used for gravestones and memorials. Granite is a hard stone and requires skill to carve by hand. Modern methods of carving include using computer-controlled rotary bits and sandblasting over a rubber stencil. Leaving the letters, numbers and emblems exposed on the stone, the blaster can create virtually any kind of artwork or epitaph.

Polished red granite tombstone

Engineering

Engineers have traditionally used polished granite surfaces to establish a plane of reference, since they are relatively impervious and inflexible. Sandblasted concrete with a heavy aggregate content has an appearance similar to rough granite, and is often used as a substitute when use of real granite is impractical. A most unusual use of granite was in the construction of the rails for the Haytor Granite Tramway, Devon, England, in 1820.

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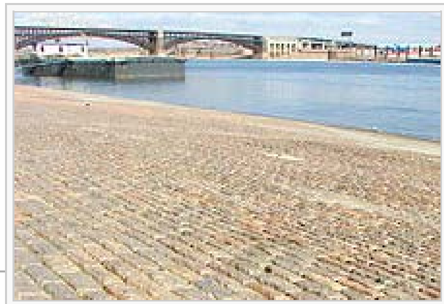

Granite was used for cobblestones on the St. Louis riverfront and for the piers of the Eads Bridge (background).

Rock climbing [edit]

Granite is one of the rocks most prized by climbers, for its steepness, soundness, crack systems, and friction. Well-known venues for granite climbing include Yosemite, the Bugaboos, the Mont Blanc massif (and peaks such as the Aiguille du Dru, the Mountains of Mourne, the Aiguille du Midi and the Grandes Jorasses), the Bregaglia, Corsica, parts of the Karakoram (especially the Trango Towers), the Fitzroy Massif, Patagonia, Baffin Island, the Cornish coast and the Cairngorms.

Granite rock climbing is so popular that many of the artificial

The granite peaks of the Torres del Paine in the Chilean Patagonia

rock climbing walls found in gyms and theme parks are made to look and feel like granite.

See also [edit]

Half Dome, Yosemite, a classic granite dome and popular rock climb

- Epoxy granite
- Falkenfelsen, or Falcon Rock
- Fall River granite
- Greisen
- Igneous rocks
- List of rock types
- Luxullianite
- Mourne Mountains
- Orbicular granite
- Pikes Peak granite, Colorado
- Quartz monzonite
- Rapakivi granite
- Stone Mountain, Georgia
- Wicklow Mountains, Ireland
- Cold Spring Granite

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Exposure to Radon and Radiation from Granite Countertops
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External links [edit]

- The Emplacement and Origin of Granite

Wikimedia Commons has media related to: ***Granite***

v • d • e Igneous rocks by composition [hide]

Type	Ultramafic < 45% SiO_2	Mafic < 52% SiO_2	Intermediate 52–63% SiO_2	Intermediate-Felsic 63–69% SiO_2	Felsic >69 % SiO_2
Volcanic rocks:	Komatiite	Basalt	Andesite	Dacite	Rhyolite
Subvolcanic rocks:	Kimberlite,	Diabase (Dolerite)			Aplite—Pegmatite
Plutonic rocks:	Lamproite Peridotite	Gabbro	Diorite	Granodiorite	Granite