# Appendix 1

# Important marbles and other related stones in Greece and the Aegean

White marble was used extensively by the Greeks, but the Romans also valued coloured marbles.[32, 103, 161] Individual marble quarries are treated separately in the text, but here we will describe some of the general features of marble, and how they form.

Marble is metamorphosed limestone or, more rarely, dolomite: that is, it has been changed by the action of heat and pressure. Quarry workers and archaeologists commonly refer to a number of other softer rocks as marble, such as some lavas and serpentinite, but to a geologist only metamorphosed limestone or dolomite is marble.

The action of heat, commonly several hundred degrees Celsius, promotes the recrystallisation of the rock so that the calcite, or more rarely dolomite, crystals become much larger, commonly big enough to see with the unaided eye. The heat can also lead to the formation of new minerals, and hence change the colour of the rock. The hot rock is much weaker than cold limestone, hence it is commonly deformed without cracking. This can give a new banding to the rock, in addition to the structures already present in the limestone.

The colour of marble reflects the amounts of minor minerals because pure calcite and dolomite are white. Red is produced by the mineral haematite, from iron oxide impurities. Grey and black are commonly due to graphite, produced during the metamorphism from organic matter, such as plant or animal remains. These colours are more rarely produced by magnetite or manganese oxides. Green can be produced by the mineral chlorite (which does not contain chlorine), muscovite mica or serpentine minerals. However, some green marbles are so rich in serpentine minerals that they are termed ophicalcite or serpentinite.

The textures of marble are a combination of those originally present in the limestone and those produced during metamorphism. Both limestone and marble are soluble in rainwater, which is how most caves are formed. Collapse of material from the roof and cementation by circulating waters produces limestone breccias, commonly with a contrast in colour between the matrix and the blocks. Original sedimentary layering in the limestone can also be inherited by marble. These textures can be preserved in the marble or they can be deformed or smeared out. Metamorphism can also produce another texture, veining. During the metamorphism there is a film of water between the crystals that is saturated with calcite in solution. If there is a sudden loss of pressure, or increase in stress, then a crack may open up which may soon be filled with relatively pure, white calcite. These veins are a good way to distinguish marble from limestone.

| Colour | Rock type | Origin | Popular name | Roman name | Notes |
|---|---|---|---|---|---|
| White | Marble, medium | Mt Penteli | Pentelic | Pentelicum | Used only in Greece |
| White, blue tint | Marble, fine | Mt Hymettos | Hymettan | | Rarely used |
| White | Marble, coarse | Paros | Parian | Lychnites | Best for sculpture |
| White | Marble, coarse | Naxos | Naxian | Naxium | Widespread |
| White | Marble, coarse | Thasos | Greco Livido | Thasium | Extensively used in Roman times |
| White | Marble | Belevi, nr Ephesus | | Artemesion | Used at Ephesus |
| White | Marble | Doliana, nr Tegea | Doliana | | Used at Tegea |
| White, grey streaks | Marble, coarse | Island of Marmara | Marmara | Proconnesus | Widespread 6C BC to 6C AD |
| White, yellow & red in grey matrix | Marble breccia | Southern Skyros | Breccia di Sette Basi | Scyrium | Roman |
| Grey | Granite, fine | Mt Cigri, nr Ezine | Granito Violetto | Marmo Troadense | Widespread in Roman times |
| Grey | Granite, fine | Kozac, nr Bergama | Granito Bigio | Marmo Misio | Widespread in Roman times |
| Green, streaky | Marble | Karystos, Euboea | Cipollino | Carystium | Widespread, Roman, splits easily |
| Green, with black inclusions | Serpentinite breccia | Larisa, Thessaly | Verde Antico | Thessalicum, Lapis Atracius | Roman, especially Byzantine 1C AD to 5-6C AD |
| Green | Metamorphosed andesite lava | Krokeai, nr Sparta | Spartan porphyry | Lapis Lacedaemonius | More popular in Roman times |
| Green | Rhyodacite lava | Samothrace | Porphyry | | Local use |
| Red (also green) | Marble | Mani, Laconia | Rosso Antico | Taenarium | Dominantly Roman |
| Red in black matrix | Marble breccia | Teos | Africano | Luculleum | Roman |
| Red, white bands | Marble | Iasos | Cipollino Rosso | Carium, Iassense | Roman, also white marble |
| Red and white | Marble | Crete | Rods of Digenis | | Roman |
| Violet, white in red matrix | Marble breccia | Khalkis, Euboea | Fior di Pesca | Chalcidicum | Roman |
| Orange-pink | Marble breccia | Chios town | Portasanta | Chium | Roman and Byzantine |
| Black | Marble | Chios | | | |
| Black | Marble | Lesbos | | | |
| Black | Marble | Cape Taenarum, Laconia | Nero Antiquo | Lapis Taenarius | |

# Appendix 2

# Glossary of geological terms

The following definitions are, by necessity, simplified and do not include all eventualities. Explanations of many of the terms and concepts can also be found in Chapter 1. Further definitions can also be found in the many glossaries and dictionaries of geology, such as *The Penguin Dictionary of Geology*, by D.G.A. Whitten and J.V.R. Brooks, Penguin Books Ltd, the more complete *Glossary of Geology*, American Geological Institute, or any introductory geology textbook. All glossary terms mentioned in other entries are in italics.

**Alabaster** See *gypsum*.

**Alluvial fan** Gently-sloping, fan-shaped accumulations of *alluvium* deposited where the slope of the river bed and hence the speed of the river diminishes rapidly. They are formed where a river leaves the mountains or exits a gorge onto a plain.

**Alluvium** Loose gravel, sand, silt and clay deposited recently from rivers.

**Amphibole** A group of minerals with a complex and variable chemical composition, but basically hydrated aluminosilicates. Amphiboles are commonly dark-coloured. An example is *hornblende*.

**Andesite** A volcanic rock with a silica content intermediate between that of *basalt* and *trachyte*. Usually pale in colour, it may contain phenocrysts of *plagioclase*, *biotite* and *hornblende*. Flows can be thick and magmas can readily form *volcanic ashes*. The *plutonic* rock equivalent in composition is *diorite*.

**Aquifer** A layer of *rock* that contains abundant quantities of water.

**Asbestos** Fibrous minerals, usually of the serpentine group. Asbestos commonly crystallises in veins in *serpentinite*, at right-angles to the walls of the vein.

**Ash-cone** A conical hill of loose *volcanic ash*.

**Baryte** A mineral with the composition of barium sulphate. It is dense and commonly white.

**Basalt** A black *volcanic* rock with a relatively low silica content. It may contain *phenocrysts* of *olivine*, *pyroxenes* and *plagioclase*. Molten basalt has a low viscosity (i.e. is runny) and hence gives thin lava flows and, rarely, ashes. A plutonic rock of similar composition is called *gabbro*.

**Basement** The lowest part of the geological succession of rocks. Commonly made up of *metamorphic* rocks.

**Bauxite** A red earthy rock made of hydrated aluminium oxide together with iron oxide and other minerals. Bauxite forms by the tropical weathering of *limestones* and other rocks and is the main ore of aluminium.

**Beach-rock** Beach sands and gravels cemented by *calcite* to give a hard rock. It usually forms close to sea-level.

**Biotite** A potassium aluminosilicate mineral, belonging to the *mica* group. It occurs as dark brown plates with a single, mirror-like breakage plane.

**Blueschist** A *metamorphic* rock formed by *metamorphism* of a variety of rocks under conditions of high pressure and low temperature, such as might be found above a *subduction zone*. It commonly contains the blue *amphibole* mineral glaucophane.

**Breccia** A breccia is made of angular fragments of rock. It has not been transported far and may form at the base of a cliff, as a result of volcanic explosions or in caves (cf. *conglomerate*).

**Calcite** A pale-coloured mineral with the composition calcium carbonate. It is the main constituent of most *limestones* and *marbles*.

**Caliche** A bed of impure *limestone* which forms in the soils of arid regions by the evaporation of mineral-laden groundwater below the surface.

**Carbon-14** A naturally occurring radioactive isotope of carbon. It is continually produced in the upper atmosphere and is incorporated into all living organisms. After death carbon-14 is no longer replenished and the amount remaining can be used to obtain the time of death.

**Chert** Nodules of finely-crystalline *quartz* in

*limestone*. The quartz is derived from the shells and skeletons of some organisms, which are dissolved during *lithification* and precipitated as nodules of chert. Flint is a type of chert that occurs in chalk (a soft *limestone*).

**Chlorite** A platy mineral akin to *mica*. It commonly gives the green colour to many *metamorphic* rocks, especially those formed at low temperatures.

**Clay** A rock made up of *clay minerals* together with variable amounts of *quartz* and other minerals. Primary clays are formed by the weathering or alteration of silicate minerals in rocks. Secondary clays form by the redeposition of primary clays.

**Clay minerals** A group of several different minerals, including montmorillonite, kaolinite and smectite. All are hydrated sodium and potassium aluminosilicates, with a platy structure. New, harder silicate minerals form when clay is fired.

**Columnar joints** A set of *joints* produced during cooling of lava flows where the rock is broken up into columns, usually with 5 to 7 sides. The joints start at the edges and progress towards the centre.

**Conglomerate** A *sedimentary* rock made up of rounded pebbles. The rounding indicates that the material has been transported in a stream or on a beach (cf. *breccia*).

**Crust** The uppermost part of the earth. It is thin (about 8 km) in the oceans but much thicker on the continents (30-80 km). The upper part of the continental crust is dominated by *sedimentary* rocks, but lower down *metamorphic* and *plutonic* rocks become more important. Below the crust is the *mantle*.

**Dacite** A volcanic rock similar to *andesite*, but commonly containing *quartz*.

**Diorite** A *plutonic* rock intermediate in silica content between *gabbro* and *granite*. A volcanic rock of similar composition is called *andesite*. It is commonly pale to dark grey.

**Dolomite** A pale mineral with the composition calcium, magnesium carbonate: the name also refers to a rock made of dolomite. Dolomite is very similar to *calcite* and occurs in some *limestones* and *marbles*.

**Dome (lava)** Very viscous lavas (such as *dacites* and *rhyolites*) cannot flow easily and tend to form domes rather than flows. They can have very steep sides.

**Dyke** A tabular body of igneous rock produced when *magma* is injected into a crack in rock and solidifies.

**Earthquake** Shaking of the ground produced by movements of the rocks on either side of a fault. The rocks typically move a few centimetres to several metres.

**Emery** A metamorphic rock containing corundum (aluminium oxide) and other minerals such as magnetite. It is formed by the metamorphism of *bauxite* layers in *limestones*. Corundum is very hard and emery was extensively used as an abrasive for working *marble* and other materials.

**Eolian** A sedimentary rock deposited by wind.

**Fault** A crack in the earth's crust, usually stretching for many kilometres. Faults are classified by their direction of movement. Normal faults have up-down movement and are a result of stretching in the horizontal direction. Thrust faults are nearly horizontal and are the result of regional horizontal compression. The upper block of a thrust fault can move many tens of kilometres. Strike-slip faults are vertical and have sideways (horizontal) movements. Transform faults are a special case of strike-slip faults that are the edges of *lithospheric (tectonic) plates*. They generally have very large movements, up to hundreds of kilometres.

**Fault-scarp** A cliff produced by recent vertical movements of a *fault*.

**Feldspars** See *plagioclase* and *potassium-feldspar*.

**Flowstone (dripstone)** *Limestone* deposited from freshwater by the loss of carbon dioxide in a cave or on a cliff (cf. *stalagmite*, *stalactite*).

**Flysch** A series of sedimentary rocks, including *sandstone*, *conglomerate*, siltstone and *clay*, deposited rapidly in the ocean adjacent to a rising mountain range.

**Fumarole** Volcanic vent of hot (100-750°C) gases, generally mostly steam, with minor amounts of sulphur dioxide, carbon dioxide and hydrogen sulphide. Fumaroles oxidise and alter the surrounding rocks to red iron oxides, *quartz* and *clay* and deposit *sulphur*.

**Gabbro** A dark-coloured *plutonic* rock with a low content of silica, comprised of *plagioclase* together with *olivine*, *pyroxene* and/or *magnetite*. A volcanic rock with similar composition is called *basalt*. It forms by melting of parts of the *mantle*.

**Galena** A grey, shiny mineral that is the principal ore of lead and silver.

**Garnet** A widespread silicate mineral formed during metamorphism. It is commonly red and when clear is a semi-precious stone.

**Gneiss** (pronounced nice) A *metamorphic* rock produced at medium to high temperatures. It is

commonly banded from strong deformation during the metamorphism and is comprised of dark *amphiboles*, pale *feldspars* and *quartz*, and *garnet*; unlike *schist* it does not contain much *mica*.

**Graben** A tectonic valley. A graben is formed when a large (kilometre-scale) block of rock is dropped down between two faults during regional tension of the *crust* (cf. *horst*).

**Granite** A plutonic rock that contains *quartz*, *potassium feldspar* and *amphibole* and/or *mica*. It generally forms by the melting of older *crust*, such as *sedimentary* or *metamorphic rocks*. A volcanic rock of similar composition is called *rhyolite*.

**Graphite** A mineral composed entirely of carbon. It is commonly present in *marbles* as small plates and gives a grey colour to the rock.

**Greenschist** A platy rock formed by the *metamorphism* of a variety of rocks at relatively low temperatures and pressures. The green colour is commonly due to *chlorite*.

**Gypsum** A mineral with the composition calcium sulphate. A rock made up of randomly oriented crystals of gypsum is called alabaster.

**Haematite** A red mineral with the composition iron oxide. It is more oxidised than *magnetite*.

**Hornblende** A dark-coloured *amphibole* mineral that occurs in some *metamorphic* and *igneous* rocks.

**Horst** A block of rock, generally many kilometres in size, between two *grabens*. It is uplifted with respect to the surrounding areas.

**Igneous rocks** Rocks that formed by cooling of molten rock (*magma*). *Volcanic* rocks cooled on the surface, *plutonic* rocks cooled at depths of up to 40 km.

**Ignimbrite** A rock produced when *volcanic ash* is sufficiently hot that it welds itself together as it settles. Ignimbrites are generally very hard and may resemble lavas.

**Intrusion** See *pluton*.

**Isopic zone** A series of different rocks with a similar geological history that contrasts with that of the adjacent zones. The boundaries of the zones are *faults*, commonly almost horizontal *thrust faults*. An isopic zone may contain one or more *nappes*. Isopic zones were stacked on top of each other during the Alpine regional compression of the crust.

**Joints** A set of cracks in a rock with no movement along them (cf. *fault*). They are best seen in outcrops along the shore, in cliffs or roadcuts as sets of parallel planes. There are commonly three or four such sets with different orientations, isolating polygonal blocks of rock. They are produced by contraction during cooling of rocks, or by expansion following release of pressure from the removal by erosion of the overlying rock.

**Lahar** A mass of mud and blocks of rock that flows like a *lava*. Commonly associated with volcanic eruptions.

**Laterite** An earthy, red rock rich in iron and occasionally nickel produced by intense tropical weathering (cf. *bauxite*).

**Latite** A volcanic rock intermediate in composition between *dacite* and *andesite*.

**Lignite** A form of low-quality coal. It is formed in swamps from decayed plant remains.

**Limestone** A *sedimentary* rock dominantly made up of *calcite*. It can be deposited from springs (*travertine*), but is usually formed in shallow seas from the accumulation of fragments of calcareous shells or lime-mud. Crystalline limestone has been metamorphosed at very low temperatures, increasing the size of the crystals. It is transitional to *marble*.

**Lithification** The process by which loose materials, such as *sediments* or *volcanic ash*, become solid rock. Percolating waters dissolve the finer particles or already carry minerals in solution. These minerals are precipitated between the larger grains, cementing them together.

**Magma** Molten rock, generally containing some crystals and dissolved gas. Temperatures vary from about 700°C for a *granite* to 1100°C for a *basalt*.

**Magnesite** A mineral with the composition magnesium carbonate. It is used in the manufacture of refractory bricks.

**Magnetite** A black, magnetic mineral composed of iron oxide. It is not as oxidised as the red iron oxide mineral *haematite*.

**Mantle** That part of the earth that lies beneath the *crust*. It is dominantly made up of *olivine* and *pyroxene* which form the rock *peridotite*.

**Marble** Metamorphosed *limestone*. It is comprised of *calcite*, sometimes with *dolomite*, *muscovite*, *graphite* and other minerals. Pure marble is white, other colours are produced by other minerals.

**Marl** A soft, impure *limestone* containing *clay* and sand.

**Massif** A region dominated by old *metamorphic* and *igneous* rocks, commonly deformed many times. Massifs (shields) form the core of many continents, around which younger mountain belts are wrapped.

**Metamorphic rocks** Rocks formed by metamorphism.

**Metamorphism** The transformation of an ig-

neous or sedimentary rock under the action of heat and pressure. The old minerals may grow larger and some new minerals may form.

**Mica** A group of platy minerals, including *biotite* and *muscovite*.

**Migmatite** A rock produced by *metamorphism* at high temperatures such that part of the rock has melted, but these *magmas* have been retained in the rock.

**Mineral** A naturally occurring material, usually crystalline, with a fixed composition or one that varies within set limits. Examples are *quartz*, *amphibole* and *magnetite*. *Rocks* are made up of aggregates of one or more minerals.

**Molasse** A series of sedimentary rocks, dominated by *conglomerates* and *sandstones*, deposited on land from rivers and at the bottom of shallow lakes adjacent to a rapidly rising mountain range.

**Muscovite** A colourless or pale green mineral of the *mica* group. It can form during crystallisation of *granites* or during *metamorphism* of sedimentary rocks. It is commonly present in *marbles* and gives the green hue of cipollino marble.

**Nappe** A package of rocks limited above and below by thrust *faults*. Nappes have slid almost horizontally for distances of up to hundreds of kilometres during compressional mountain-building events.

***Nuée ardente*** A glowing cloud of hot gas and *volcanic ash* or *pumice* then descends the side of volcano like a dense liquid,

**Obsidian** A glassy *volcanic* rock produced by the rapid sub-aerial cooling of silica-rich magma, such as *rhyolite*. Obsidian readily recrystallises and loses its glassy texture following contact with water or during metamorphism.

**Olivine** An olive-green mineral with the composition iron-magnesium silicate (also known as Peridot). *Phenocrysts* of olivine can be seen in some *basalt* lavas.

**Ophiolite** A series of different rocks that originally made up part of the sea-floor, but now uplifted and exposed on land. An ophiolite ideally comprises, from bottom to top, *peridotite*, *gabbro*, gabbro-dykes, *pillow-lava basalts* and *cherts*, but commonly some parts are missing.

**Peridotite** An igneous rock primarily made up of *olivine*. Most of the *mantle* is made of peridotite and this can be seen in the sections of the ocean-floor exposed in *ophiolites*. Peridotite is commonly metamorphosed to *serpentinite*.

**Phenocrysts** Large or prominent crystals in a igneous rock, commonly visible to the unaided eye. *Olivine*, *pyroxene*, *amphibole*, *plagioclase*, *potassium-feldspar*, *magnetite* and *quartz* commonly occur as phenocrysts.

**Phreatic eruptions** Volcanic eruptions produced by *phreatic explosions*. The volcanic productions of such eruptions do not necessarily contain any solidified magma, just disrupted older rocks.

**Phreatic explosions** Explosions produced by the interaction of hot rock and underground water. The water flashes to superheated steam which expands and disrupts the rock with explosive force. Such explosions can be directly related to movement of *magma* and volcanic activity.

**Phyllite** A metamorphic rock formed from shale at low temperatures, containing fine-grained *chlorite* or *mica*. Metamorphism at higher temperatures produces *schist*.

**Pillow lava** When lava erupts underwater or flows into water it forms a series of pillow-shaped blobs between one and five metres long. Pillow lavas exposed on land indicate the former presence of a lake, or of a sea whose bed has been uplifted.

**Placer** Deposits of heavy minerals, such as gold, that form in rivers or on beaches. The winnowing action of running water removes the lighter minerals and leaves behind a concentrate of heavy minerals.

**Plagioclase** A sodium, calcium aluminosilicate mineral of the feldspar group. Usually pale coloured or even white, it has several good breakage planes some of which show striations.

**Phonolite** A lava poor in silica.

**Plates** Lithospheric (commonly tectonic) plates are made up of continental and/or oceanic *crust* together with the uppermost part of the mantle (*lithosphere*). They are about 200 kilometres thick and slide on a basal zone that contains a small amount of *magma*.

**Plinian eruption** A volcanic eruption in which the *magma* boils in the conduit at some depth below the surface. The resultant *pumice* and *volcanic ash* leave the volcano as a high-speed jet, which may rise to heights of 30-40 km.

**Pluton (intrusion)** A body of rock that was originally liquid (*igneous*) and was emplaced in the *crust* (cf. lavas). Plutons can vary in size from a few hundred metres to tens of kilometres.

**Plutonic** Refers to rocks formed when *magma* solidifies below the surface of the earth, in contrast to *volcanic* rocks. Plutonic rocks are typically coarser-grained than volcanic rocks. Examples are *granite*, *gabbro* and *peridotite*.

**Polje** A plain or small basin surrounded by mountains that drains internally into *sink-holes*.

**Poros** A common term in Greece for soft porous *limestone*, sandy limestone or *sandstone*.

**Porphyry** A term for a characteristic texture of *volcanic* or shallow *plutonic* rocks in which well-developed *phenocrysts* float in a fine matrix. The name also refers to a rock with this texture, usually an *andesite* or *dacite*.

**Potassium feldspar** A mineral with the composition potassium aluminosilicate. It is an essential mineral in *granites*.

**Pumice** A light frothy volcanic rock formed when the water in a silica-rich *magma* boils before solidification. There is not sufficient water vapour to completely disrupt the rock and form a *volcanic ash*.

**Pyrite** A mineral with the composition iron sulphide. It is yellow and shiny and is commonly called 'fool's gold'. Its shiny breakage surface easily distinguishes it from true gold.

**Pyroclastic rocks** A general term for all solid volcanic products except lava. It includes loose deposits of *volcanic ash* and *pumice* as well as lithified materials such as *tuff* and *ignimbrite*.

**Pyroxene** A group of minerals with the composition iron-magnesium-(calcium) silicate. *Phenocrysts* of pyroxene can be seen in some lavas.

**Quartz** A commonly colourless mineral comprised of silicon oxide (silica). It can crystallise from silica-rich magmas deep in the earth in *granites* or in volcanic rocks such as *rhyolites*. It can also crystallise at much lower temperatures (400 – 200°C) from watery liquids to form the quartz veins seen in many *metamorphic* rocks. Finely crystalline varieties include *chert* (flint), chalcedony, cornelian, agate, opal and jasper.

**Rhyodacite** A volcanic rock intermediate between *rhyolite* and *dacite*.

**Rhyolite** A volcanic rock rich in silica. It can contain *phenocrysts* of *quartz*, *feldspar* and *amphiboles*. The magma is usually very viscous and forms short, thick flows or lava *domes*, or *volcanic ash*. Rapid cooling of rhyolite can produce glassy rocks termed *obsidian*. A plutonic rock of similar composition is called *granite*.

**Rock** A rock is an aggregate of one or more *minerals*. Rock names are generally based on the proportions of the minerals, the texture of the minerals and the way the rock was formed.

**Sandstone** A sedimentary rock formed by the lithification of sand. The most common mineral is *quartz*. The sand may be deposited from the air (Eolian) or, more commonly, from water.

**Scree (talus)** Steep, loose piles of rock at the base of cliffs. (cf. *alluvial fan*)

**Schist** A rock rich in *micas* produced by *metamorphism* of *sedimentary* and *volcanic* rocks at low to medium temperatures. The presence of mica gives the rock an ability to split into slabs. Metamorphism of *limestones* under the same conditions produces *marbles*, hence the two are commonly intimately mixed (cf. *blueschist*, *greenschist*).

**Sea-level stand** An ancient sea-level above the present level. The sea-level stayed at this height for sufficient time to develop features such as notches in the cliffs, wave-cut platforms and raised beaches.

**Sediments** Loose boulders, pebbles, sand, mud, etc., deposited from water or more rarely from the air.

**Sedimentary rocks** Rocks formed by the lithification of *sediments*. They include those formed from fragments of rocks (clastic), such as *sandstone* and *conglomerate*, and those formed by accumulation of minerals precipitated from water, such as *gypsum*, salt and some kinds of *limestone*.

**Serpentine, serpentinite** A soft green rock composed of serpentine minerals, which are hydrated magnesium silicates. These minerals form by the low *metamorphism* at low to medium temperatures of *igneous* rocks rich in *pyroxene* or *olivine*. Changes in the volume of the rock during metamorphism lead to extensive brecciation. This rock is the 'lubricant' of many thrust *faults*. Fibrous forms of serpentine are the most important form of *asbestos*.

**Shale** A soft sedimentary rock, produced by the accumulation of silt and clay.

**Sink-hole (swallow-hole, Katavothres)** The entrance to a *limestone* cave system where a river or stream disappears into the ground. The water flows through the cave to reappear at the exit or at a spring.

**Skarn** A rock produced by the reaction between watery solutions released during the crystallisation of *granite* and the surrounding rocks, especially *limestone*. Skarns can be rich in iron, lead, silver, gold and other metals.

**Sphalerite** A brown and translucent to grey and shiny mineral which is the main ore of zinc and cadmium.

**Steatite or soapstone** See *talc*.

**Subduction zone** An ancient part of the ocean floor that has descended into the *mantle* beneath a continent or ocean. Melting associated with the subduction zone produces *magmas* that rise to form plutons and volcanos.

**Stalagmite, stalactite** *Limestone* formations in caves precipitated from flowing water. Stalac-

tites grow from the roof (they hold on tite), stalagmites grow on the floor.

**Sulphur** A yellow mineral that occurs in volcanic areas and some sedimentary rocks. Sulphur is a component of the minerals *pyrite*, *sphalerite*, *galena*, *baryte* and *gypsum*.

**Talc** A soft, green mineral formed by the metamorphism of rocks rich in *olivine* and *pyroxene*. It is a hydrated magnesium silicate and forms under very similar circumstances to the *serpentine* minerals. The soapy feel of this mineral has led to the term soapstone or steatite for rocks rich in this mineral.

**Tectonics** Tectonics is the study of earth-building forces. Tectonic forces are due to large-scale movements of blocks of the crust.

**Trachyandesite** A *volcanic* rock intermediate in composition between *trachyte* and *andesite*.

**Trachyte** A *volcanic* rock that contains *potassium-feldspar*, but not much *quartz*. Usually pale in colour with *phenocrysts* of *feldspar*, and *amphibole*. A plutonic rock of similar composition is called syenite.

**Travertine** A *limestone* produced around hot or cold springs, by the loss of the gas carbon dioxide and the precipitation of *calcite*.

**Tsunami** A wave, or series of waves, on the ocean produced as a result of an *earthquake*, landslide or volcanic eruption.

**Tufa** See *travertine*.

**Tuff** Lithified *volcanic ash*.

**Tuff-ring** A hill of *volcanic ash* or *pumice* with the form of a ring or horse-shoe (cf. *ash-cone*).

**Volcanic** Refers to rocks formed when *magma* pours out onto the surface of the earth and crystallises there. These rocks are generally finer-grained than *plutonic* rocks as they have cooled faster. Examples are *basalt*, *andesite* and *rhyolite*.

**Volcanic ash** Ashes produced during explosive eruptions of volcanos. Boiling of water in the magma produces a foam which is eventually disrupted. (cf. *tuff*, *pumice*)

**Zone** See *isopic zone*.