aa *See* LAVA.

AABW *See* ANTARCTIC BOTTOM WATER.

AAC *See* ANTARCTIC CONVERGENCE.

Aalenian A *stage in the European Middle *Jurassic (175.6–171.6 Ma, Int. Commission on Stratigraphy, 2004). *See also* DOGGER.

AAV *See* AGGREGATE TESTS.

Ab *See* ALKALI FELDSPAR.

abandoned channel A former stream channel through which water no longer flows (e.g. a *cut-off).

abandonment facies association A *facies association formed under conditions of rising sea level, when *clastic deposition has ceased and sediment is deposited very slowly.

abapical A directional term meaning away from the shell *apex.

abaptation The process by which an organism is fitted to its environment as a consequence of the characters it inherits, which have been filtered by *natural selection in previous environments. Because present environments seldom differ greatly from recent past environments, adaptive fitness can resemble *adaptation. In this sense, however, adaptation appears to imply advance planning, or design, which is misleading.

Abbé refractometer *See* REFRACTOMETER.

abiogenesis Development of living organisms from non-living matter; as in the supposed origin of life on Earth, or in the concept of spontaneous generation, which was once held to account for the origin of life but which modern understanding of evolutionary processes (*see* EVOLUTION) has rendered outdated.

abiotic Non-living; devoid of life. *Compare* BIOTIC.

ablation 1. Removal of snow and ice by melting and by direct alteration from the solid to the gaseous phase (sublimation). The rate of loss is controlled chiefly by air temperature, wind velocity, *humidity, rainfall, and *solar radiation. Ablation on snowfields is also influenced by aspect, depth of snow, and the nature of the underlying surface. Ablation *till is the glacial debris that may be released. The ablation zone of a glacier is that area in which losses, including *calving, exceed additions. **2.** Removal of *rock material, especially by wind action.

ablation till *See* ABLATION 1; and TILL.

ablation zone *See* ABLATION.

aboral Away from the mouth; on the opposite side of the body from the mouth.

abrasion (corrasion) The erosive (*see* EROSION) action that occurs when *rock particles of varying size are dragged over or hurled against a surface. Some common agents of abrasion are the *bed load of streams, rock debris embedded in the bases of *glaciers, and *sand and *shingle transported by wind or waves.

abrasion ramp A gentle, seaward slope, with a gradient of approximately 1°, in an intertidal *shore platform that is caused by wave *abrasion. The removal of material by wave action leaves the base of the cliff exposed, leading to further cliff retreat. Abrasion ramps usually terminate on the seaward side where the sea depth reaches about 10 m.

absolute age (true age) The age of a geologic phenomenon measured in present Earth years, rather than its age relative to other geologic phenomena (*compare* RELATIVE AGE). The term 'absolute age' has been considered rather misleading, as the means for measuring ages (*radiometric dating, *dendrochronology, *varve analysis) are subject to experimental error and the dates obtained are not precise. The alternative term 'apparent age' has been suggested. *See also* DATING METHODS; and GEOCHRONOLOGY.

absolute humidity *See* HUMIDITY.

absolute plate motion The motion of a lithospheric *plate (*see* LITHOSPHERE) with

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respect to a fixed frame of reference. Various frames of reference have been used, including those defined by *hot spots, no net torque of all the plates, and palaeomagnetic (*see* PALAEOMAGNETISM) Euler poles (*see* POLE OF ROTATION).

absolute pollen frequency (APF) *Pollen data from sediments, expressed in terms of the absolute numbers for each *species, *genus, or *family, per unit volume of sediment and, where deposition rates are known, per unit time. In certain circumstances this approach gives clearer information than does the traditional way of expressing pollen data as *relative pollen frequencies (RPFs). APFs are particularly useful in site comparisons in which one or more high pollen producers vary. For example, when trees first appear in the regional pollen rain their prolific pollen may, in an RPF method, give the impression of declining herbaceous species, whereas examination by an APF method will show constant values for herb species.

absolute porosity *See* POROSITY.

absolute temperature Temperature measured using the *Kelvin scale.

absolute vorticity *See* VORTICITY.

absolute zero *See* KELVIN SCALE.

absorptance The ability of a material to absorb *electromagnetic radiation of a specified wavelength. *See also* ABSORPTANCE BAND.

absorptance band The range of wavelengths of *electromagnetic radiation which are absorbed by a material. *See also* ABSORPTANCE.

absorption The amount of seismic energy lost during transmission, by conversion to heat. The absorption coefficient is the fractional loss of energy over a distance of one *wavelength; hence higher-*frequency signals are attenuated more readily than those of lower frequencies over the same path. Typical values for *rocks range from 0.25 to 0.75 dB per wavelength.

abstraction (extraction) The artificial removal of water from a well, *reservoir, or river.

Abukama-type metamorphism The *recrystallization of *rocks under a high *geothermal gradient so that at any given temperature the pressure is relatively low. The term originally referred to a belt of *metamorphic rocks stretching south-westwards from the Abukama Plateau in Japan, and characterized by the development of *andalusite and *sillimanite in rocks that were originally *shales (*pelites). This belt lies parallel to, and on the continental side of, a high-pressure metamorphic belt.

abundance zone *See* ACME ZONE.

ABW *See* ARCTIC BOTTOM WATER.

abyssal hills Relatively small topographic features of a dominantly flat, deep-ocean floor, commonly 50–250 m in height and a few kilometres in width. They are most typical of the *Pacific Ocean floor at depths of 3 000–6 000 m.

abyssal plain Smooth, almost level area of the deep-ocean floor in which the gradient is likely to be as low as 1 : 10 000. The covering sediments are usually thin deposits of a *pelagic ooze or *distal *turbidite.

abyssal storm (benthic storm) A large pulse of energy, possibly transferred from the surface, that accelerates *contour currents on the ocean floor to about 40 cm/s, raising large amounts of fine sediment.

abyssal zone Zone of greatest ocean depth, i.e. below a depth of 2 000 m. This zone lies seaward of, and deeper than, the *bathyal zone, and covers approximately 75% of the total ocean floor. It is the most extensive Earth environment, cold, dark, with slow-moving currents (less than a few centimetres per second), supporting *fauna that typically are black or grey, delicately structured, and not streamlined.

Acadian orogeny A phase of mountain building affecting an area from the northern Appalachians in what is now New York State to the Bay of Fundy in maritime Canada (the name refers to the colony of Acadie in that region of French Canada). It occurred in the *Devonian about 390 Ma ago, although the precise date and duration are uncertain, and was most intense east of the Taconic area (*see* TACONIC OROGENY). It was caused by the westward movement of the Avalon *terrane. *See* APPALACHIAN OROGENIC BELT.

Acado-Baltic Province *See* ATLANTIC PROVINCE.

acanthodians *See* ACANTHODII.

Acanthodii (acanthodians) Class of primitive, fossil fish, characterized by the presence of a true bony skeleton (*see* BONE), a *heterocercal tail *fin, a persistent *notochord, *ganoid scales, and stout spines in front of the fins. The acanthodians lived from the *Silurian to the *Permian Period and may be related to ancestors of the more modern bony fish.

Acanthograptidae *See* DENDROIDEA.

Acanthostega *See* ICHTHYOSTEGA.

acceleration *Evolution that occurs by increasing the rate of ontogenetic (*see* ONTOGENY) development, so that further stages can be added before growth is completed. This form of *heterochrony was proposed by E. H. Haeckel as one of the principal modes of evolution.

acceleration, gravitational *See* GRAVITATIONAL ACCELERATION.

accelerograph (earthquake seismometer) An instrument used to measure *earthquake movements that are too strong for more sensitive *seismometers to register accurately. An accelerograph contains three *accelerometer heads aligned to measure movement in three directions. The accelerograph is often connected directly to the Internet.

accelerometer A device whose output is directly proportional to acceleration. Accelerometers are used in the measurement of the motion of a ship, helicopter, or aircraft during *gravity surveys. A *seismometer or moving-coil *geophone can also function as an accelerometer.

accessory, lithic *See* LITHIC FRAGMENT.

accessory cloud A small cloud that is seen to be associated with a much larger cloud belonging to one of the ten cloud genera (*see* CLOUD CLASSIFICATION). *Pileus, *tuba, and *velum are accessory clouds.

accessory mineral A *mineral *phase within a rock whose presence does not affect the root name of the rock. For instance, the root name 'granite' is defined by the presence of *quartz, *alkali feldspar, and *mica. These are the '*essential minerals'. The presence of the mineral *sphene does not affect the root name and hence would be an example of an accessory mineral. *Apatite and *zircon are also common accessory minerals.

accessory plate (sensitive tint) In optical microscopy, a plate used to determine the optical properties of *minerals. *Quartz, *mica, and *gypsum are the common minerals used to determine the slow and fast *vibration directions that relate to the two *refractive indices of an *anisotropic mineral. The terms 'length-fast' and 'length-slow' may then be assigned to a given mineral for identification purposes. A wedge of quartz (quartz wedge) is used to determine the order of *interference colour exhibited by a mineral.

accidental lithic *See* LITHIC FRAGMENT.

accommodation space The space in which sediment may accumulate.

accommodation zone A region of intermeshed *normal faults, with very complex geometry, that lies between the boundary faults of a series of interlinked half-grabens (*see* GRABEN) in an area of crustal extension.

accordion fold *See* CHEVRON FOLD.

accretion 1. Process by which an inorganic body grows in size by the addition of new particles to its exterior. It is the mechanism by which primitive planetary bodies are believed to form as a result of the accumulation of minute, cold, homogeneous particles (homogeneous accretion). An alternative hypothesis is that iron-rich cores accumulated first and were later surrounded by silicate material (heterogeneous accretion). Homogeneous accretion yields a planet that initially has the same composition from centre to surface; heterogeneous accretion yields a planet that has a layered structure from the start.
2. The accumulation of sediments from any cause, representing an excess of deposition over *erosion.
3. The addition of continental material to a pre-existing continent, usually at its edge. The use of 'accretion' in this sense has evolved from theories of *nucleation to newer theories of the horizontal addition of *allochthonous *terranes of initially coherent bodies of continental *rock, usually more than 100 km^2 in area, which can collide, rotate, and fragment as they become sutured to a continent.

accretional heating The heating of bodies orbiting a star due to bombardment by smaller objects, the kinetic energy of the impacting body ($\frac{1}{2}mv^2$, where m is mass and v velocity) being released mainly as heat.

accretionary basin A small basin, much smaller than a *fore-arc basin, that develops on the top of an *accretionary wedge and fills

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with *debris-flow material, *turbidites, and volcanic rocks.

accretionary lapilli Pellets of *ash, ranging in size from 2 mm to 64 mm, which commonly exhibit a concentric ('onion skin') internal structure. The *lapilli are formed by the accretion of very fine ash around condensing water droplets or solid particles, particularly in steam-rich eruptive columns (*see* ERUPTION). Once formed they can be transported and deposited by *pyroclastic fall, *surge, or flow processes.

accretionary levée *See* LAVA LEVÉE.

accretionary prism *See* ACCRETIONARY WEDGE.

accretionary wedge (accretionary prism) A tectonically thickened wedge of *sediment found on the landward side of some *trenches. The accretionary wedge consists of oceanic sediment scraped off the subducting *plate (*see* SUBDUCTION), plus sediment derived from landward and deposited in the trench. Slices of sediment are added to the wedge by *underthrusting and the trench migrates seaward, the continuation of this process producing an *inversion.

accumulated temperature Surplus or deficit of temperature with respect to a defined mean value and expressed as an accumulation over a given period, e.g. a month, season, or year. For example, a datum value of 6 °C is used as a critical temperature for sustained vegetation growth, against which accumulated surpluses or deficits may be measured.

accumulation zone That part of a *glacier where the mean annual gain of *ice, *firn, and snow is greater than the mean annual loss. The zone consists of stratified firn and snow together with ice from frozen meltwater. Its lower boundary is the *equilibrium line.

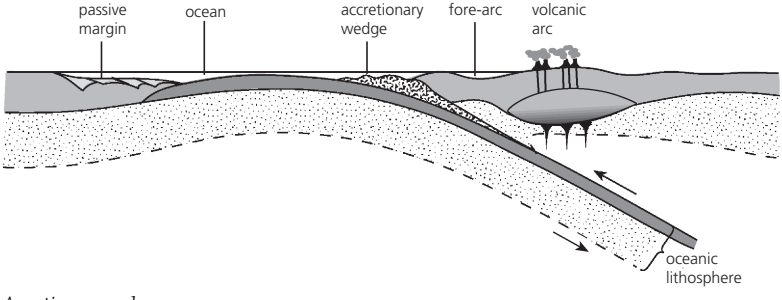
ACD *See* ARAGONITE COMPENSATION DEPTH.

ACF *See* ACF DIAGRAM; and AUTOCORRELATION.

ACF diagram A three-component, triangular graph used to show how metamorphic *mineral assemblages vary as a function of *rock composition within one *metamorphic facies. Besides SiO_2, the five most abundant oxides found in *metamorphic rocks are Al_2O_3, CaO, FeO, MgO, and K_2O. The three components plotted on ACF diagrams are A (Al_2O_3), C (CaO), and F (FeO + MgO), making the diagrams particularly useful for showing assemblage variations in metamorphosed, *basic, *igneous rocks, and impure *limestones. However, each of these components has to be modified slightly to account for the presence of other, minor components in the rock. Such modification leads to: A ($Al_2O_3 - Na_2O - K_2O$); C ($CaO - [(10/3)P_2O_5] - CO_2$); and F ($FeO + MgO - Fe_2O_3 - TiO_2$). The minerals *quartz and *albite are assumed to be present in the rocks and are not shown on the diagram. *Tielines connect minerals which coexist in equilibrium and can thus define triangular areas in which three minerals are in equilibrium in the rock, lines on which two minerals are in equilibrium in the rock, and points at which one mineral is in equilibrium in the rock (in addition to the ubiquitous quartz and albite). *See* AFM DIAGRAM.

achnelith *See* PELÉ'S HAIR.

achondrite Rare stony *meteorite lacking *chondrules and with low nickel-iron



Accretionary wedge

content. It is more coarsely crystalline than a *chondrite. Basaltic achondrites resemble terrestrial *lavas.

achromatic line In the three-dimensional graph which plots quantities of the three *additive primary colours contributing to *pixels against each other, the line which runs at 45° to the axes. Pixels which plot close to this line will not be strongly coloured and may be subject to *decorrelation stretching.

acicular Pointed or needle-shaped.

acid According to the Brønsted–Lowry theory, a substance that in solution liberates hydrogen *ions or protons. The Lewis theory states that it is a substance that acts as an electron-pair acceptor. An acid reacts with a *base to give a salt and water (neutralization), and has a *pH of less than 7.0. The theory was proposed in 1923 by the Danish physical chemist Johannes Nicolaus Brønsted and the British chemist Thomas Lowry, and independently by the American theoretical chemist Gilbert Newton Lewis.

acidophile An *extremophile (domain *Archaea) that thrives in environments where the *pH is below 5.0.

acid rain Precipitation with a *pH of less than about 5.0, which is the value produced when naturally occurring carbon dioxide, sulphate, and nitrogen oxides dissolve into cloud droplets. The effects of increased acidity on surface waters, soils, and vegetation are complex.

acid rock *Igneous rock containing more than about 60% *silica (SiO_2) by weight, most of the silica being in the form of silicate minerals, but with the excess of about 10% as free *quartz. Typical acid rocks are *granites, *granodiorites, and *rhyolites. *Compare* BASIC ROCK; and INTERMEDIATE ROCK. *See also* ALKALINE ROCK.

acid soil *Soil having a *pH less than 7.0. Degrees of soil acidity are recognized. Soil is regarded as 'very acid' when the reaction is less than pH 5.0. The *USDA lists five standard ranges of soil acidity (less than pH 4.5, extremely acid; 4.5–5.0, very strongly acid; 5.1–5.5, strongly acid; 5.6–6.0, medium acid; and 6.1–6.5, slightly acid). Surface *soil horizons of acid *brown earths have a reaction of pH 5.0 or less.

acme zone (peak zone, flood zone, epibole, abundance zone) An *informal term for a body of *strata containing the maximum abundance of a particular *taxon occurring within the stratigraphic range of that taxon, and after which the *zone is named.

acoustic impedance (*Z*) The product of density (ρ) and the acoustic velocity (*v*) for a given rock mass; $Z = \rho v$. The *reflection coefficient for an interface is governed by the contrast in the acoustic impedances of the two adjacent *rock masses.

acquired characteristics Characteristics that are acquired in the lifetime of an organism, according to early evolutionary theorists such as *Lamarck. Lamarck further suggested that traits acquired in one generation in response to environmental stimuli would be inherited by the next generation. Thus over several generations a particular type of organism would become better adapted (*see* ADAPTATION) to its environment. The kinds of acquisition envisaged by Lamarck and their heritability are now discredited, although there has been a recent revival of some aspects of Lamarckism in modified form.

Acrisols A reference soil group in the soil classification scheme used by the *FAO. Acrisols are *acid soils with an argic B horizon (see ARGIC HORIZON) having a *cation-exchange capacity of less than 24 $cmol_c/kg$.

acritarchs Hollow fossil structures, 5–240 μm in diameter, inside which dinoflagellates and single-celled algae survived dry periods. They range from *Precambrian to *Recent times. They are found in marine strata, although some non-marine examples are reported from Recent beds. Acritarchs are used in *correlation and to distinguish onshore from offshore *sediments.

Acrothoracica *See* CIRRIPEDIA.

acrozone *See* RANGE ZONE.

actinium series *See* DECAY SERIES.

actinolite A member of the *amphiboles, $Ca_2(Mg,Fe)_5(Si_4O_{11})_2(OH,F)_2$, with the ratio Fe/Fe + Mg = 0.9 to 0.5, belonging to the *tremolite–*ferroactinolite series of Ca-rich amphiboles; sp. gr. 3.0–3.4; *hardness 5–6; *monoclinic; light greenish-grey to dark green; white *streak; *vitreous *lustre; habit *acicular, often fibrous and felted; *cleavage *prismatic, good {110}; occurs widely in low- to medium-grade *schists and some *igneous rocks. The asbestiform variety is called

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*nephrite and such felted forms were used in the past for insulation and fire-resistant materials, but the development of asbestosis in workers has severely restricted their use.

Actinopterygii (ray-finned fish) A subclass of the *Osteichthyes (bony fish, *see* BONE), comprising the ray-finned fish, which include the majority of living bony fish of sea and fresh water. The *fins are composed of a membranous web of skin supported by a varying number of spines and soft rays. They appeared first during the *Devonian.

activation analysis *See* NEUTRON ACTIVATION ANALYSIS.

activation energy (energy of activation) The energy that must be delivered to a system in order to increase the incidence within it of reactive molecules, thus initiating a reaction.

active geophysical methods Geophysical exploration methods which require an artificial signal to be generated. For example, exploration seismology, some *electromagnetic techniques, *electrical resistivity, *remote sensing, and *induced polarization are said to be active geophysical methods. The term is contrasted with *passive geophysical methods.

active layer Seasonally thawed surface layer between a few centimetres and about 3 m thick, lying above the permanently frozen ground in a periglacial environment. It may be subject to considerable expansion on freezing, especially if silt-sized particles dominate, with important engineering implications. *See also* MOLLISOLS; and PERMAFROST.

active margin (seismic margin) The margin of a continent that is also a *plate margin. The alternative term, 'Pacific-type margin', indicates the range of features (e.g. *earthquakes, andesitic (*see* ANDESITE) volcanic chains, offshore oceanic *trenches, and young fold mountains) which may be associated with active margins. Some authors distinguish an 'Andino-type margin', involving an oceanic and a continental plate, from a 'Japan-type margin', involving an oceanic plate and an *island arc. The term 'Mediterranean-type margin' is also in use, although to a lesser extent, to signify the coincidence of continental edges and plate margins in a *collision zone.

active methods *See* ACTIVE GEOPHYSICAL METHODS.

active pool The part of a *biogeochemical cycle in which the nutrient element under consideration exchanges rapidly between the biotic and abiotic components. Usually the active pool is smaller than the *reservoir pool, and it is sometimes referred to as the 'exchange' or 'cycling' pool.

active remote sensing *Remote sensing which is based on the illumination of a scene by use of artificial radiation. An example is *radar. *Compare* PASSIVE REMOTE SENSING.

activity A broadly used term which refers to the rate or extent of a change associated with some substance or system. For example, it may be the tendency of a metal high in the electromotive series to replace another metal lower in the series, e.g. magnesium displacing copper from most of its compounds. It may also be used to describe the rate of decay of atoms by radioactivity.

activity coefficient (γ) The ratio of chemical activity (i.e. the effective concentration, a) of a component in a solution, to the actual mole fraction (X) present in solution: ($\gamma = a/X$). Values for activities are determined experimentally in a number of ways, including measuring the ratio of the *vapour pressure (p) of a known concentration of the substance in solution to the vapour pressure (p^*) of the pure substance: $a = p/p^*$. In an ideal solution the activity coefficient = 1, and the activity of the component is equal to its mole fraction. In general, the greater the amount of dissolved material, the lower the activity coefficients of each of the species present.

Actonian A *stage of the *Ordovician (453–454 Ma ago) in the Upper *Caradoc, underlain by the *Marshbrookian and overlain by the *Onnian.

actual evapotranspiration (*AE*) The amount of water that evaporates from the surface and is transpired by plants if the total amount of water is limited. *Compare* POTENTIAL EVAPOTRANSPIRATION.

actualism The theory that present-day processes provide a sufficient explanation for past geomorphological phenomena, although the rate of activity of these processes may have varied. The theory was first clearly expressed in 1749 by G. L. L. *Buffon (1707–88), and was the essential principle of *uniformitarianism as presented in 1830 by C. *Lyell (1797–1875).

acuity The ability of a human to discern spatial variation in a scene.

ACV *See* AGGREGATE TESTS.

Adam The postulated male ancestor for all modern humans, who lived in Africa between about 100 000 and 200 000 years ago. 'Adam' is based on a change in the human Y chromosome that occurred at that time in one descendant of Adam and is now present in all human males, except for some Africans. *See also* MITOCHONDRIAL EVE.

adamantine Of mineral *lustre, brilliant, like a polished diamond.

adamellite A rock of granitic composition (*see* GRANITE) characterized by the presence of *quartz, *plagioclase feldspar, and potassic feldspar (*see* ALKALI FELDSPAR) accompanied by *biotite and/or *hornblende. The two feldspar types occur in approximately equal proportions, the plagioclase composition lying within the oligoclase range. The name is derived from the type locality of Adamello in the Tyrol where granites of this type were originally defined. In Britain the best-known example occurs at Shap Fell in Cumbria.

Adams–Williamson equation Equation describing a fundamental relationship between seismic velocities (v_p and v_ω), the *gravitational acceleration (g), and the adiabatic change in density ($d\rho$) within the *Earth (assuming only hydrostatic pressure) as a function of radium (dr):

$$d\rho = \frac{g\rho}{dr v_\rho^2 - (4/3)v_\omega^2}$$

This equation is directly applicable to the lower *mantle and outer *core, but is invalid where the composition is variable, the pressure is not hydrostatic, or the increase in pressure is not adiabatic.

adapical A directional term meaning towards the shell *apex.

adaptation 1. Generally, the adjustments that occur in animals in respect of their environments. The adjustments may occur by *natural selection, as individuals with favourable genetic traits breed more prolifically than those lacking these traits (genotypic adaptation), or they may involve non-genetic changes in individuals, such as physiological modification (e.g. acclimatization) or behavioural changes (phenotypic adaptation). *Compare* ABAPTATION. **2.** In an evolutionary sense, that which fits an organism both generally and specifically to exploit a given environmental zone.

adaptive radiation 1. A burst of evolution, with rapid divergence from a single ancestral form, resulting in the exploitation of an array of habitats. The term is applied at many *taxonomic levels, e.g. the radiation of the mammals at the base of the *Cenozoic refers to *orders, whereas the radiation of 'Darwin's finches' in the Galápagos Islands resulted in a proliferation of *species. **2.** Term used synonymously with '*cladogenesis' by some authors.

adaptive zone The adaptive specialization(s) that fit the *taxon to its environment, e.g. feeding habits.

addition rule (Weiss zone law) With reference to crystallographic notation, the rule stating that the indices (*see* MILLER INDEXES) of two *crystal faces in the same *zone always add up to the indices of a face bevelling the edge lying between them. The rule may be used to index faces on a *stereogram, or faces at the intersection of two zones.

additive primary colours The spectral colours red, green, and blue, which, when mixed together by projection through filters, can be used to produce all other colours. None of the primary colours can be produced by combinations of the other two. *See also* SUBTRACTIVE PRIMARY COLOURS.

adductor muscles *See* MUSCLE SCAR.

Adelaidean A *stage (542–1 300 Ma ago) of the Upper *Proterozoic of south-eastern Australia, underlain by the *Carpentarian and overlain by the Hawker (*Cambrian).

Adelaidean orogeny A late *Proterozoic and *Ordovician phase of mountain building, affecting what is now southern Australia, in which *sedimentary rocks of the Adelaidean System were raised by severe thrusting and overfolding, first in the south and later along the northern margin of the system.

adhesion ripples *See* ADHESION WARTS.

adhesion warts (adhesion ripples) A *sedimentary structure consisting of an irregular, wart-like or blistered, *sand surface, formed by the wind blowing dry sand over a moist surface. The warts tend to be slightly asymmetrical, with steeper sides in the upwind direction.

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adiabat The rate at which a *parcel of air cools as it rises and warms as it descends, as indicated by two lines (dry adiabat and wet adiabat) on a *tephigram.

adiabatic Applied to the changes in temperature, pressure, and volume in a *parcel of air or liquid that occur as a consequence of the vertical movement of the fluid, and without any exchange of energy with the surrounding fluid. *See also* DRY ADIABATIC LAPSE RATE; and SATURATED ADIABATIC LAPSE RATE.

adit Horizontal or nearly horizontal tunnel from the surface into a mine, for entry, drainage, or exploration.

admission The substitution of a *trace element for a major element with a similar *ionic radius but a higher *valency during the crystallization of a *magma, e.g. the substitution of Li^{+} for Mg^{2+} in the *pyroxenes, *amphiboles, and *micas.

adobe A silty *clay, often calcareous, found in dry, desert-lake basins. This fine-grained *sediment is usually deposited by desert floods which have eroded wind-blown *loess deposits. The term is of Spanish origin.

adoral On the same side of the body as the mouth.

Adrastea (Jupiter XV) A jovian satellite (a *moom) that orbits within the main ring of Jupiter; it and *Metis may be the source of the material comprising the ring. Both are considered too small to suffer tidal disruption, but eventually their orbits will decay. Adrastea is one of the smallest satellites in the solar system. It was discovered in 1979 by David Jewitt. Its diameter is 20 km (±20) (23 × 20 × 15 km); mass 1.91×10^{6} kg; mean distance from Jupiter 129 000 km.

adsorption The attachment of an ion, molecule, or compound to the charged surface of a particle, usually of *clay or *humus, from where it may be subsequently replaced or exchanged. Ions carrying positive charges (e.g. those of calcium, magnesium, sodium, and potassium) become attached to, or adsorbed by, negatively charged surfaces (e.g. those of clay or humus).

adsorption complex Various materials of the soil, mainly *clay and *humus and to a lesser degree other particles, capable of adsorbing ions and molecules.

adularia *See* ALKALI FELDSPAR.

advection The horizontal transfer of heat by means of a moving gas (usually air).

adventive cone *See* PARASITIC CONE.

AE *See* ACTUAL EVAPOTRANSPIRATION.

aedifichnia A category of *trace fossils that comprises structures in full relief that were constructed by organisms from raw materials, e.g. mud nests of wasps, caddis fly cases, spiders' larders consisting of concentrations of insects, insect remains, and spiders.

aegirine *Pyroxene mineral, $NaFe^{3+}Si_2O_6$; sp. gr. 3.5; *hardness 6; *monoclinic; greenish-black or brown; occurs as fairly short, *prismatic crystals in *igneous and *metamorphic rocks. A variety intermediate in composition between aegirine and augite is called 'aegirine–augite'. *See also* AUGITE; and CLINOPYROXENE.

Aegyptopithecus zeuxis A genus and species of early *catarrhine primates, known from abundant remains, including several nearly complete skulls, from the early *Oligocene of the Jebel al-Qatrani Formation, Fayum, Egypt. The size of a small, living monkey, it had a long tail and could jump from branch to branch. It possessed the dental and some of the cranial characteristics of living catarrhines, but lacked many of the other cranial and most of the postcranial diagnostic features, and so represents a time when catarrhines had separated from other primates, but remained more primitive than living hominoids (*Hominoidea) or Old World monkeys and it could have been ancestral to living catarrhines.

aeolian abrasion The erosion of a surface that is caused by bombardment with loose particles carried by the wind.

aeolianite General term for the sedimentary products of wind (aeolian) deposition.

aeolian processes (eolian processes) The erosion, transport, and deposition of material due to the action of the wind at or near the Earth's surface. Aeolian processes are at their most effective when the vegetation cover is discontinuous or absent.

aeolian ripple (eolian ripple) A ripple on the surface of a sedimentary rock that is caused by saltating grains. Aeolian ripples have a wavelength approximately equal to the *saltation path of the grains, and they usually have no internal *cross-lamination.

Aeolis Quadrangle A region of Mars formed in the Late *Noachian or Early *Hesperian Epoch, containing both extensional and compressional land-forms and *valles, some of which may be outflow channels, but some of which may be tectonic rift features.

aerial photograph A photograph taken from an aircraft. In hydrology, false-colour infrared photographs are used to determine the wetness and temperature of soils and to detect *springs.

aerial photography The taking of aerial photographs of rock exposures and of the ground surface for purposes of geologic interpretation. The photographs may be taken vertically, or at a high-oblique or low-oblique angle, and may be assembled like a mosaic to provide a picture of a large area. Stereoscopic cameras (two cameras within a single body) may be used to produce pairs of pictures that provide three-dimensional pictures when observed through a stereoscopic viewer. *See* PHOTOGEOLOGY.

aerobic 1. Of an environment: one in which air (oxygen) is present. In the case of a depositional environment, one with more than 1 ml of dissolved oxygen per litre of water. *Compare* ANAEROBIC; and DYSAEROBIC. **2.** Of an organism: one requiring the presence of oxygen for growth, i.e. an aerobe. **3.** Of a process: one that occurs only in the presence of oxygen.

aerodynamic roughness Uneven flow of air caused by irregularities in the surface (which may be of a solid, or of air of different density) over which the flow takes place.

aerological diagram Diagram to demonstrate variations with height of the physical characteristics of the atmosphere, particularly its temperature, pressure, and *humidity.

aeromagnetic survey Survey of the Earth's magnetic field, based on data from *magnetometers towed behind aircraft or suspended below helicopters. These instruments measure the total intensity of the *geomagnetic field or, occasionally, components of this field. The resulting measurements can then be compared with theoretical models for the value of the field and the differences (*magnetic anomalies) can be interpreted in terms of changes in the magnetic properties of the rocks below the survey line or grid. The magnetometers are usually flown with other instrumentation, e.g. *radiometric and electromagnetic, at the lowest practicable constant height above the ground. Usually the magnetometer is housed in a 'bird' towed behind the aircraft, or in a wing-tip pod, or in a 'stinger' in the tail. In cases where the magnetometer is on board, in-board coil systems compensate for the aircraft's own magnetic field.

Aeronian A *stage (436–439 Ma ago) of the Lower *Silurian (*Llandovery Period) underlain by the *Rhuddanian and overlain by the *Telychian.

aerosol Colloidal substance, either natural or man-made, that is suspended in the air because the small size (0.01–10 μm) of its particles makes them fall slowly. Aerosols in the *troposphere are usually removed by *precipitation and their *residence time is measured in days or weeks. Aerosols that are carried into the *stratosphere usually remain there much longer. Tropospheric aerosols may act as *Aitken nuclei but the general effect of aerosols is to absorb, reflect, or scatter radiation. Stratospheric aerosols, mainly sulphate particles resulting from volcanic *eruptions, may reduce *insolation significantly. About 30% of tropospheric dust particles are the result of human activities. *See* ATMOSPHERIC STRUCTURE; MIE SCATTERING; RAYLEIGH SCATTERING; and VOLCANIC DUST.

Aëtosauria Mainly *Triassic group of primitive thecodontian ('tooth-in-socket') reptiles (*see* THECODONTIA). They resembled heavily armoured crocodiles, and appear to have been specialized herbivores or possibly omnivores. They grew up to 3 m long, and their armour plating comprised rows of bony *plates.

AFC *See* ASSIMILATION-FRACTIONAL CRYSTALLIZATION.

AF demagnetization *See* ALTERNATING MAGNETIC FIELD DEMAGNETIZATION.

AFM diagram A three-component, triangular graph used to show how metamorphic *mineral assemblages vary as a function of *rock composition within one *metamorphic facies. Besides SiO_2, the five most abundant oxides found in *metamorphic rocks are Al_2O_3, CaO, FeO, MgO, and K_2O. The three components plotted on AFM diagrams are derived from a tetragonal diagram, with species Al_2O_3, K_2O, FeO, and MgO, and are ideal for showing mineral assemblage variations as a function of the composition of *pelites. Mineral and rock compositions plotting within this diagram are projected on to the Al_2O_3–FeO–MgO face from either the *muscovite or K-feldspar point on

a

the Al_2O_3–FeO edge. The components of the diagram are thus A (Al_2O_3), F (FeO), and M (MgO), with the projection geometry being accommodated on specially scaled axes. Each of these components has to be modified slightly to account for the presence of other, minor components in the rock, leading to: A ($Al_2O_3 - 3K_2O$); F (FeO – TiO_2 – Fe_2O_3); and M (MgO). The minerals *quartz and *albite are assumed to be present in the rocks and are not shown on the diagram. As in *ACF diagrams, *tielines connect minerals which coexist in equilibrium.

AFMAG EM system *A*udio-*F*requency *M*agnetic *E*lectro*M*agnetic method, which uses natural electromagnetic (EM) fields (*sferics) in the audio-frequency range (1–1 000 Hz) generated by thunderstorms to investigate lateral changes in the *resistivity of the Earth's surface.

African Plate One of the present-day major lithospheric *plates, consisting of the continental mass of Africa surrounded, except to the north, by *oceanic crust and oceanic *ridges. To the north, a complex picture of collision and *subduction zones and *transform faults has been postulated for the boundary with the *Eurasian Plate and various minor plates, e.g. the *Aegean Plate. The northern part of the African Plate also contains remnants of the oceanic crust of *Tethys. To the north-east the Red Sea is interpreted as an actively forming ocean, at the young stage of the *Wilson cycle, while the E. African *rifts, partially defining what is called by some the 'Somali Plate' to the east, may be at the embryonic stage of ocean development, or possibly a stillborn ocean.

aftershock A seismic event that occurs after an *earthquake, usually within days or weeks. Although often of small *magnitude, aftershocks can be more destructive as buildings and structures have already been weakened.

Aftonian The earliest (1.3–0.9 Ma) of four *interglacial *stages in N. America, following the *Nebraskan glacial episode, and approximately equivalent to the *Donau/Günz interglacial of Alpine terminology. Climatically it was marked by mild summers and winters warmer than those in present-day N. America.

Agassiz, Jean Louis Rodolphe (1807–73) A Swiss geologist who worked initially on fossil fish, Agassiz is better known for his *glacial theory (1837). He met *Buckland in 1840, and persuaded him that *drift deposits in Britain were evidence of a glacial epoch. In 1846 he moved to the USA to become professor of zoology and geology at Harvard, where he founded the Museum of Comparative Zoology (1859).

agate (mocha stone) Variety of chalcedonic silica (SiO_2) that is *cryptocrystalline. It is similar to *chalcedony except that impurities of iron and manganese may give it a distinct colour banding which is frequently precipitated in concentric zones. Moss agate contains delicate, fern-like, dendritic patterns. Agates may be cut and polished as decorative stones.

age 1. The interval of geologic time equivalent to the *chronostratigraphic unit '*stage'. Ages are subdivisions of *epochs and may themselves be subdivided into *chrons. An age takes its name from the corresponding stage, so like the stage name it carries the suffix '-ian' (or sometimes '-an'); the term 'age' is capitalized when used in this formal sense, e.g. '*Oxfordian Age'. **2.** An *informal term to denote a time span marked by some specific feature, e.g. '*Villefranchian mammalian age'.

ageostrophic wind The vector difference between the *geostrophic and the actual winds.

agglomerate Coarse-grained volcanic rock with rounded to subangular fragments. These fragments are mainly larger than 2 cm in size, but the mixture of fragments is typically ill sorted and the *matrix may be fine grained. An agglomerate may be the product of a volcanic explosion and therefore a *pyroclastic rock, but often the term 'agglomerate' is applied to brecciated volcanic rocks of uncertain origin. Those deposits may range from vent *breccias to debris from mudflow or lahar deposits.

agglutinate A constituent of lunar soils comprising glass-bonded *aggregates, which consist of *glasses and rock and mineral fragments welded together by glass. These aggregates form during the impact of micrometeorites into lunar soils. Their abundance in a lunar soil is an index of exposure to micrometeorite bombardment, and hence to soil maturity. The average size of agglutinates in mature soils varies, but tends toward a mean of 60 μm.

aggradation The general accumulation of unconsolidated sediments on a surface, which thereby raise its level. A large range of