Four billion years of rock formation

For all life forms the most important zone of the earth is the thin outermost rocky shell—the earth's crust. Averaging only about 10 km thick under the oceans and about 30 km under the landmasses, the crust is relatively much thinner than the shell of a hen's egg. Importantly, however, the crust contains chemical elements that are essential for plant and animal life.

Oxygen and silicon are the most abundant elements, together comprising more than 75% of the crustal rocks, mostly in the form of silicate minerals. The most common of these is quartz (silicon dioxide). Eight other elements (aluminium, iron, calcium, sodium, potassium, magnesium, hydrogen and phosphorus) make up virtually all the remaining 25% of the crustal rocks. These elements occur in a large variety of combinations as rock minerals with an equally wide variation in composition and physical characteristics.

There are three main types of crustal rock, categorised according to their mode of formation—igneous, sedimentary and metamorphic.

Igneous rocks—the most common crustal rocks—have resulted from the solidification of molten material (magma) upwelling from below the crust. They have either been intruded into pre-existing crustal rocks or extruded onto the earth's surface and almost all are aggregates of silicate minerals with distinct crystalline structures.

Intrusive igneous rocks such as granite, which have cooled and solidified slowly while enclosed in the surrounding insulating crustal rock, are formed of large crystals. They have coarse-grained structures and relatively low densities.

By comparison *extrusive* igneous rocks such as basalt, which have formed from the rapid cooling and solidification of molten lava forced to the surface by volcanic activity, consist of small crystals. They have fine textures and relatively high densities.

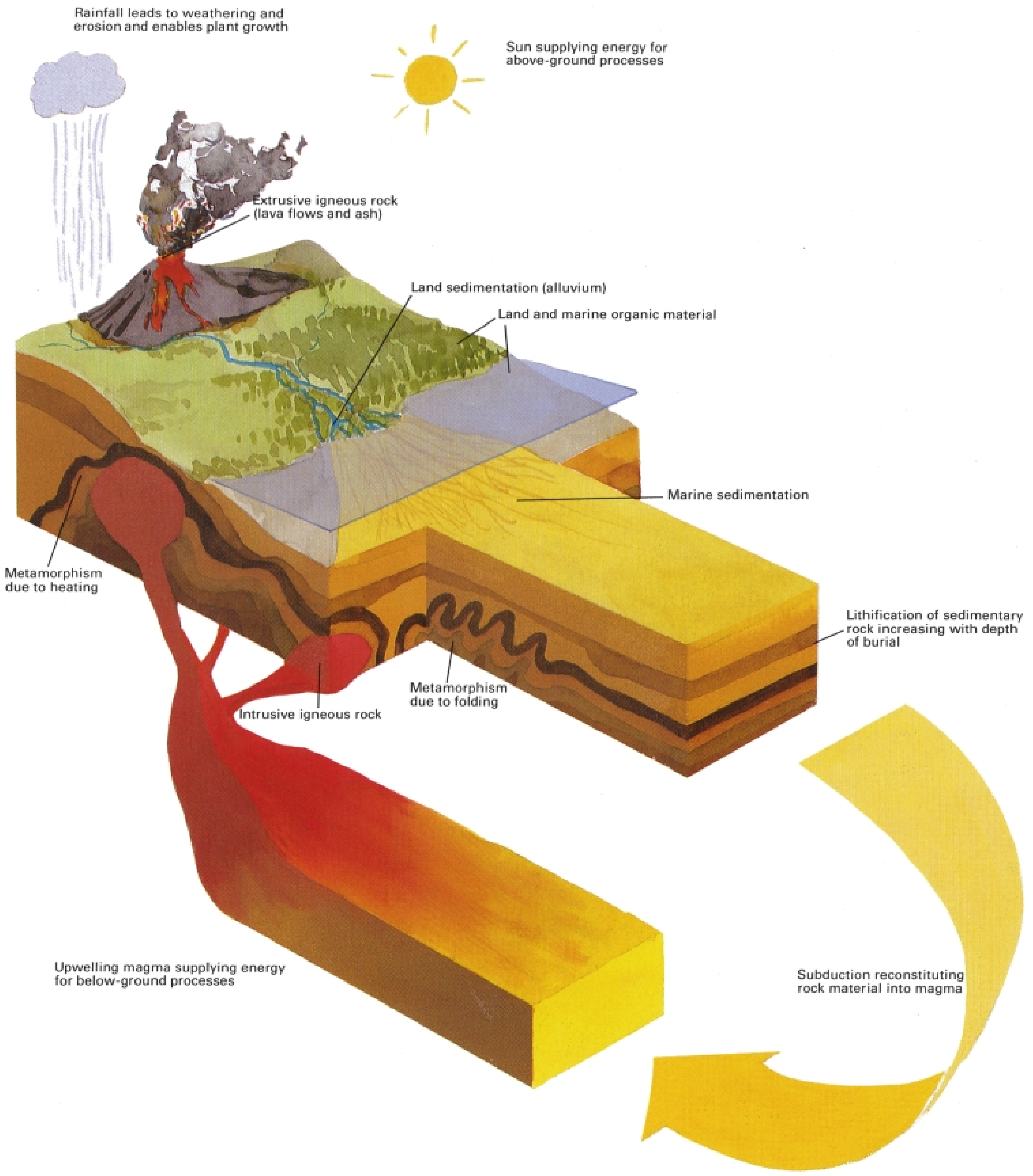
Igneous rocks are also broadly subdivided according to their chemical composition into acid or basic. *Acid* rocks (such as granite) have a large proportion of silica and are also termed *felsic* (containing much felspar and silica). *Basic* rocks (such as basalt) contain much less silica and, because they are often rich in magnesium and iron, are termed *mafic*.

Sedimentary rocks, as their name implies, mostly result from the deposition of weathering or erosional products of pre-existing rocks. They were mostly laid down in seas or freshwater lakes as sediments which later consolidated. Rocks formed in this way are termed *detrital* or *clastic*; sandstone is a common example.

Two other important types of sedimentary rocks have organic or chemical origins. *Organic* sedimentary rocks are composed of the calcareous remains of marine shells or corals forming fossiliferous limestone or of compressed plant material forming coal. *Chemical* sedimentary rocks have formed from chemical precipitation in seawater to form rocks such as crystalline limestone (from the precipitation of calcium carbonate) or chert (from a precipitate of silica). Rock salt and gypsum also belong to this type but result from evaporation of shallow seawater.

Metamorphic rocks have been formed by the alteration (metamorphism) of pre-existing rocks under conditions of extreme temperature and pressure caused by magmatic intrusion or tectonic activity. Metamorphism changes the texture (generally making the altered rock more flaky or plate-like) and increases the hardness and mineralisation. To a certain extent all rocks, except those formed in the most recent geological time, have experienced metamorphism and therefore degrees of metamorphism are recognised. For example a mudstone (a sedimentary rock) can be altered by mild metamorphism to a slate (a low grade metamorphic rock) or, under extreme conditions, to a gneiss (a high grade metamorphic rock).

The rock cycle



Geological time

The earth's crustal rocks have been forming over a very long time—at least four billion years.

This long history of rock formation is conventionally divided into two eons, which can be further subdivided into eras and periods whose names were first applied by 19th century geologists working in the British Isles and Europe.

Some period names are derived from the names of ancient British tribes (for example the Cambrian, Silurian and Ordovician periods); others are named after areas or places where rocks of that age were first identified (for example the Devonian, Jurassic and Permian periods); while yet others were named according to the rock type most characteristic of the area where the periods were first studied in Britain (such as the Carboniferous, derived from the important British coal measures, and the Cretaceous, derived from the extensive English chalk deposits). Even though these names are not at all appropriate world-wide, they still remain in universal conventional use.

The two eons—the prime subdivisions of geological time—are termed the **Precambrian** (also called the Cryptozoic or 'time of hidden life') and, beginning about 570 m.y. ago, the **Phanerozoic** or 'time of obvious life'.

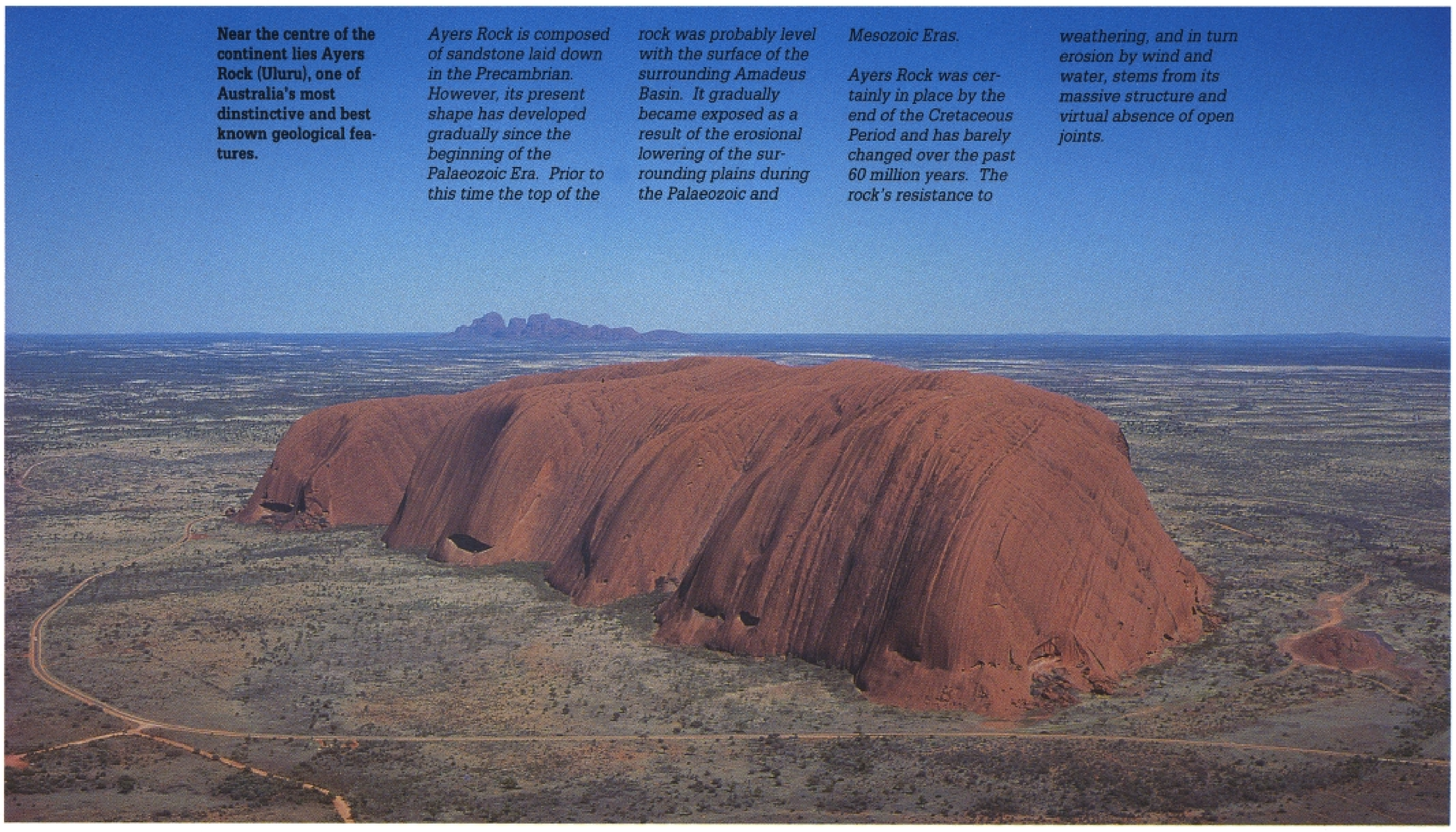
Up to the end of the Precambrian only life forms with soft bodies, such as jellyfish, worms and algae, had evolved so their fossilised remains in surface rocks are scarce and difficult to detect today. However, during the Palaeozoic Era, in the first part of the Phanerozoic Eon, life forms with hard shells, skins or bones evolved and as a result their fossilised remains are easier to detect and study.

By the beginning of the Mesozoic Era, some 200 m.y. ago, fish, insects, reptiles and land plants had evolved. This era was characterised by the large reptilean dinosaurs, though they became extinct at its end. The most recent era, the Cainozoic, which began about 65 m.y. ago, saw the main evolution of present-day land plants, birds and mammals including, most recently, mankind.

The following sections in this volume provide a brief overview of Australia's very long geological history, from about 3500 m.y. ago up to the present. The growth of the continent is traced through successive periods by deducing the changing distribution of land and sea, and the progression of crustal movements and igneous activity which together built up the land as we see it today.

The 1:5 million scale map 'Geology' shows the surface geology of Australia classified according to age of deposition of sedimentary rocks and in the case of igneous rocks their mode and age of formation.

The absolute age of igneous rocks can be determined by measuring the radioactivity of minerals within the rocks. Because radioactive elements disintegrate at a constant rate to give a known series of decay products it is possible, by analysis of some radioactive minerals in rocks, to estimate when the mineral was formed in the crust, thus giving the rock's absolute age.



Near the centre of the continent lies Ayers Rock (Uluru), one of Australia's most dinstinctive and best known geological features.

Ayers Rock is composed of sandstone laid down in the Precambrian. However, its present shape has developed gradually since the beginning of the Palaeozoic Era. Prior to this time the top of the rock was probably level with the surface of the surrounding Amadeus Basin. It gradually became exposed as a result of the erosional lowering of the surrounding plains during the Palaeozoic and Mesozoic Eras.

Ayers Rock was certainly in place by the end of the Cretaceous Period and has barely changed over the past 60 million years. The rock's resistance to weathering, and in turn erosion by wind and water, stems from its massive structure and virtual absence of open joints.

Geological time is so vast in comparison to the time that mankind has been on earth that an analogy with a calendar year provides an interesting illustration. If the Phanerozoic Eon (which alone only covers about one-eighth of total geological time) was compressed into one year amphibians would be found crawling up onto the Australian continent for the first time in mid April; dinosaurs evolving in early July but then dying out in late October; and Aboriginals migrating to Australia within forty minutes of New Year's Day.

Geological time-scale