between these two regions. It seems that lighter elements such as silicon are present, and that there could be a small proportion of nickel, perhaps 6 per cent, as found in metallic meteorites. The crust, which does not greatly affect the Earth's overall density because of its relative thinness (7–40 km), is very light with large quantities of silicon and aluminium compounds and a high concentration of sodium, potassium and the two radioactive elements uranium and thorium.

It is known that there is a flow of heat from the interior of the Earth, but that this is only about 0·04 per cent of the heat received from the Sun. Part of this internal heat is probably a remnant of the heating produced when the Earth was originally formed, and the rest has come from the decay of radioactive elements. It is difficult to calculate the temperature which exists at the centre, but there is general agreement that this must be in the region of 4 000–5 000 K to be consistent with seismic results. This heat is thought to produce convection within the liquid outer core (which is probably of importance with regard to the Earth's magnetic field), and to be a contributory factor in causing the flow in the middle layer of the mantle, which is suggested by plate tectonic studies.

Table 5·1 **Major subdivisions of the Earth**

	thickness or radius (km)	**mass (kg)**	**mean density (kg per m³)**
oceanic crust	7	$7{\cdot}0 \times 10^{21}$	2 800
continental crust	40	$1{\cdot}6 \times 10^{22}$	2 800
mantle	2 870	$4{\cdot}08 \times 10^{24}$	4 600
core	3 480	$1{\cdot}87 \times 10^{24}$	10 600
oceans	4	$1{\cdot}39 \times 10^{21}$	1 000
atmosphere	—	$5{\cdot}1 \times 10^{18}$	—

The distribution of density within the core is difficult to determine, there being a range of possibilities, but the probable mean densities are approximately 10 000 kg per m³ for the outer core, and 13 000 kg per m³ for the inner.

Plate tectonics

The most obvious division of the Earth's surface is into continents (40 per cent) and ocean floors (60 per cent). With this in mind, and using geological evidence from the continents as well as noting the way the coastlines of European, African, and North and South American continents fit together, Alfred Wegener proposed in 1915 a theory of continental drift. The continents were supposed to have formed one large land mass and then to have drifted apart. Increasing information about the oceans, the sea-beds and rock magnetism has led to continental drift being superseded by the theory of plate tectonics. This states that the crust is carried upon the outer layer of the mantle, which is in the form of a number of relatively rigid, thin (100–200 km) plates which are in motion both with respect to one another and to the interior of the Earth. This movement, which is naturally very slow, is permitted by a flow in the underlying weak layer. A circulation of material exists, rising towards the surface (generally in the centre of the oceanic areas), flowing horizontally over considerable distances and then descending again into the interior (Fig. 5·2).

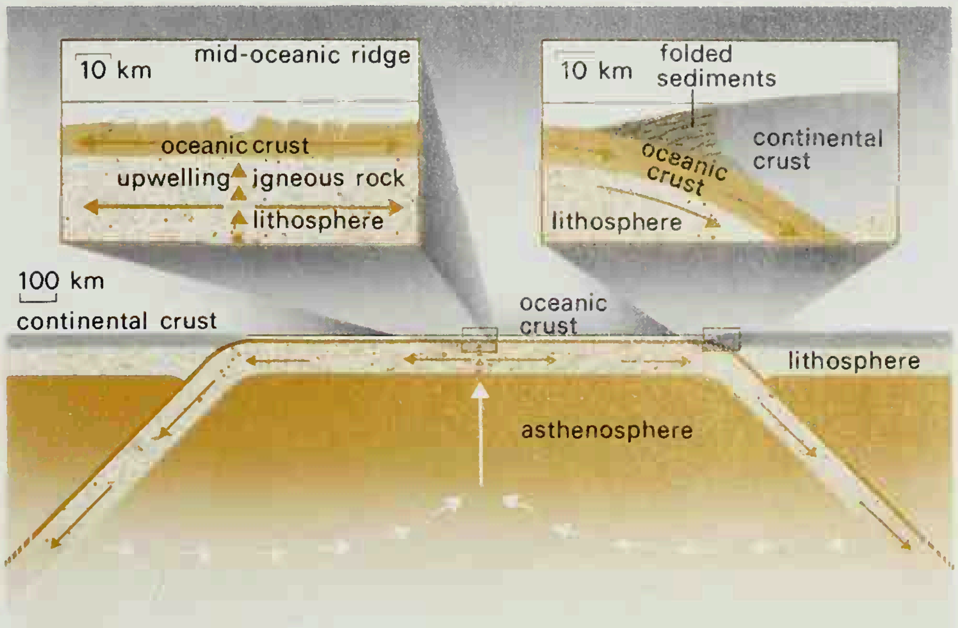

Fig. 5·2
A schematic diagram of plate tectonic movements. Material rises from the mantle under the mid-oceanic ridges and, spreading sideways, carries plates of both oceanic and continental crust. Mountains are formed where crustal regions 'collide'.

The upwelling is particularly noticeable at the mid-oceanic ridges which rise about 2 km above the general level of the ocean floors and where the injection of IGNEOUS ROCK adds to the edges of the separating areas of crust. On cooling such MAGMAS are magnetized by the effect of the Earth's general magnetic field. One of the main factors leading to the acceptance of the plate tectonic theory was the discovery that due to periodic reversals in the Earth's magnetic field, the rocks had been magnetized in opposite directions to give a series of magnetic stripes, and that these were repeated on the other side of the mid-oceanic ridge.

A further effect of the separation of the plates is the production of rift valleys, or **graben**, along the centre of the oceanic ridges. The regions where the plates descend into the interior are often associated with ocean trenches. By determining the depths at which earthquakes occur, it is found that the plates descend at an angle of 45° down to about 700 km where the increasing temperature and pressure cause them to lose their identity.

It is the mobility of the plates which has resulted in the long, curved mountain-building belts which are so characteristic of the Earth and which are absent from the other planets. The average thickness of the continental crust is 40 km, compared with the 7 km of the oceanic crust, and where these two types meet, the oceanic one descends beneath the continental region. Large quantities of volcanic rocks are produced and the resulting mountains are like those of the Andean Cordillera. The other conspicuous type of mountain belt, such as the Himalayan and Alpine chains, is formed by the interaction of two continental regions resulting in the folding, over-thrusting and uplift of thick layers of SEDIMENTARY ROCKS.

The mountain belts surround regions of continental rocks which have been geologically stable for long periods of time. By RADIOISOTOPE DATING methods it has been established that these shield areas, or **cratons**, are generally $2{\cdot}2$–$2{\cdot}7 \times 10^9$ years old and that the very oldest Earth rocks have ages of