PLATE TECTONICS

K.V. Wilbert Kehelpannala

The lithosphere of the Earth is fragmented into many parts, of which about 10 are very important. These fragments, which move over the asthenosphere of the Earth, are called "plates". This process is called "plate tectonics" and is responsible for mountain building, earthquakes, volcanism and other major phenomena occurring in the Earth. Figure 1 shows the major plates of the Earth and their boundaries.

Generally lithospheric plates are of two types. They are: (I) continental plates and (ii) oceanic plates. The continental plates consist of continents, together with parts of the oceanic crust (Figure 2). The North American, South American, Eurasian, African, India-Australian, Antarctic and Arabian plates are examples for oceanic plates (Figure 1). Plates are separated by plate boundaries that are of three types (Figure 3). These are

(I) divergent plate boundaries (mid oceanic ridges and rift zones),
(ii) convergent plate boundaries (subduction zones) and
(iii) transform faults.

At divergent plate boundaries, plates move apart creating a new sea floor between the moving plates. The Atlantic Ocean (Figures 1, 3a, 4a) has opened in this manner about 180 million years ago, when the South American plate separated from the African Plate. At the initial stages of opening of a sea at divergent plate boundaries, rift zones are formed (Figure 3a).

In contrast, at convergent plate boundaries, plates move towards each other, and finally they collide to form mountain belts. The collision can occur between continental-continental plates, continental-oceanic plates and oceanic-oceanic plates. At the beginning of a continental collision, the oceanic crust of the involving plates may collide first. Subsequently, the continental parts may collide into a single landmass, closing the ocean between them (Figure 4). The collisional zones are characterized by geological features called subduction zones, where the heavier plates subduct into the asthenosphere under the overlying plates (Figure 3b). The oceanic crust at subduction zones is deflected to form trenches that are the deepest parts of the oceans (Figure 1, 3b, 4).

All the mountain belts of the world have formed through collision between plates at subduction zones (Figure 1, 4). The mountain belts can be grouped into two classes. These are (i) interior mountain belts and (ii) peripheral mountain belts. Interior mountain belts form through the collision between two continental plates. The best examples for interior mountain belts are the Himalayas (Figures 1, 4d) and the European Alps (Figure 1). The Himalayas formed about 40 million years ago when the India-Australian Plate collided with the Tibetan Plate (or Eurasian Plate). This collision is still active and is responsible for earthquakes in India. Peripheral mountain belts form through the collision between oceanic plates and continental plates. The Rocky and the Andes in western America (Figure 1, 4a) are excellent examples for this type of mountain belts.

Plates slide past each other along transform faults. There are many transform faults in the world, and they are responsible for changing the configuration of the mid oceanic ridges (Figure 1). The San Andrea's fault in California and the fault, which separates the North American plate from the Caribbean plate, are two major transform faults (Figure 1).

The break-up and collision of different plates accounted for the distribution of the present-day continents, which formed from a single supercontinent called "Pangaea" that existed about 200 million years ago (Figure 5). The break-up of the Pangaea began about 180 million years ago with the separation of the Gondwanaland (landmass consisting of South America, India,

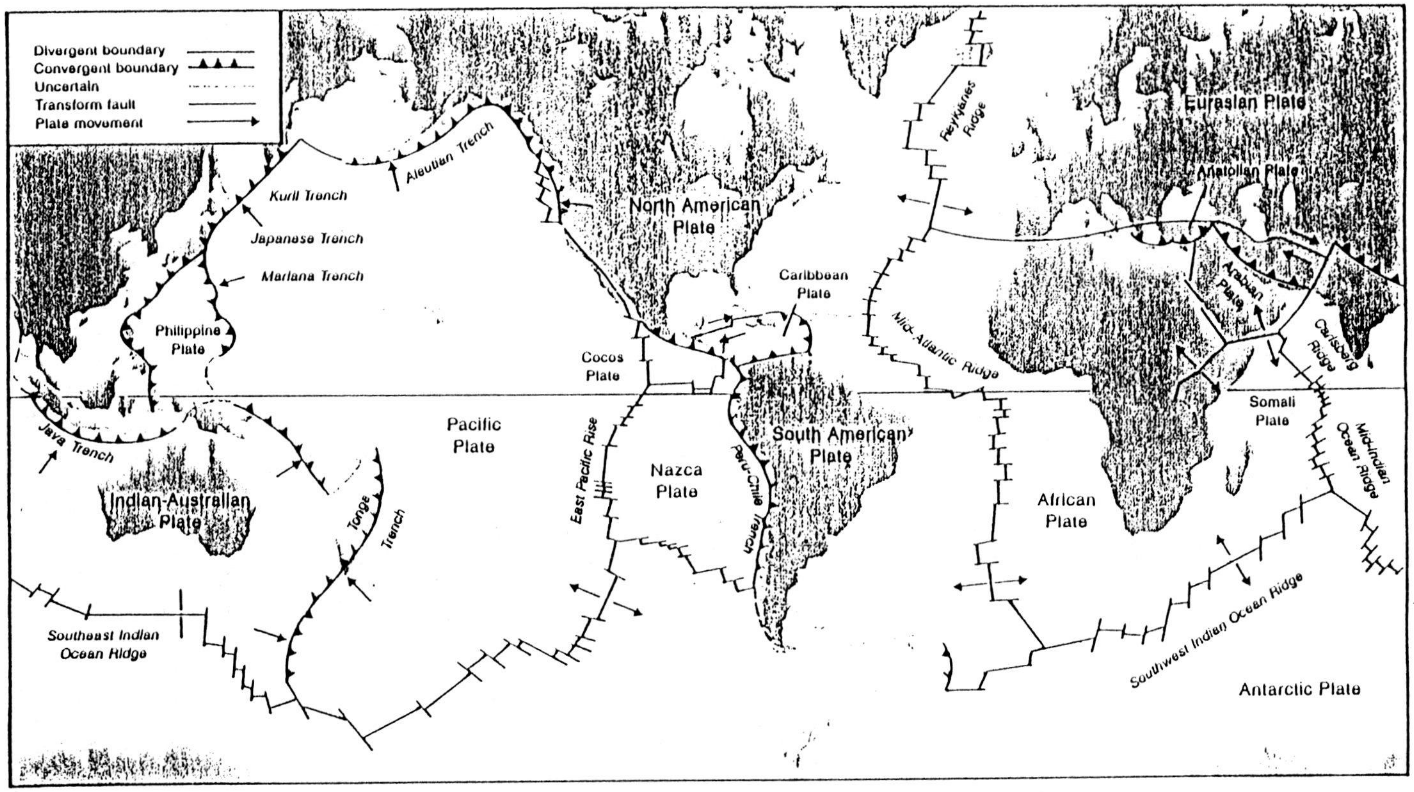

Figure 1. The Earth's major lithospheric plates are in motion with respect to one another. At divergent plate boundaries (such as mid oceanic ridges) the plates move apart, only to collide and overlap at convergent boundaries (subduction zones). Plates slide past each other along transform faults, the most famous of which is the San Andreas fault that runs the length of California. Arrows show the direction of movements of plates.

Australia, Antarctica, Africa, Madagascar and Sri Lanka) from the Laurasia (continent consisting of North America and Eurasia) (Figure 5). Almost all continents were separated through rifting between 60 and 180 million years ago. Subsequent divergence and collision shaped the present-day configuration of the continents (Figure 5c).

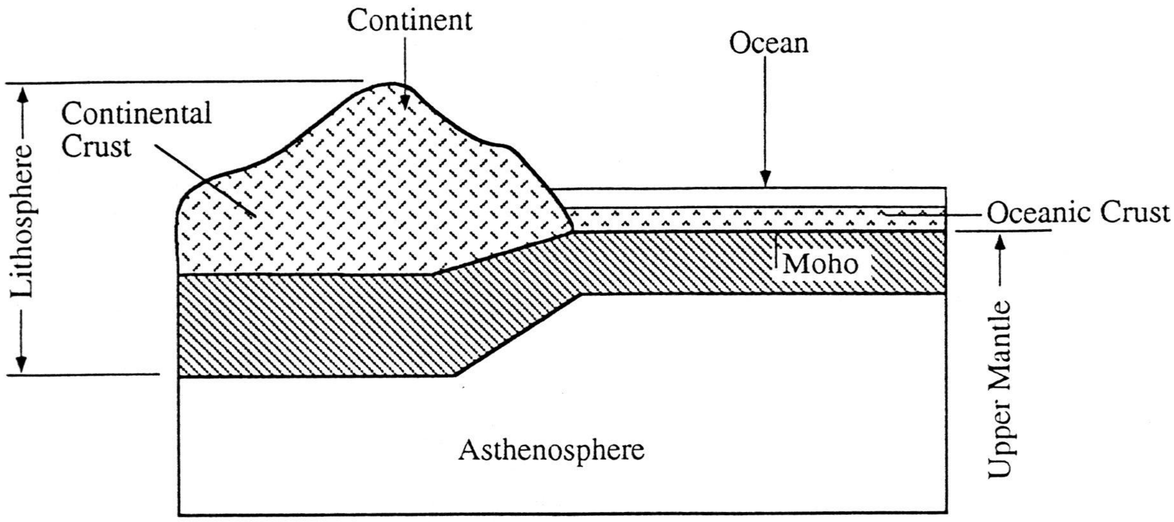

Figure 2. Major parts of a lithospheric plate.

Break-up of continents, collision through subduction and faulting have also existed before the birth of Pangaea. The supercontinent Pangaea had formed through collision and amalgamation of continents about 360 million years ago. The formation of supercontinents has also occurred during Archaean (>2400 million years) and Proterozoic (570 to 2300 million years) times. The formation and fragmentation of supercontinents seem to be a cyclic process, which is referred to as the "Wilson Cycle". Recently, geologists have established that the lifetime of a supercontinent cycle is about 500 million years. Sri Lanka is also a fragment of the Gondwanaland and may have formed through the collision of three different geological units, with different ages, about 600-500 million years ago.

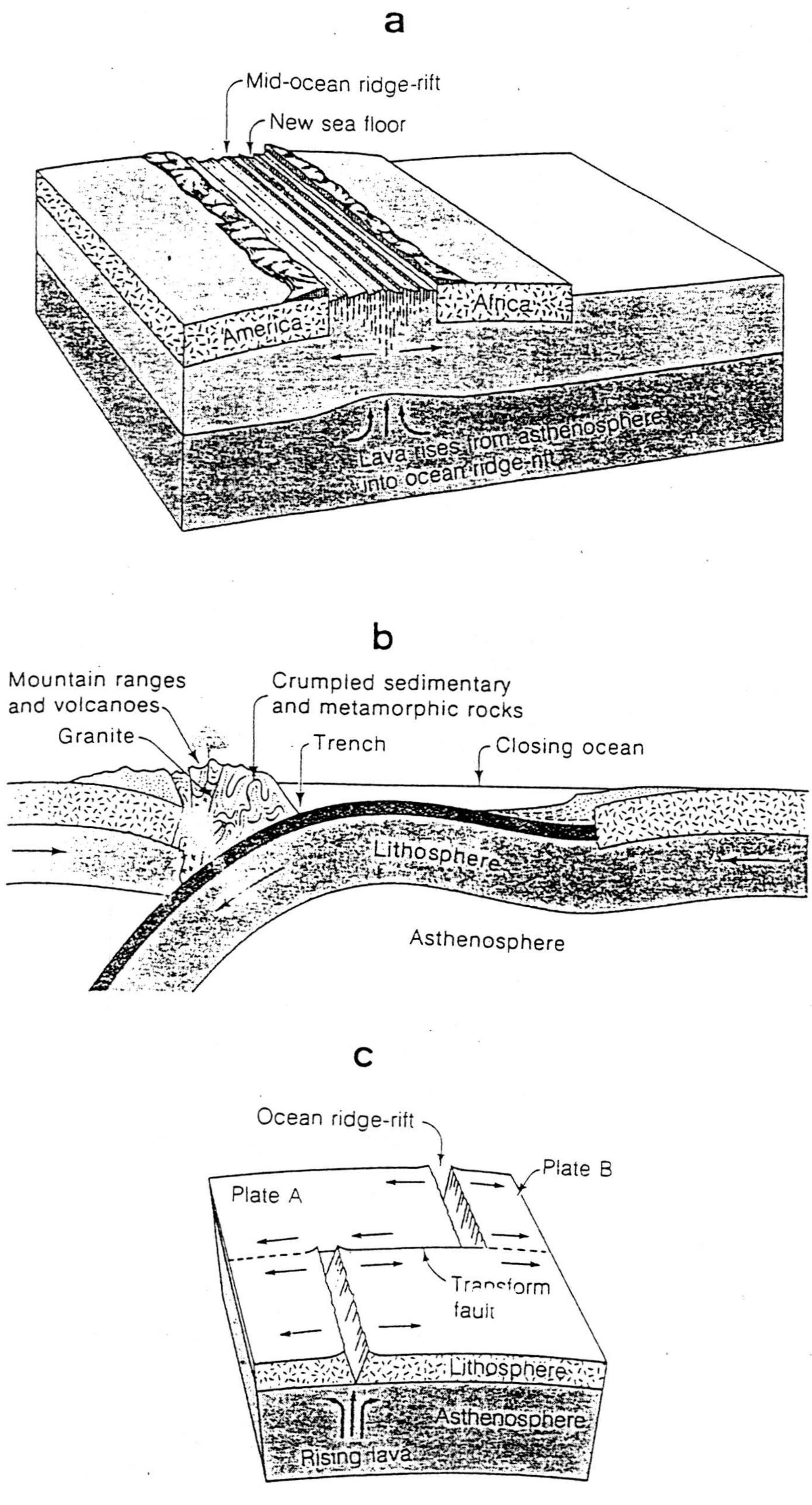

Figure 3. Types of plate boundaries. (a) Mid oceanic ridge-rift where plates move apart. New material from the deep interior of the Earth rises to the surface at these boundaries. (b) Subduction zone at which plates collide and subduct. Here rocks are crumpled, deformed and metamorphosed, and the collision leads to the formation of mountain belts. (c) Transform faults where plates slide past each other.

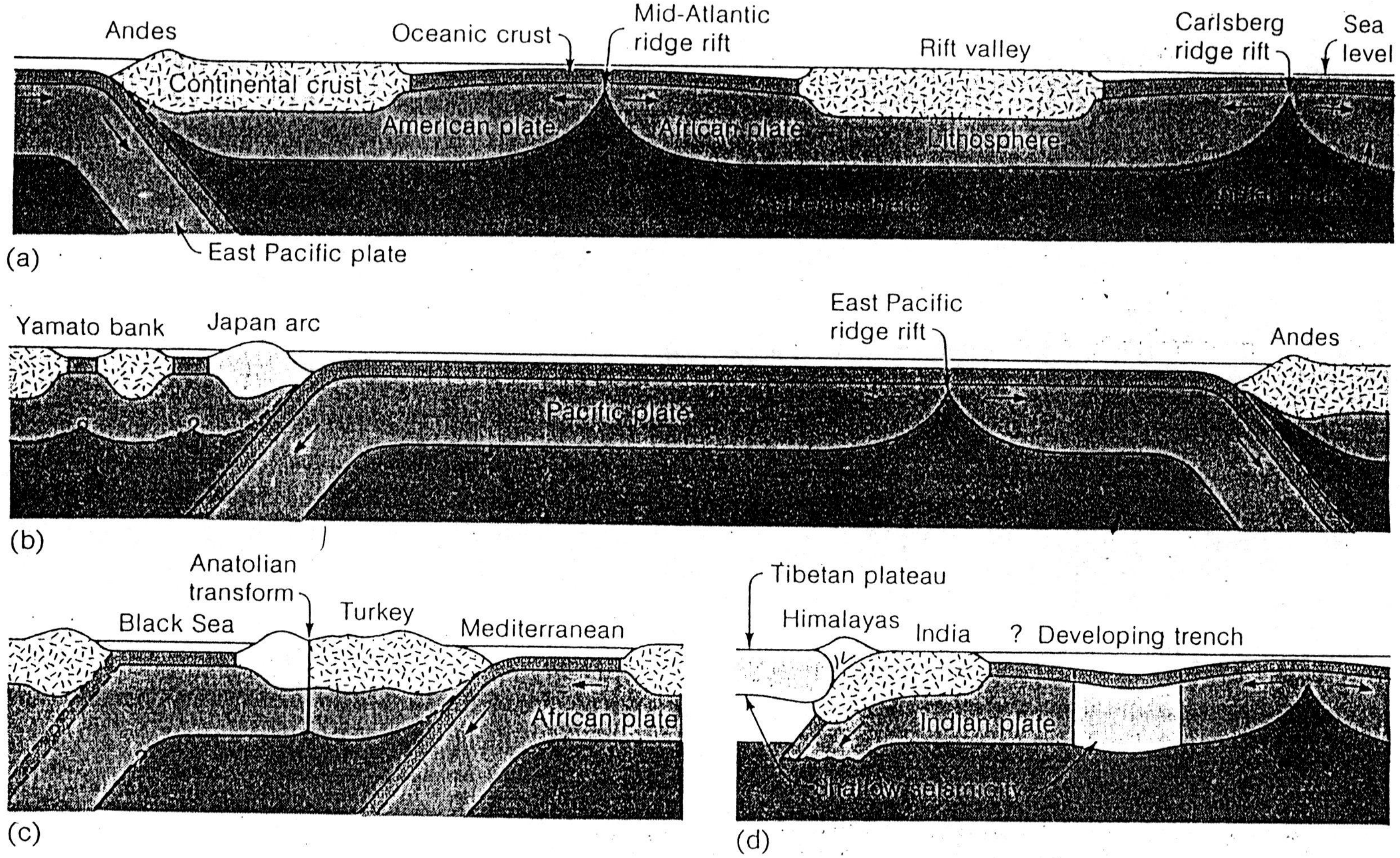

Figure 4. Plate tectonic models explaining origin of some large geological features of the world. (a) Opening of the Atlantic Ocean at mid-Atlantic ridge rift, and the subduction zone creating the Andes mountains. (b) Opening of Pacific ocean and the formation of Japan. (c) Origin of Black sea and Mediterranean sea. (d) Collision between the Tibetan plate and the India-Australian plate creating the Himalayas.

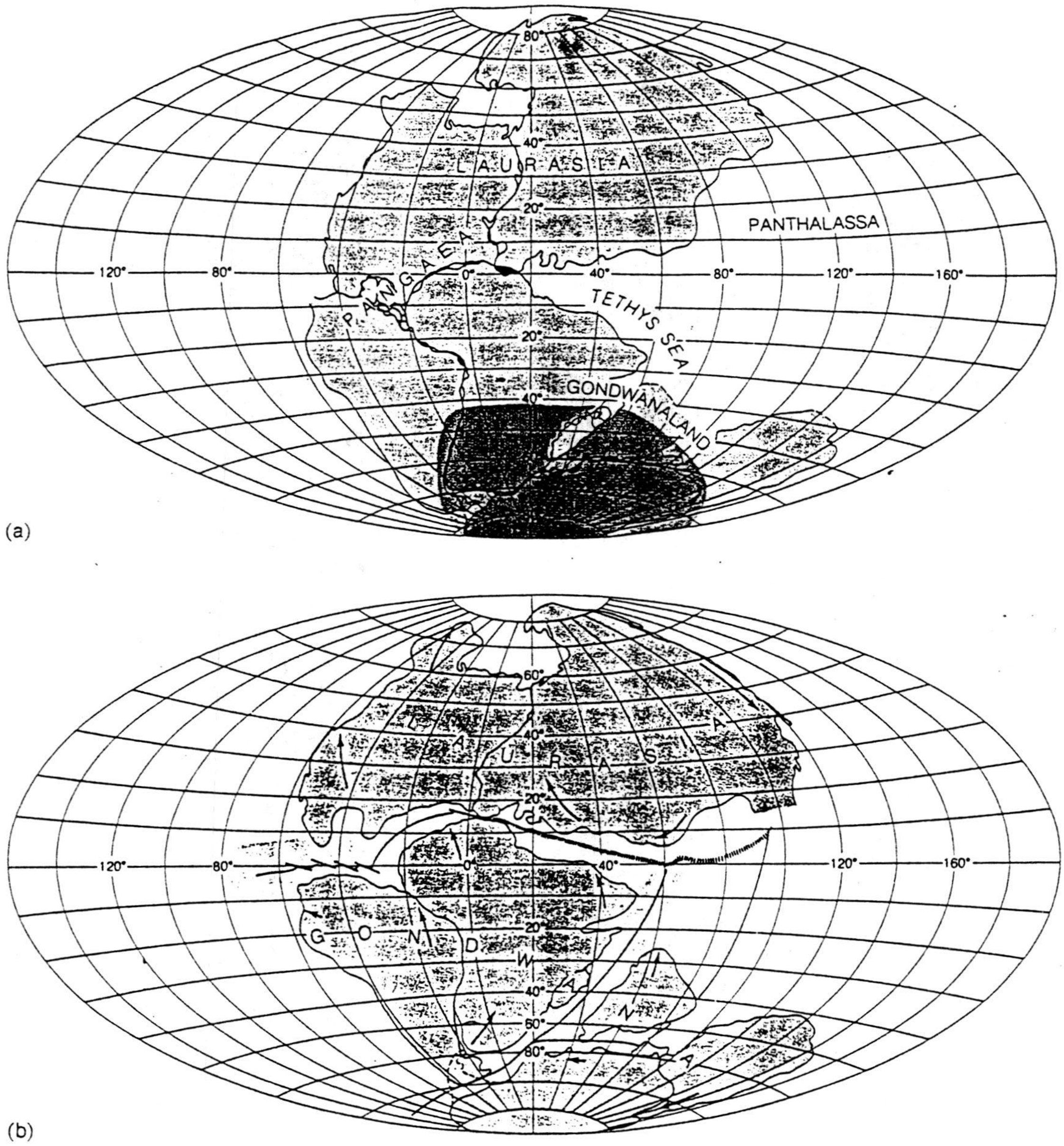

Figure 5. The break-up of Pangaea. (a) Ancient landmass Pangaea, meaning "all lands," may have looked like this some 200 million years ago at the close of the Palaeozoic and beginning of the Mesozoic. Panthalassa ("all seas") evolved into the present Pacific Ocean, and the present Mediterranean sea is a remnant of the Tethys. Permian glacial deposits are found in widely separated areas, such as South America, Africa, India, and Australia. This distribution is simply explained by postulating a single continental glacier flowing over the south polar regions of Gondwanaland in Permian time, before the break-up of the continents. The probable extent of the glacier is shown by dark shading.(b) One view of world geography at the end of the Triassic Period, 180 million years ago, after some 20 million years of drift. New ocean floor is shown in light grey. Arrows depict motions of continents since drift began. (c) World geography at the end of the Jurassic Period, 135 million years ago, after some 65 million years of drift. Ocean floor created in the preceding 45 million years is shown in light grey. (d) World geography at the end of the Cretaceous Period, 65 million years ago. Light grey indicates new ocean floor created after some 135 million years of drift. (e) World geography today. Light grey shows sea floor produced during the past 65 million years, in the Cenozoic period.

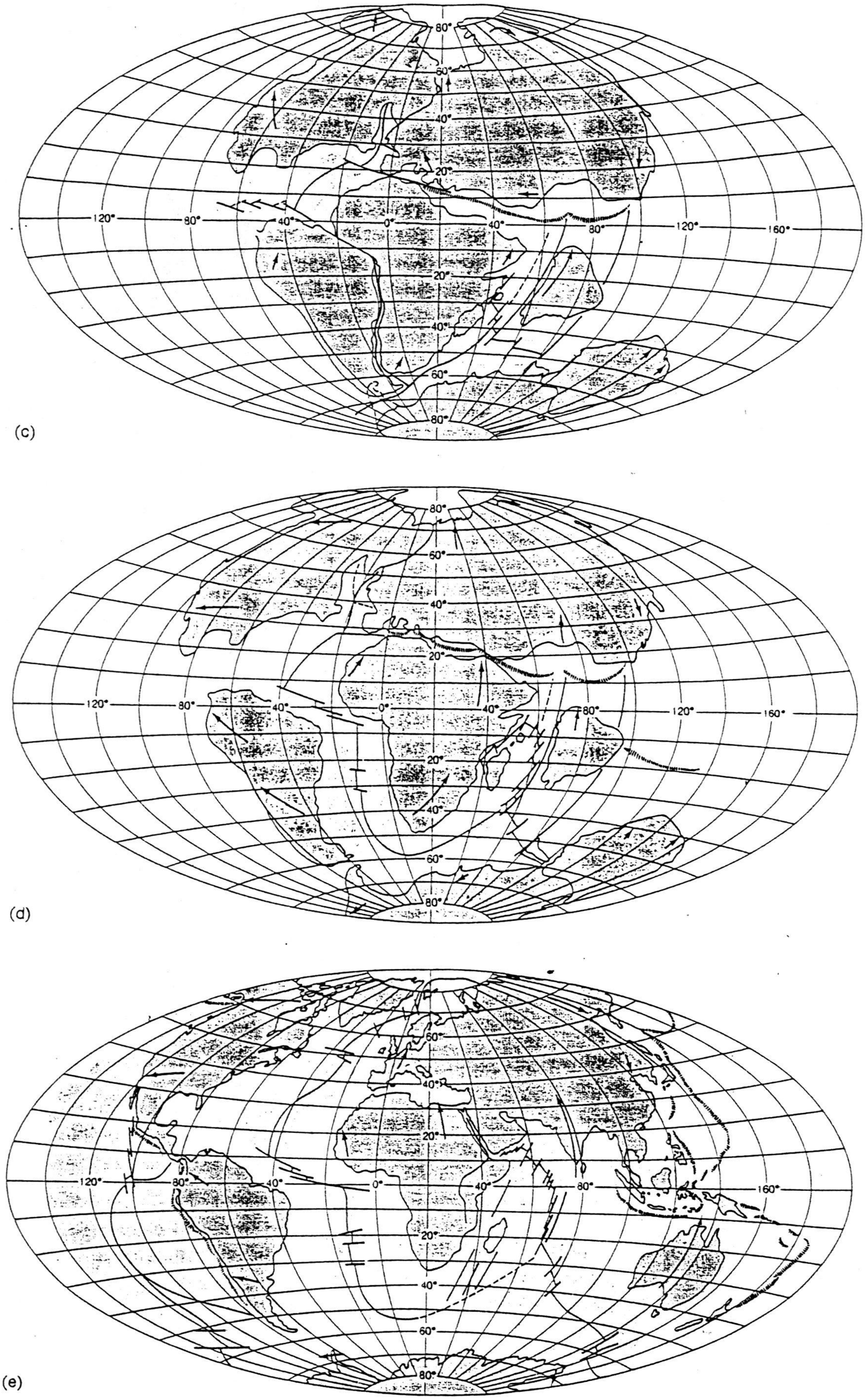

Figure 5 continued