Chapter 2

Sedimentary Basins and Plate Tectonics

2.1 Scope

The outer part of the earth’s crust, the lithosphere, is constructed predominantly of sedimentary rocks of Mesozoic, Tertiary, and Quaternary deposits extending to a depth of about 12 km on land and only 1 km or less on the ocean floors.

The crust itself is the bedrock of the outer layer of the earth and is relatively thin, 20–40 km thick under the continents, composed mainly of acidic igneous rocks (granites, granodiorites, etc.); but is much thinner, about 8 km thick or less, under the oceans, where it is composed mainly of basaltic rock. The crust differs in composition and thickness depending on whether it underlies the continents or the oceans. The crust is floating generally on a solid mantle about 3,000 km in thickness, and is composed of very dense rocks surrounded by outer shell layers of the ultradense and highly viscous liquid rock of the asthenosphere. The core, which is the innermost solid iron mass, with a radius of about 3,500 km, is surrounded by the mantle.

During the past three decades (since 1967), the theory of plate tectonics has dominated geological thinking. According to this theory, the surface of the earth’s crust (under both continents and oceans) is made up of rigid, aseismic lithospheric blocks which are slowly and intermittently in motion. There are major and minor plates, together with more complex smaller units. The plates are separated by linear “active bands,” in which volcanicity and seismic activity seem to be concentrated (Fig. 2.1; Komatina 2004).

The plate tectonic theory of continental displacement replaced the geosynclinal theory of the development of the folded mountain ranges of the earth’s crust; the term “geosyncline” was originally used to describe the long, narrow, subsiding depressions in which thick sediments accumulated and were affected by orogenesis (violent folding and uplift accompanied by volcanic activity). In general, the average rate of recent plate movements is usually from 1 to 2 mm/yr (Komatina 2004). There are two forms of tectonic movements:

(a) Active tectonic movements consist of epeirogenic movements (upliftings and downwellings) and orogenic movements (mountain formation on “geosynclinal” areas), which have led to Alpine and Mesozoic mountain ranges where tectonic activity was manifested in powerful seismicity and the development of volcanism, e.g., in the Alpine-Mediterranean zone in Eurasia.

(b) A passive tectonic system is characteristic of a large part of the Precambrian platforms, and applies to the entire territory of North American and Russia, and the large central zone of Africa, e.g., the Algerian Saharan platform, where the relief is level, low-lying in some areas and elevated in others.
2.2 Continental Shelves

The earth’s crust consists of two types, continental and oceanic, below which lie the vastly more bulky and heavier mantle and core. The continental crust, which is three to four times as thick as the oceanic crust, includes all the major land masses with submerged borders, known as continental shelves. The boundary zones between the continents and the oceans form the continental margins, which are made up of three components: (1) the continental rises, which largely comprise the “fans” of continental sediments; (2) the gently dipping shelves 5–250 miles in width, which constitute the submerged edges of the continents; and (3) the steeper slopes, about 10–30 miles wide, the bases of which mark the transition zone between the continental-type crust and the oceanic-type crust.

Under the 1958 Geneva Convention, the continental shelf is legally defined as “the sea bed and subsoil of the submarine areas adjacent to but outside the area of the territorial sea to a depth of 200 m or, beyond that limit, to where the depth of the superjacent waters admits the exploitation of the natural resources of such areas.”

From the edge of the continental shelf, the surface of the continental crust slopes gradually downwards to the deep oceanic basins, which are underlain by the thinner oceanic-type crust. The thickness of the continental crust decreases gradually below the continental slope until the thinner oceanic crust is reached (Fig. 2.2).

Fig. 2.2–The world’s continental shelves include the major seas, lakes, and some marine platforms within the 200-m depth range (Petroleum Press Service 1951).

In some oil field provinces, a broad “geosynclinal belt” of much sedimentation, which typically evolves to a large asymmetrical structural basin by being subjected to orogenesis, is the consequence of developments that have taken place over a long period of time. Sedimentary basins of such type are termed active when the floors have continued to sink and the depressions thus formed due to gravitational forces have filled with sediments. On the gentler side, older rocks underlying the sediments may outcrop on a part of one of the major shields where faulting is common in some belts, especially along the hinge line. On the more disturbed side (of the mobile belt side), there are foothills and mountain ranges; strong folds and overthrusting occur. The thickness of the sediments formed is less on the shelf or platform side than elsewhere.

Fig. 2.3–An asymmetrical structural basin “geosyncline trough” showing a maximum thickness that lies between the shelf side and the mobile rim where strong structures have developed; examples of this broad pattern are the Arabian shield of Saudi Arabia and the area of the Tigris-Euphrates valley of Iraq (Hobson 1975)

2.3 Plate Interactions

In plate tectonic theory, composite continents are assembled by crustal collisions that occur when the consumption of oceanic lithosphere beneath arc-trench systems results in the closure of an oceanic basin. The arrival of a continental block at a subduction zone where the intervening oceanic lithosphere was consumed, will thus throttle subduction, and the