Chapter 4
The Benue Trough

The Benue Trough of Nigeria is a rift basin in central West Africa that extends NNE–SSW for about 800 km in length and 150 km in width. The southern limit is the northern boundary of the Niger Delta, while the northern limit is the southern boundary of the Chad Basin (Fig. 4.1). The trough contains up to 6,000 m of Cretaceous – Tertiary sediments of which those predating the mid-Santonian have been compressionally folded, faulted, and uplifted in several places. Compressional folding during the mid-Santonian tectonic episode affected the whole of the Benue Trough and was quite intense, producing over 100 anticlines and synclines (Benkhelil, 1989). Major such deformational structures include the Abakaliki anticlinorium and the Afikpo syncline in the Lower Benue, the Giza anticline and the Obi syncline in the Middle Benue, and the Lamurde anticline and the Dadiya syncline in the Upper Benue Trough.

Following mid-Santonian tectonism and magmatism, depositional axis in the Benue Trough was displaced westward resulting in subsidence of the Anambra Basin. The Anambra Basin, therefore, is a part of the Lower Benue Trough containing post-deformational sediments of Campanian-Maastrichtian to Eocene ages. It is logical to include the Anambra Basin in the Benue Trough, being a related structure that developed after the compressional stage (Akande and Erdtmann, 1998).

The Benue Trough is arbitrarily subdivided into a lower, middle and upper portion (Figs. 4.1, 4.2, 4.3, and 4.4). No concrete line of subdivision can be drawn to demarcate the individual portions, but major localities (towns/settlements) that constitute the depocentres of the different portions have been well documented (Petters, 1982; Nwajide, 1990; Idowu and Ekweozor, 1993; Obaje et al., 1999). The depocentres of the Lower Benue Trough comprise mainly the areas around Nkalagu and Abakaliki, while those of the Anambra Basin centre around Enugu, Awka and Okigwe. The Middle Benue Trough comprises the areas from Makurdi through Yandev, Lafia, Obi, Jangwa to Wukari. In the Upper Benue Trough, the depocenters comprise Pindiga, Gombe, Nafada, Ashaka (in the Gongola Arm) and Bambam, Tula, Jessu, Lakun, and Numan in the Yola Arm.
Fig. 4.1  Sedimentary Basins of Nigeria

Fig. 4.2  Idealized N–S stratigraphic cross-section across the Benue Trough and the relationship to the Niger Delta and the Chad Basin (vertical scale exaggerated; erosion and uplift not considered)
Fig. 4.3  Idealized N–S stratigraphic cross-section across the Chad Basin–Benue Trough – Niger Delta depicting a connected Trans-Atlantic seaway between the South Atlantic and the Tethys Sea during the Coniacian – Turonian

Fig. 4.4  Stratigraphic successions in the Benue Trough and the Nigerian sector of the Chad Basin
The Lower Benue Trough and the Anambra Basin

Sedimentation in the Lower Benue Trough commenced with the marine Albian Asu River Group, although some pyroclastics of Aptian – Early Albian ages have been sparingly reported (Ojoh, 1992). The Asu River Group in the Lower Benue Trough comprises the shales, limestones and sandstone lenses of the Abakaliki Formation in the Abakaliki area and the Mfamosing Limestone in the Calabar Flank (Petters, 1982). The marine Cenomanian – Turonian Nkalagu Formation (black shales, limestones and siltstones) and the interfingering regressive sandstones of the Agala and Agbani Formations rest on the Asu River Group. Mid-Santonian deformation in the Benue Trough displaced the major depositional axis westward which led to the formation of the Anambra Basin. Post-deformational sedimentation in the Lower Benue Trough, therefore, constitutes the Anambra Basin. Sedimentation in the Anambra Basin thus commenced with the Campanian-Maastrichtian marine and paralic shales of the Enugu and Nkporo Formations, overlain by the coal measures of the Mamu Formation. The fluviodeltaic sandstones of the Ajali and Owelli Formations lie on the Mamu Formation and constitute its lateral equivalents in most places. In the Paleocene, the marine shales of the Imo and Nsukka Formations were deposited, overlain by the tidal Nanka Sandstone of Eocene age. Downdip, towards the Niger Delta, the Akata Shale and the Agbada Formation constitute the Paleogene equivalents of the Anambra Basin (Figs. 4.2, 4.4, 4.5, and 4.6; Explanatory Note 4).

The Enugu and the Nkporo Shales represent the brackish marsh and fossiliferous pro-delta facies of the Late Campanian-Early Maastrichtian depositional cycle (Reijers and Nwajide, 1998). Deposition of the sediments of the Nkporo/Enugu Formations reflects a funnel-shaped shallow marine setting that graded into channelled low-energy marshes. The coal-bearing Mamu Formation and the Ajali Sandstone accumulated during this epoch of overall regression of the Nkporo cycle. The Mamu Formation occurs as a narrow strip trending north–south from the Calabar Flank, swinging west around the Ankpa plateau and terminating at Idah near the River Niger (Fig. 4.5). The Ajali Sandstone marks the height of the regression at a time when the coastline was still concave. The converging littoral drift cells governed the sedimentation and are reflected in the tidal sand waves which are characteristic for the Ajali Sandstone. The best exposure of the Nkporo Shale is at the village of Leru (Lopauku), 72 km south of Enugu on the Enugu – Port Harcourt express road, while that of Enugu Shale is at Enugu, near the Onitsha-Road Flyover. The Mamu Formation is best exposed at the Miliken Hills in Enugu, with well-preserved sections along the road cuts from the King Petrol Station up the Miliken Hills and at the left bank of River Ekulu near the bridge to Onyeama mine.

The Nsukka Formation and the Imo Shale mark the onset of another transgression in the Anambra Basin during the Paleocene. The shales contain significant amount of organic matter and may be a potential source for the hydrocarbons in the northern part of the Niger Delta (Reijers and Nwajide, 1998). In the Anambra Basin, they are only locally expected to reach maturity levels for hydrocarbon expulsion. The
Eocene Nanka Sands mark the return to regressive conditions. The Nanka Formation offers an excellent opportunity to study tidal deposits. Well-exposed, strongly asymmetrical sandwaves suggest the predominance of flood-tidal currents over weak ebb-reverse currents. The presence of the latter are only suggested by the bundling of lamine separated from each other by mud drapes reflecting neap tides. A good outcrop of the Nanka Formation is the Umunya section, 18 km from the Niger Bridge at Onitsha on the Enugu – Onitsha Expressway.
Erosional effects in most places expose older (subsurface formations) to surface studies and sampling.

Fig. 4.6 Stratigraphic successions in the Anambra Basin

**Explanatory Note 4:**
Sedimentary Basins of Nigeria

1. **The Benue Trough**
   - The Lower Benue Trough
   - The Anambra Basin
   - The Middle Benue Trough
   - The Upper Benue Trough
   - The Gongola Basin
   - The Yola Basin

2. **The Chad Basin**
3. **The Mid-Niger / Bida Basin**
4. **The Sokoto Basin**
5. **The Dahomey Basin**
6. **The Niger Delta Basin**

**The Middle Benue Trough**

In the Middle Benue Trough, around the Obi/Lafia area, six Upper Cretaceous lithogenic formations comprise the stratigraphic succession (Fig. 4.7). This succession is made up of Albian *Arufu, Uomba* and *Gboko Formations*, generally
referred to as the Asu River Group (Offodile, 1976; Nwajide, 1990). These are overlain by the Cenomanian – Turonian Keana and Awe Formations and the Cenomanian – Turonian Ezeaku Formation. The Ezeaku Formation is coterminous with the Konshisha River Group and the Wadata Limestone in the Makurdi area. The Late Turonian – Early Santonian coal-bearing Awgu Formation lies conformably on the Ezeaku Formation. In the Makurdi area, the Makurdi Sandstone interfingers with the Awgu Formation. The mid-Santonian was a period of folding throughout the Benue Trough. The post-folding Campano-Maastrichtian Lafia Formation ended the sedimentation in the Middle Benue Trough, after which widespread volcanic activities took over in the Tertiary.

The Asu River Group outcrops mainly in the Keana anticline east of Keana town and south of Azara; and in the area around Gboko with a typical section in the Quarry of the Benue Cement Company near Yandev. The lithologic composition of the Asu River Group comprises limestones, shales, micaceous siltstones, mudstones and clays (Offodile, 1976; Obaje, 1994). The average thickness is estimated to be about 1,800 m.

The Awe Formation was deposited as passage (transitional) beds during the Late Albian Early Cenomanism regression. Its typical sections occur around the town of Awe, where Offodile (1976) estimated the thickness to be about 100 m. The formation consists of flagy, whitish, medium to coarse grained calcareous sandstones, carbonaceous shales and clays. The Keana Formation resulted from the Cenomanian regression which deposited fluviodeltaic sediments. The formation consists of cross-bedded, coarse grained feldspathic sandstones, occasional conglomerates, and bands of shales and limestones towards the top. Massive outcrops occur at Keana, Noku, Chikinye, Jangerigeri, Azara, and Daudo.
The deposition of the Ezeaku Formation is attributed to the beginning of marine transgression in the Late Cenomanian. The sediments are made up mainly of calcareous shales, micaceous fine to medium friable sandstones and beds of limestones which are in places shelly. The deposition took place in a presumably shallow marine coastal environment. Outcrops of the Ezeaku Formation include those at Ortesh, about 4 km east of the village of Jangerigeri, where the sediments are composed mainly of shelly limestones (almost entirely of oyster shell). In the bank of River Tokura, about 20 km east of Keana town, on the Chikinye – Awe road, a typical section of the Ezeaku Formation occurs, consisting mainly of intercalations of shelly limestones and black shales, with brownish fine to coarse grained feldspartic sandstones at the top.

The deposition of the Awgu Formation marks the end of marine sedimentation in this part of the Benue Trough. The formation is made up of bluish-grey to dark-black carbonaceous shales, calcareous shales, shaley limestones, limestones, sandstones, siltstones, and coal seams. The major outcrop of the coal-bearing Awgu Formation is at the bank of River Dep in Shankodi, 7 km to the west of the village of Jangwa. Along the bank of this river, the coal seams can be traced laterally for about 500 m. The borehole cores of the Steel Raw Materials Exploration Agency (formerly National Steel Council) stock-piled at the Obi camp contain coal seams and coal bands at various depths within the Awgu Formation. The occurrence of low diversity arenaceous foraminifera in the Awgu Formation (Fig. 4.8) indicate deposition in marshy, deltaic and shallow marine conditions (Obaje, 1994).

Fig. 4.8 Arenaceous benthic foraminifera from the Turonian – Coniacian Awgu formation in the Middle Benue Trough, indicating marshy – shallow water – deltaic conditions (captured from Obaje, 1994)
The Lafia Formation is the youngest formation in this area. The formation was deposited under continental condition (fluvial) in the Maastrichtian and lies unconformably on the Awgu Formation. It is lithologically characterized by ferruginized sandstones, red, loose sands, flaggy mudstones, clays and claystones. Outcrops and sections of the Lafia Formation occur in and around the town of Lafia, and along the bank of River Amba on the Lafia – Doma road.

The Upper Benue Trough

The Upper Benue Trough is made up of two arms, the Gongola Arm and the Yola Arm (although some authors have sub-divided the Upper Benue Trough to include a third central Lau-Gombe sub-basin, eg. Akande et al., 1998), and the stratigraphic succession is as shown on Figs. 4.4, 4.9 and 4.10. In both arms of the basin, the Albian Bima Sandstone lies unconformably on the Precambrian Basement. This formation was deposited under continental conditions (fluvial, deltaic, lacustrine) and is made up of coarse to medium grained sandstones, intercalated with carbonaceous clays, shales, and mudstones. The Bima Sandstone was subdivided by Carter et al. (1963) into a Lower, Middle and Upper Bima. The Middle Bima is reported to be shaley in most parts with some limestone intercalations and was assumed to be deposited under a more aqueous anoxic condition (lacustrine, brief marine). An
approximation to this description are the dark, carbonaceous shales within the Bima Sandstone in the section along the river channel to the south of the bridge, 200 mm (just) before the village of Bambam. Similar shales also occur within units of the Bima Sandstone that outcrop extensively on the Lamurde anticline (2 km to the town of Lafiya, on the Gombe – Numan road). Good exposures of the Bima Sandstone (however, without the so-called Middle Bima can be studied at Biliri, Filiya and Shani.

The Yolde Formation lies conformably on the Bima Sandstone. This formation of Cenomanian age represents the beginning of marine incursion into this part of the Benue Trough. The Yolde Formation was deposited under a transitional/coastal marine environment and is made up of sandstones, limestones, shales, clays and claystones. Typical localities of the Yolde Formation are along the valley of Pantami River in Gombe town and in the village of Yolde, 50 km to Numan town.

In the Gongola Arm, the laterally equivalents Gongila and Pindiga Formations and the possibly younger Fika Shale lie conformably on the Yolde Formation. These formations represent full marine incursion into the Upper Benue during the Turonian – Santonian times. Lithologically, these formations are characterized by the dark/black carbonaceous shales and limestones, intercalating with pale colored limestones, shales and minor sandstones. The type locality of the Gongila Formation is at the Quarry of the Ashaka Cement Company at Ashaka, while that of Pindiga Formation is at Pindiga village. The Fika Shale is lithologically made up of bluish-greenish carbonaceous, sometime pale gypsiferous, highly fissile shales.
and occasional limestones in places. The formation is entirely marine and has its
type locality at Nafada village on the Gombe – Ashaka road.

In the Yola Arm, the *Dukul, Jessu* and *Sekuliye Formations*, the *Numanha Shale*, and the *Lamja Sandstone* are the Turonian – Santonian equivalents of the
Gongila and Pindiga Formations. The Turonian – Santonian deposits in the Yola
Arm are lithologically and palaeoenvironmentally similar to those in the Gongola
Arm, except the Lamja Sandstone which has a dominating marine sandstone

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**Fig. 4.12** Planktonic foraminifera from the Sekuliye formation in the Yola Arm of the Upper Benue Trough, indicating deep to shallow marine environment when interpreted alongside the arenaceous assemblage. 1. 2. *Heterohelix globulosa*, 3. 4. 5. 6. *Heterohelix reussi*, 7. and 8. *Pseudotextularia elegans*
lithology. The recovery of diversified assemblages of arenaceous alongside planktonic foraminifera from samples obtained from the Dukul, Jessu and Sekuliye formations (Figs. 4.11, 4.12) indicate deposition in shallow marine – neritic – shelfal environments. The type locality of the Dukul Formation is in the village of Dukul with good exposures also at Bambam and Lakun on the Gombe – Yola road. All the other formations have their type localities in the villages named after them.

The Santonian was a period of folding and deformation in the whole of the Benue Trough. Post-folding sediments are represented by the continental Gombe Sandstone of Maastrichtian age and the Keri–Keri Formation of Tertiary age. The Gombe Sandstone is lithologically similar to the Bima Sandstone, attesting to the re-establishment of the Albian palaeoenvironmental condition. The Gombe Sandstone Formation, however, contains coal, lignite, and coally shale intercalations which in places are very thick. The type locality of the Gombe Sandstone is along the bank of Pantami River in town. Good exposures are also encountered in many parts of Gombe town and Birin Fulani village.

The Keri–Keri Formation is made up of whitish grey sandstones, siltstones, and claystones with the claystones dominating the lithology in most places. Typical sections are exposed in Gombe Aba, Duku (not Dukul) and Alkaleri.