# T2.4 THE CARBONIFEROUS BASIN



## THE LOWER CARBONIFEROUS: INTERIOR MOUNTAIN VALLEY AND SEA

During late Paleozoic and early Mesozoic times, Atlantic Canada occupied an interior position in the near-equatorial region of Pangea. The attachment of North America to this supercontinent began in the Early Devonian Period and is represented in Atlantic Canada by the Acadian Orogeny, the result of the collision of the northeastern part of the North American continent and the continent of Africa. The collision created a large mountain belt with topography perhaps like the present-day Rocky Mountains of western Canada. The eroded roots of these Appalachian Mountains extend from the southeastern United States to Newfoundland, and they occur as the highland areas of Atlantic Canada.

### *Paleogeography*

The waning phase of the Acadian Orogeny was followed by the development of a complex of interconnected sedimentary basins during the Late Devonian Period. The area was still tectonically active, and volcanic rocks, including basalts and rhyolites, were extruded locally, especially in the earliest stages of basin formation (e.g., Fountain Lake Group and the McAras Brook and Fisset Brook formations). From the surrounding mountains, gravels, sands and mud were transported in streams flowing to the northeast and deposited as the conglomerates, sandstones and mudstones that form the lower part of the filling of the basins (the Horton Group). There were repeated marine invasions into the basins in Middle Carboniferous time, when limestones and evaporites were deposited, but continental deposits again overlie them and coal was deposited in extensive swamps during the Late Carboniferous.

Erosion gradually reduced the topography of the mountains created by the Acadian Orogeny and transported the debris into the Carboniferous basins, which continued to deepen by progressive subsidence related in part to fault movement. The deposits gradually extended onto the gentle slopes of the eroded highland areas, which became buried beneath the sediments. The basins locally accumulated sediments up to eight kilometres deep (e.g., Cumberland County).

The present-day highlands were not highlands throughout the entire Carboniferous Period. For example, the Cobequid Hills (Unit 311), in northern mainland Nova Scotia, was not a highland until Late Carboniferous time, when it was tilted and uplifted by movement on the adjacent Cobequid-Chedabucto Fault system and became a source of coarse sediment.

The Late Devonian, Carboniferous to Early Permian basin-fill material in the Maritimes Basin probably extended over a much larger area than those rocks do today. Just as the older rocks were uplifted and eroded to become the Carboniferous basin-fill, the Carboniferous basins were uplifted and eroded to become the source of even younger basin-fill during the Mesozoic Era. The original sedimentary basins have been modified, deformed and broken apart by subsequent tectonic processes, producing a locally highly fragmented record of their original form. Erosion of the Carboniferous rocks not only reduced their areal extent, but their low resistance to erosion, compared to surrounding basement rocks (e.g., water-soluble strata of the Windsor Group), led to the development of lowlands and valleys (Region 500). In short, erosion of the hard, resistant rocks of the Avalon terrane produced our highlands, the somewhat less resistant Meguma and granitic rocks produced our upland areas, and the Carboniferous and Triassic rocks produced our lowlands. Today, the lowlands underlain by the soft Carboniferous and Triassic rocks are our agricultural areas, and their development is inherited from sedimentary basins formed between 280 and 380 million years ago. The coincidence of development and settlement in these areas and their underlying mineral and energy resources produces a growing challenge for land-use planning and future resource development.

**Plate T2.4.1:** The East Milford Quarry, Halifax County (Unit 511), showing the extensive evaporite deposits of the Windsor Basin. Photo: R. Merrick

***Distribution***

Strata of Early Carboniferous age are widely distributed in Nova Scotia. They were deposited in valleys formed by the down-faulting of blocks of older rocks and were then preserved in those valleys after later regional erosion. They underlie the lowland-valley areas in parts of Antigonish, Colchester, Cumberland, Guysborough, Hants and Halifax counties of mainland Nova Scotia (north of latitude 45 degrees). They also occur extensively in the lowlands of Cape Breton Island (Units 512, 522 and District 560), where they underlie an area equal to that of the highlands. Note that the Lower Carboniferous rocks do not come to the surface everywhere, but in some areas, such as in Cumberland County, are buried beneath extensive Upper Carboniferous strata.[1]

The thickness of Lower Carboniferous sediment differs from place to place. Typically it is greater than 2000 m and may be as much as 4000 m where the sediments are preserved in their entirety.

 

***The Interior Valleys***

In the beginning of Early Carboniferous time, the sedimentation pattern was dominated by the erosion of the local highlands and transportation by a complex drainage system to the lowlands. The steepest highland slopes were marked by coarse alluvial fans comprising poorly sorted boulder to gravelly sand debris. Initially the valley bottoms between the highlands were steep enough to have braided streams, which permit little vegetation, and there were a few lakes. The deposits are sandstones and mudstones, with minor conglomerate. Note that ground-stabilizing vegetation was rare, although the environment was suitable. These initial intermontane flood-plain, river and lake sediments are preserved today as the Horton Group and are 1000 to 2000 m thick. The climate in the later part of Horton time was evolving to hot, desert-like conditions (perhaps like the present-day Dead Sea). Strata typical of the Horton Group are exposed along the Avon River near Hantsport and Cheverie (Unit 511a).[2]

***The Interior Seas and Lakes***

This valley complex, which extended throughout Atlantic Canada, was then flooded by the rapid invasion of seawater. This invasion is inferred to have occurred along a low trough area extending from the interior of Pangea to the major world ocean called Tethys. Excess evaporation and restricted influx of seawater from the ocean caused this basin to become an evaporitic marine environment. Limestone, gypsum, salt and potash salts were deposited in a progressive sequence as the water reached saturation in each of these salts. The least soluble salts were deposited first and the most soluble ones last. Later, repeated flooding produced cyclic interbedded sequences of fossiliferous marine limestone, evaporites (mineral salts of seawater) including gypsum ($CaSO_4{\cdot}2H_2O$) and anhydrite ($CaSO_4$), as well as thick sections of red mudrocks; collectively they form the Windsor Group. It is interesting to note that the repeated flooding and drying that produced the cyclic deposits in the Windsor Group may have been caused by variations in worldwide sea level controlled by glacial events in the southern part of Pangea. Strata typical of the Windsor Group are exposed along the Avon River near Avondale (Unit 511a), and near Antigonish and Port Hawkesbury.[2]

From their present distribution, the inland sea that deposited the Windsor rocks must have been about 800 km by 300 km at least (i.e., a bit smaller than the present Baltic Sea). Complete evaporation of seawater cannot produce gypsum or halite (NaCl) without also producing sylvite (KCl) and more complex salts. Individual deposits have 50 to 100 m of pure gypsum and anhydrite, so the more concentrated brines that would have produced sylvite and complex salts must have escaped. That is, the connection of the Windsor Basin to the ocean must have permitted both inflow of seawater, and simultaneous outflow of more saline water, from which the gypsum or halite had been precipitated.

The Windsor Group is approximately 1000 m thick and is a major source of industrial minerals and base metals mined today in the province. It is the primary source of limestone used in the manufacture of cement for concrete, of gypsum for wallboard and of salt for the fishery and road de-icing. Nova Scotia is one of the leading gypsum-producing areas in the world, providing 75 per cent of Canada's total production (see Plate T2.4.1). The mineral wealth of the Windsor Group is the legacy of salts deposited from an ocean invading a desert-valley region 340 million years ago.

The Windsor Group is overlain by up to 2000 m of red and grey mudrocks, sandstones and minor thin limestones of the Mabou Group (previously known as the Canso Group). The Mabou Group was deposited in a river-mudflat-and-lake complex which succeeded the evaporitic marine deposition in the underlying Windsor Group. The lower part of the Mabou Group contains interbeds of gypsum, anhydrite and salt, like the Windsor Group. This indicates the early lakes were very saline, perhaps like the Great Salt Lake in the western interior of the United States. The abundant red strata of the Mabou Group indicate that the prevailing climate was dry with highly seasonal precipitation. The co-existing grey mudrocks were deposited in extensive lakes that were probably sustained by river systems originating in distal regions. Strata typical of the Mabou Group are exposed along the Strait of Canso near Port Hastings (Unit 571).

The later part of the Early Carboniferous (between 310 and 315 million years ago) heralded a fundamental change in the depositional character of the basins in Nova Scotia and in much of Atlantic Canada. The climate evolved to become very wet and the region was flooded by extensive deposition of grey sandstones and mudrocks with coal deposits. The coal age was born in a burst of prolific, lush vegetation and wetlands in vast floodbasins.

T2.4
The
Carboniferous
Basin

## THE COAL AGE

### *Paleogeography*

In the Late Carboniferous, Nova Scotia had a subdued topography of low hills separated by broad river valleys and freshwater lakes. Vegetation flourished in the warm climate, particularly large trees (some 30 m high) and swamp plants. Some of the swamp plants had large tops and laterally spreading roots which were ideally suited to the topography, with its wide, flat, poorly drained surfaces. These plants grew densely in bogs and swamps along the floodplains, estuaries and shorelines of lakes, and possibly in coastal areas. As the plants died and decayed, they became buried and compressed by new organic material growing above. Some of these environments were stable for millions of years, experiencing only gentle subsidence or rhythmic oscillations in elevation. In these locations tremendous thicknesses of organic material accumulated, were compressed and eventually turned into coal.

In the Maritimes, coal was deposited in two types of basins: (a) limnetic basins—lakes and adjacent plains which were regularly flooded; and (b) paralic basins—in coastal lowlands subject to periodic, sustained influxes of seawater and marine sediments. On the mainland, all the coalfields, except possibly Joggins, are of the first type, and the Pictou field is typical. The coal was deposited in a narrow intermontane-lake basin that was subsiding between boundary faults, i.e., a graben. The rate of subsidence approximated the rate of accumulation for a very long time, and thick coal seams resulted (up to 13 m for the Foord seam). In the centre of the basin, clean, low-ash coal was formed. Mud accumulated on the margin of the basin, so the seams grade outward from the centre through shaly coal (high ash) to coaly shale to shale. By contrast, most of the coalfields of Cape Breton are of the second type, and Sydney is an example. Deposition occurred on the floodplain portion of the alluvial part of a large paralic basin. Some of the sediments were deposited by braided streams, and brackish-water foraminifera indicate that the sea encroached at other times. (The swamps of the Mississippi Delta are a modern example of such a basin.) At Sydney the seams are relatively thin (up to 3 m) but have great lateral continuity. They are broken up by rock partings—the sediment introduced by streams—and the seams terminate by such splitting and gradual pinching out of individual coal layers, not by lateral transition of coal into shale, as at Pictou.

### *Occurrence*

The coal age began in Nova Scotia with the deposition of sandstones, black shales and thin coal seams in the Riversdale Group. Exposures of these strata are limited, and few contain economically important coal seams; the most extensive are those in the Port Hood area of Cape Breton. (The St. George's coal seam, in Newfoundland, is also of this group.) More-productive coal measures are found in the succeeding Cumberland and Pictou Groups (Districts 520, 580). The strata are predominantly sandstone and contain few fossils; however, a striking exception to this is the 1700 m of Cumberland sandstones which are exposed along the Chignecto Bay shoreline near Joggins and contain fossil trees, amphibians, the earliest reptiles, and two of the earliest land snails. In the Joggins section, there are also 65 coal seams, 39 of which are also found at Springhill. Other seams have also been worked at Debert. The Pictou coalfield, formed in the sandstones of the Pictou Group, occupies an area of 3 by 15 km. It has numerous thick coal seams of relatively limited area, and some deposits of oil shales. Some oil has been collected dripping from the roof of the Thorburn colliery.

At Mabou and Inverness in Cape Breton, the coalfields barely touch the land and lie mainly under the waters of the Gulf of St. Lawrence. Similarly, only 3 per cent of the huge Sydney coalfield is found onshore. The seams run for 30 km along the coast but dip northeastwards under the Cabot Strait. The practical mining limit is probably five or six kilometres offshore, but the seams have been identified in bore holes 40 km from the land. These deposits are part of the Late Carboniferous Morien Group. The Sydney Basin extends almost to Newfoundland.

## THE "MARITIME DISTURBANCE"

At the end of the Carboniferous Period, there was a crustal disturbance in Nova Scotia which produced folds and faults in a narrow band between the Cobequids and the Southern Uplands. This was the shadow of a much larger disturbance felt in Europe and the rest of the Appalachians, and marked the final readjustment in the grouping of continents in Pangea. The coalfields within this band, particularly the Pictou field, were distorted and the seams were disrupted, thereby reducing their economic value. The coalfields of Cape Breton, however, were almost undisturbed.

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***Associated Topics***

T2.2 The Avalon and Meguma Zones, T12.3 Geology and Resources

***References***

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