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FIELD EXCURSION TO THE SYDNEY BASIN, NOVA SCOTIA

Martin R. Gibling, Dalhousie University and Gary M. Grant, Geological Survey of Canada (Atlantic)

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Leader: Martin Gibling, Dept. of Earth Sciences, Dalhousie University
Excursion Organizers: Phil Moir, Bill MacMillan and Rob Fensome GSC Atlantic
Poster Compilation: Gary Grant

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SYDNEY COALFIELD - A BRIEF HISTORY

Early exploration
The famous French explorer, colonizer and Governor of Acadia, Nicholas Denys, declared in a book published in Paris in 1672 that "there is a mountain of very good coal four leagues up the river" (i.e. Baie-des-Espannols or Sydney Harbour, quoted by Brown, 1871, p. 103).

The first commercial coal mine in Canada was opened at Cow Bay (Port Morien) in 1720. It was developed to supply the fortress at Louisbourg and probably also periodically supplied exports to the New England colonies.

In 1785, Governor DesBarres of the Colony of Cape Breton opened the mine at Sydney Mines which set off a virtually unbroken sequence of coal development in the Sydney Coalfield.
Brown (1871) refers to a Mr. Miller, sent by the British Secretary of State to superintend mines (1794-1799), as the first person to notice the fossil trees in the coal measures of Cape Breton. Miller's observations predate by over 40 years those of W.E. Logan (1840) on the origin of coal.

The General Mining Association held leases on virtually all Nova Scotia's coal-resources, including those on Cape Breton Island, from 1826-1857. During, this time, Richard Brown directed mining activities in the Sydney Coalfield. He presented numerous papers on the geology and paleontology, of the Sydney Coalfield to the Geological Society of London and he wrote two books on the history of Cape Breton and on the early coal trade.

Most operations in the Sydney Coalfield were consolidated under the Dominion Steel and Coal Company in 1893 the consolidation was virtually complete by 1920.

Recent mining
Mining records indicate that close to 300 million tonnes of coal have been produced from the Sydney Coalfield over the past two centuries. In 1968 most mines were taken over by the Cape Breton Development Corporation (Devco), and recent production has been at about 4 million tonnes per year. Mining in recent years has mainly been under the nearshore area -- a difficult and expensive zone for operation.

Two subsea mines were recently active in the coalfield, the Phalen Colliery offshore from New Waterford (now closed), and the Prince Colliery offshore from Point Aconi.

Mapping and geological work
Comprehensive regional mapping of the Sydney Basin, by Hugh Fletcher, was carried out in the 1870s to the 1890s.

Other economic possibilities
In addition to coal, the Sydney Basin has considerable potential for hydrocarbons, that are present in sandstones and along faults in the coal mines (Haites, 1951; Devco mine data).
Gas emerges at the sea floor along faults under the nearshore area, as noted by Courtney (1996). Oil shows are evident in the basal carbonates of the Windsor Group. Farther offshore, the two wells, Murphy et al North Sydney P-05 and Shell et al North Sydney F-24 (Fig. 1), recorded gas shows at numerous levels.

GEOLOGICAL SETTING

The Sydney Basin is a large, composite Upper Paleozoic depocentre in Atlantic Canada. It forms part of the regional Maritimes Basin which covers large onshore and subsea areas of Atlantic Canada and includes the southern Gulf of St. Lawrence and parts of the Grand Banks of Newfoundland. Strata of the Sydney Basin fill are exposed onshore in Cape Breton Island and extend offshore to Newfoundland, passing eastward into strata of the Burin Platform (Fig.1)

Basement rocks
Precambrian and Lower Paleozoic rocks that underlie the Upper Paleozoic section on Cape Breton Island have been assigned to several terranes (Fig. 1) that amalgamated prior to or during the mid Devonian Acadian Orogeny (Barr et al., 1995, 1998).

McAdams Lake Formation
The Upper Paleozoic section commences with the McAdam Lake Formation, which is known only from a small outcrop area (Fig. 2). The formation comprises >2 km of sandstone, conglomerate, dark grey to black shale, minor redbeds and coal, deposited in a lacustrine to alluvial setting (White and Barr, 1998).

Grantmire Formation (Horton Group)
The Grantmire Formation (assigned to the Horton Group by Boehner and Giles, 1986) rests with angular unconformity on the McAdams Lake Formation and basement rocks. It consists of conglomerate with sandstone, shale and minor pedogenic limestone, of alluvial fan or braided stream origin, and is up to 800 m thick, wedging out locally (Boehner and Giles, in review).

Windsor Group
The Windsor Group is up to 1000 m thick in the Sydney Basin but is highly, variable in thickness locally (Boehner and Giles, in review). Windsor carbonates at Cape Dauphin and the nearby location of Fairy Hole contain abundant boulders to granules of local granitic rocks, testifying to the persistence of strong relief locally during Windsor deposition. In general, Windsor strata in the Sydney Basin are similar to those elsewhere in the Maritimes Basin.

Mabou Group
The lacustrine Mabou Group, of late Visean to early Namurian age, rests conformably on the Windsor Group. The basal Cape Dauphin Formation is at least 85 m thick, and comprises grey shale, sulphate evaporites and thin limestones. The Point Edward Formation overlies and is laterally equivalent to the Cape Dauphin Formation, and comprises approx. 100 m of red and grey sandstone, siltstone and shale, with minor conglomerate and limestone.

The Morien Group
The Morien Group is 1500-1800 m thick in onshore and nearshore areas, and the strata thin over basement highs (Hacquebard, 1983). The group comprises three formations of late Westphalian B to Stephanian age. The Sydney Mines Formation is approx. 1000 m thick in the Glace Bay Syncline with at least seven major economic coals present in the formation (Fig. 4).

Pictou Group
Red mudstone and sandstone that overlie the coal measures in the nearshore area were assigned to the Pictou Group by Boehner and Giles (in review). They are at least 640 m thick, and may be approx. 1000 m thick based on dip extrapolation. The basal strata are early Stephanian in age, and the uppermost strata could be as young as Permian.

Permian - Cenozoic rocks
The history of the Sydney Basin from the Permian onwards is poorly known because no pre-Quaternary rocks record has been identified over most of the area.

The Orpheus Graben south of the Sydney Basin (Fig. 1), as well as other extensional basins in the Fundy area, Scotian Shelf and Grand Banks, contain a thick Late Triassic to Cenozoic succession. Cretaceous rocks overlie the Upper Paleozoic section on the Burin Platform (Maclean and Wade, 1992) and the eastern part of the Sydney Basin (Fig. 1).

Structural Geology
Major NE-trending faults cut the Devonian and Lower Carboniferous strata and divide the lower basin fill and underlying basement into blocks (Fig. 2). Many of these faults cut the Horton, Windsor and Mabou groups.

REFERENCES:
Some of the material for this informal field guide was adapted from "Carboniferous Coal Basins of Nova Scotia". (GAC 1992 Field Guide) by M.R. Gibling, J.H. Calder and R.D. Naylor. Part of the Geological History was adapted from a paper in preparation by V. Paszucki, M.R. Gibling and M.A. Williamson. John Calder kindly made available a stratigraphic log of the Sydney Mines section.

Thanks to Gary Grant of the GSC Atlantic Electronic Publishing for the compilation, layout and production of the poster and the use of his photos from the field excursion.

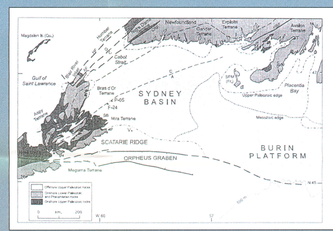


Figure 1. Geology setting of the Sydney Basin in Atlantic Canada, between Cape Breton (Nova Scotia) and Newfoundland.

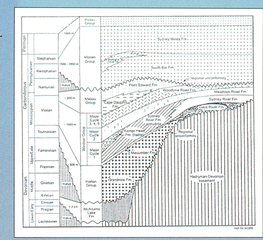


Figure 3. Stratigraphic relationships and age for rock units onshore in the Sydney Basin, (modified from Boehner and Giles, in review. Time scale from Okulitch, 1995.

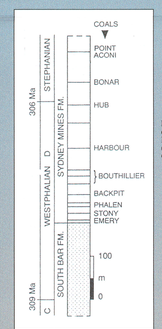


Figure 4. Major coal seams of the Morien Group, (from Tandon and Gibling, 1997).

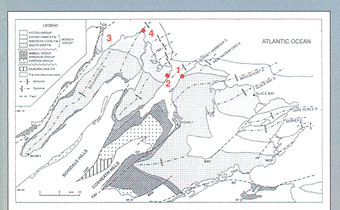


Figure 2. Geology map of the onshore Sydney Basin, also location of excursion stops 1-4. (1). Victoria Mines (2). Sydney Mines (3). Bird Island Boat Tour (4). Point Aconi.

STOP 1: VICTORIA MINES

Formations
The Victoria Mines section is located on the eastern side of Sydney Harbour, and provides an excellent place to examine the detailed sedimentology of the coal measures. The strata we observe form part of several "cyclothems" (Fig. 5). These are cyclic successions similar to the classic Upper Carboniferous examples first identified by John Udden in 1914 in the Illinois Basin and later made famous by Weller and Wanless in the early 1930s. Their origin has been the cause of furious debate in the literature.

The topmost strata of the South Bar Formation are easily accessible on the beach, which is part of the type section. The strata are thick-bedded sandstones with minor grey mudstones, with distinct erosive channel bases visible. Sedimentary structures include trough cross-beds, antidune structures, and casts of flutes and grooves, as well as fill casts (low-water drainage features). They are interpreted as braided river deposits.

About 130 m of the overlying Sydney Mines Formation is well exposed, including the Emery, Stony, Phalen, Backpit and Bouthillier Seams. Poor exposure continues up to the Harbour Seam and above. A generalised diagram applicable to the cyclothems in this section is shown in Figure 5.

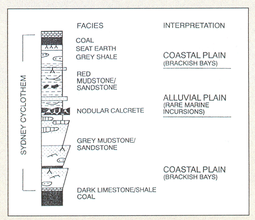
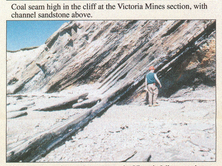


Figure 5. Generalised Sydney cyclothem (from Tandon and Gibling, 1997)

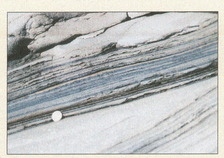
Looking towards the Victoria Mines section, east side of Sydney Harbour.

Victoria Mines section, east side of Sydney Harbour.

Coal seam high in the cliff at the Victoria Mines section, with channel sandstone above.

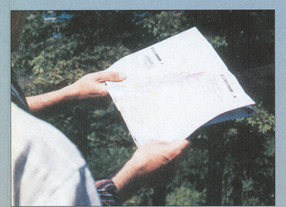


Coal seam running to the ocean at the Victoria Mines section, (probably Stony Seam).



Thin laminated beds at the Victoria Mines section, part of a channel sandstone body.

Siderite nodules in siltstone.



Martin Gibling, field trip guide with map, gives a brief talk on the surrounding geology at the St. Anns look-off on the west side of Kelly's Mountain.

STOP 2: SYDNEY MINES

The Sydney Mines Formation is famous for its erect trees, many of them standing atop coal seams where they contributed to the top stratum of the peat (now coal). Some of the best "fossil forests" are located on splits of the Harbour Seam, and a suite of approx. 30 erect trees is entombed in a 2-3 m sandstone body over 200 m of exposure at Table Head on the Bras d'Or Channel (Calder et al., 1996). At Sydney Mines, one of the best fossil forests is exposed in cliffs below the town, and is currently under study by J.H. Calder. It was here in the 1840s that mine manager Richard Brown first realised that large, pitted tree axes (Stigmaria) were not trees of a separate genus but were roots extending outwards from the trunks of large lycopsid trees. The Sydney Mines town council is currently making plans to set up an interpretative centre at the locality.

The strata consist of coals, grey shales, siltstones and sandstones arranged in cycles a few metres thick (Fig. 6). A representative cycle coarsens upward, and comprises coal, dark grey laminated shale, siltstone coarsening up into sandstone, and pale-mudstone.

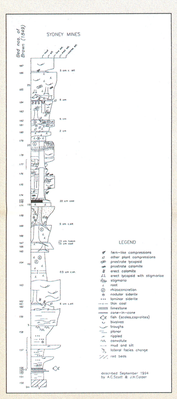
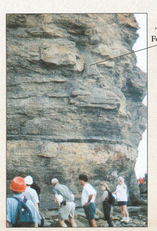


Figure 6. Stratigraphic column for the Sydney Mines section.



Below the fossil tree at Sydney Mines section.

Tree Fossils

Grey shale and sandstone.

STOP 3: BIRD ISLAND BOAT TOUR (Hertford and Ciboux Islands)

Cape Dauphin area
The outcrop at Cape Dauphin provides the only place in the basin where a good section displays the entire sequence of Carboniferous formations (with the exception of the Pictou Group). It is also the only place where the important unconformity beneath the Morien Group is exposed.

The uppermost beds of the Grantmire Formation form the western part of the outcrop belt. The formation is thought to be of Tournaisian age and was probably deposited in alluvial fans or braided rivers close to the source.

The contact with the overlying Windsor Group of Visean age is not seen but appears conformable. The main cliff-forming unit above is a massive, dolomitised carbonate rock, mapped by Boehner and Giles (1986) as the Meadows Road and Woodbine Road Formations.

The Mabou Group (Cape Dauphin Formation) rests conformably on the Windsor Group, and is mainly a black shale unit.

The South Bar Formation, the basal unit of the Morien Group, rests on the Mabou Group with a distinct, angular unconformity and a dip discordance of about 10°.

The basal few metres of strata above the unconformity are coarse conglomerates.

Fairy Hole
Carboniferous strata west of the Bras d'Or Channel lie closely adjacent to the Mountain Fault (Fig. 2). At Fairy Hole, west of the fault, carbonate beds of the Windsor Group, about 15 m thick, lap up against granitic cliffs, mapped by Boehner and Giles (1986) as the Gays River Formation.

Hertford and Ciboux Islands (the Bird Islands)
These are small, isolated outcrops of the South Bar Formation that appear to lie within a faulted block bordered by branches of the Mountain Fault (Fig. 7). The cliffs are composed of sandstone (98%) and mudstone (2%). The sandstones are brown weathering, and consist of stacked cosets of trough cross-beds.

The Bird Islands form the nesting site of about 1500 pairs of Atlantic Puffins. Other commonly seen species include the Razorbilled Aux, Black Guillemot, Black-legged Kittiwake, Great and Double-Crested Cormorant, Great Black backed and Herring Gulls, and the occasional Bald Eagle. Surrounding the island is excellent terrain for lobster. Seals and whales frequent the area.

Cliffs along the Bras d'Or Channel
One of the best exposures of the Sydney Mines Formation is seen in the cliffs on the east side of the Bras d'Or Channel, running all the way to Point Aconi. About 210 m of section is visible from below Black Point Lighthouse to Table Head and Mill Cove, including seams up to the Harbour Seam (Fig. 7). This is an equivalent section to Victoria Mines and Sydney Mines - about 20 km distant. The strata are also strongly cyclic and can be divided into seven "cyclothems", 20-45 m thick. From the boat it is possible to pick out the main coals, as well as intervening red mudstones. At Table Head, an excellent fossil forest is present on a coal belonging to the Harbour Seam group.

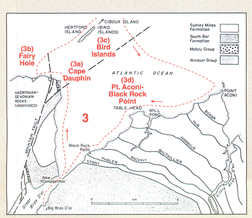
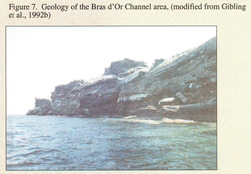


Figure 7. Geology of the Bras d'Or Channel area, (modified from Gibling et al., 1992b)



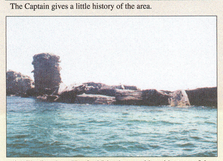
(3c) On the east side of Hertford Island looking south.

At the Bird Island Boat Tour wharf at Big Bras D'Or.

(3a) Cape Dauphin Windsor Group (left) resting on conglomerates of the Grantmire Formation (centre). Granitic basement rocks at right.

(3a) Mafic dyke in basement rocks at Cape Dauphin near the Fairy Hole.

The Captain gives a little history of the area.



(3c) The Booth on Hertford Island, west side, with strata of the South Bar Formation.

(3c) Close-up of the Booth on Hertford Island.

STOP 4: POINT ACONI

The strata at Point Aconi are the youngest exposed on land in the Sydney Basin. They belong to the Sydney Mines Formation and include thick red mudstones as well as coal. A general stratigraphic column for the area is shown in Figure 8.

Rock Types
The lowest strata observed on the headland at Point Aconi are red mudstones with concave-up joints and weak stratification, the product of well-drained soils.

The overlying Point Aconi Seam is 1 m thick and rich in pyrite which locally is visible as large elongate nodules.

The Point Aconi Seam is overlain by a laminated dark shale rich with leaf and other plant fragments.

The cliff face is capped by a channel sandstone body about 5 m thick (Fig 9). The channel deposit contains three units with erosional bases, each 1-2 m thick (a "multistorey" channel body) and separated by mudstone. The cliff section terminates with a red mudstone, the home of nesting swallows.

The strata at Point Aconi form part of a thick cyclothem (approx 60 m), with a red to grey to red pattern evident.

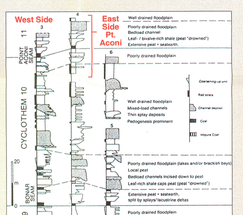
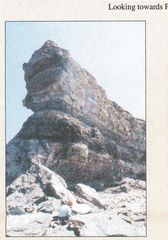
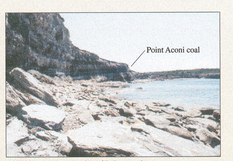


Figure 8. Evolution of depositional setting for the cyclothem at Point Aconi, (from the Bonar Seam to the Point Aconi Seam). Modified from Gibling et al., 1992.

Looking towards Point Aconi from the east side.



Point Aconi, with strata sets that coarsen upward from plant-rich shale to sandstone with roots and trees.



Cliff face on the west side of Point Aconi.

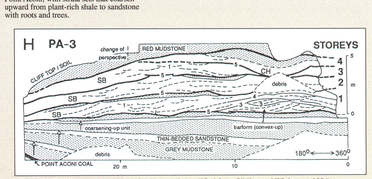


Figure 9. Cliff face of the east side of Point Aconi, (modified from Gibling and Wightman, 1994).