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Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada

DESCRIPTIVE NOTES

INTRODUCTION

The Westphalian Stellarton Basin is located on a complex of faults in central mainland Nova Scotia. The basin occupies a northeast-southwest trending rectangular area of about 100 km by 20 km. The basin is well known to the mining community and writers Prichard and Hacquebard have historically been the site of substantial mining, more recently the basin has been exploited for coalbed methane. As a result of many years of coal exploration, the basin contains over 400 recorded boreholes, approximately 25 coal seams and about 60 of these units may be correlated laterally between boreholes (e.g. Hudgins et al. 1989).

Data sources

Because of the economic interest, mapping efforts in the Stellarton Basin date back into the last century. Early maps by Poole (1904), Dawson (1866) and Hacquebard (1957) were based on extensive field observations and were produced at a scale of 1:24000, determined the stratigraphic ages of most of the stratigraphic units and established the present division of the Stellarton Formation into members. More recently, the Stellarton area was included in a 1:50 000 compilation of the Pictou County area (Ryan et al. 1991) and a detailed map of the Westville area was published at 1:10 000 scale based on a dense fault pattern (Fralick and Schenk 1981; Yeo and Gao 1987). Detailed maps at 1:5 000 scale, by Naylor et al (1990) and Smith et al (1989), cover all outcrops known at that time in the basin.

Although the Stellarton Basin has been well studied, there has been little modern sedimentological field mapping in the areas of less detailed previous coverage, notably the basin margins. Within the basin, the observations shown on this map summarize the results of earlier mapping at larger scales. We show an interpreted geometry of the basin margin which is based on the mapping of Ryan et al. (1991) and Yeo and Gao (1987). Some minor modifications to Ryan et al. (1991) Hay (1987) and Murphy et al (1992), at the east end of the basin, summary is based, and Minerals&Energy coordinates, somewhat in doubt, our interpretation of the geometry is consistent with Chandler et al (1987).

An extensive subsurface data set is available for the central, southeastern part of the basin. Unpublished maps, based on surveyed coal mine plans for T.S.Parks (held at Nova Scotia Department of Natural Resources), formed the basis for the structural interpretation of the Westville area. Structure contours on selected coal seams are available for this area shown for the Pictou County. Data from boreholes have been compiled by R.D. Naylor (unpublished reports) and by D.Hughes Hughes &Wachell 1992; Hughes 1993). In addition, several seismic lines, shot during more recent exploration for coal, have been interpreted and have contributed to our understanding of the structure of the basin. Although, in our contour interpretation of the Forrest seam (base of East Foord), Both the borehole and the seismic data leave ambiguities in the trends of subsurface fault intersections with the Foord seam. Our interpretation is therefore based on the assumption that fault trends are similar to those in the better known area of historic mining, west of East River.

STRATIGRAPHY

Pre-Westphalian Units

Pre-Carboniferous units occur only in the southwest corner of the map area, where they are not subdivided. They consist of Devonian granites of the South Mountain Batholith, Ordovician-Silurian metasediments of the Meguma Group and redbeds of the Mabou Group, Carboniferous. This area forms the eastern extremity of the Antigonish Highlands, for details of outcrops and the distribution of units, readers are referred to the maps of Murphy et al.(1991) and Yeo (1987), and the references cited therein.

South of the basin, Early Carboniferous, mainly Visean rocks of the Windsor Group are exposed in the Eureka area (Ryan et al.1991) and in the Antigonish Highlands (Boehner et al.1989; Boehner and Giles 1990). Detailed mapping of outcrop and subsurface exposures occur in this structurally complex area. Recent interpretation by Chandler et al (1987) suggests that low-angle detachment surfaces are present within the Windsor stratigraphy. Small areas of Windsor Group rocks are also exposed in the southwest part of the Stellarton Basin.

The Windsor Group is overlain by clastic sedimentary rocks of the Mabou Group, predominantly of Namurian age. The group consists of variably grey to red, poorly fossiliferous mudstones and very fine to medium sandstones with rough cross-bedding, fining upward cycles and local conglomerate units. Conglomerate units are more abundant and coarser in charge area to the south and west of the Stellarton Basin, where they are internally deformed by folding and faulting, and are locally overturned. The lack of penetrative fabrics makes this area difficult to interpret structurally. The Mabou Group is well exposed in the Eureka area (Ryan et al.1991) and in the Antigonish Highlands (Boehner et al.1989; Boehner and Giles 1990). The area mapped as Mabou Group may include some strata laterally equivalent to the Windsor Group, as suggested by two Visean spore ages obtained from kaolinitic mudstones in the Stellarton Basin. Other Mabou Group units are assigned to the Mabou Group since it is undivided above the east end of the Stellarton Basin, where they are unrelated with the Lorraine Formation that lies further east (Chandler et al.1987).

Stellarton Formation

The mid to late Westphalian B of the Stellarton Basin was designated the Stellarton Group by Bell (1940), but is now considered to be a formation with three members (Hacquebard and Donaldson 1969; Ryan et al.1991). The lithostratigraphic nomenclature proposed by Ryan et al.(1991) for the Stellarton Formation is adopted, together with other coal-bearing Late Carboniferous units, in the Cumberland Group.

We have included in the Stellarton Formation some early Westphalian rocks at the southwest basin margin, equivalent to part of the Middle River Formation of Yeo (1987) and the Cumberland Group of Bell (1940). We infer that this unit was deposited in a fault bounded basin, but the nature of the bounding faults is not known. Where the Middle River Formation is present, the units does not justify separation at formation level. The base of the Stellarton Formation, thus redefined, is placed at the mapped boundary between steeply dipping to overturned, indurated fine-grained clastic sediments of the Mabou Group and less deformed, less indurated sediments of the Stellarton Formation. This boundary is a fault, or a fault-bounded, angular unconformity, is not exposed, but its location is constrained within about 50 m at Brown Brook.

The Middle River Member of the Stellarton Formation (formerly part of the Middle River Formation of Yeo 1987) consists of coarse-grained, poorly sorted, feldspathic sandstones with minor mudstones and conglomerate units. Coal is subordinate well-rounded, red, granule and pebble conglomerates. Upward, the mudrock becomes increasingly mottled with grey-green reduced patches, transitional into the overlying Skinner Brook Member. Previous biostratigraphic work, based on spores, suggests that the Middle River Member is Westphalian B.

The *Skinner Brook Member* consists predominantly of red to grey-green rooted/bed mudrock, siltstone, and fine sandstone. Subordinate coarser sandstone and local conglomerate are present near the basin margins. Spore samples from the Skinner Brook Member have been dated as Westphalian B and the lithostratigraphic correlation appears to be linear (Hacquebard and Donaldson 1969). Westphalian B rocks are considered to merge within the member.

The Westphalian C *Westville Member* consists of predominantly grey claystone, weakly-rooted siltstone, and minor sandstone, with coal seams near the base. The Scott and Acadia seams have been extensively mined. The upper part of the Westville Member is poorly exposed and is known mainly from boreholes. It consists of a generally monotonous succession of grey mudstone with minor sandstone and coal seams.

The base of the overlying *Albion Member* (Westphalian C) is drawn at the reappearance of coal in the subsurface. Academy seam, or a laterally equivalent shale where the Academy seam is absent. The present interpretation of structural contours on the Foord seam (Figure 2) suggests that the Albion Member may be locally absent, due to faulting or erosion, an interval of mudrock (Plymouth Member) separates the Westville and Albion Members. There, the base of the Albion Member is drawn at the transition from predominantly red to predominantly grey lithologies. The Albion Member is a cyclic succession of mudstone, sandstone, coal and seatrock, similar to that of the Westville Member. Sandstone in the Albion seems become more abundant towards the north and stratigraphically upward in the member, culminating in the thick Foord seam, the top of which marks the top of the member.

The *Morien Member* (Westphalian C) overlies the Albion Member (also Westphalian C). The Plymouth Member consists of predominantly red mudrock, interbedded with red and grey sandstone and minor conglomerate, confined to the southern marginal part of the basin.

The *Westphalian C Coal Brook Member* consists predominantly of grey to black shale, including abundant, laterally continuous rail shale units, and only rare coal. Much of the member is finely laminated. Near basin margins, sandstone units are more abundant and conglomerate units are present. In the central basin, the Foord seam, the Mckay seam, the Mckeen seam, in the middle of the member, but it ceases laterally, toward the basin centre, into all shale.

The base of the overlying *Thorburn Member* (Westphalian C/D) is placed at the base of the McGillivari coal seam. The Thorburn Member consists of grey to black shale, including abundant, laterally continuous rail shale units, and coal seams that pass westward into all shale. Minor conglomerates occur at the south margin of the basin. The highest strata of the Thorburn Member occur in two structural basins at the east end of the Stellarton Basin, the upper limit of the member is not seen.

Other Westphalian Units

The *New Glasgow Formation* (equivalent to part of the Middle River Formation and the New Glasgow Formation of Yeo 1987) consists of boulder to granule conglomerate, crossbedded red sandstone, and subordinate red shale. It is of uncertain age, but is cut by faults that are known to cut the Stellarton Formation, and is, thus, pre-late Westphalian D. The units are dominated by sandstone; conglomerate predominates in the Upper Member. (Lower and Upper Members are not distinguished on this map).

The *Boss Point Formation* (Westphalian C/D) is poorly exposed in the area of this map. At the base, a thin limestone is locally present at the boundary with the underlying New Glasgow Formation. The contact appears conformable, but regional map relationships (Ryan and Boehner 1990; Chandler et al.1988) suggest a significant unconformity. The formation is dominated by grey to black shale, including abundant, laterally continuous rail shale units, coal seams and sandstone with subordinate of shale and rare poorly developed coal seams. The limestone or the formation contains algal pisolites, lime- to coarse-grained sandstone interbedded with grey and red mudrock. Sandstone units typically comprise multicolored channel-successions (1440 m). Rare mixture coal seams are present.

Younger Units

The only known younger units in the area are extensive tills and river gravels of informal Quaternary age. These have not been investigated in the present study, and are not represented on the map, which shows only the bedrock geology.

STRUCTURE

Structural work in the Stellarton Basin dates back to the last century, when the geological setting of coal mines was investigated by Poole (1904). Subsequent extension of coal mines into the Albion Syncline led to further work by the Dominion Coal Company, culminating in the publication of a detailed map of the area by Dawson (1866) at 1:24 000 scale. During the 1940s and 1950s exploration and mining by the Acadia Coal Company led to the preparation of detailed contour plans of coalseams (T.S.Parks, unpublished data held at Nova Scotia Department of Natural Resources). Hacquebard (1957) compiled the data of Dawson and Poole and published a map at 1:24 000 scale showing the structure of the Albion and Westville members were interpreted as equivalent. Subsequent paleobotanical studies (e.g. Hacquebard and Donaldson 1969) have not confirmed this hypothesis. Fralick and Schenk (1981) suggested the Stellarton Basin was a pull-apart basin, but this interpretation was based on a generalized structure map of the Pictou County area. Yeo and Gao (1987) and Gillis (1991) revealed an array of structures consistent with formation of the basin at a releasing bend on a dextral fault system.

Basin boundary structures

Along the southwest basin margin, a variety of Stellarton Formation strata occur in contact with both Mabou and Windsor groups. Between Hilma and Hazel Glen the Middle River Member dips gently northeast, away from the mapped contact with internally deformed, locally overturned Visean and Namurian rocks. This contact, though not exposed, is interpreted as a fault, because the Middle River Member is in fault contact with younger units elsewhere in the Stellarton Group rocks. The basin fill is therefore inferred to infeps the southern basin margin, with higher parts of the Mississippiangroup farther over an adjacent Westphalian upland formed by deformed Mabou and Windsor rocks. In the area of Hazel Glen, Ryan et al.(1991) show the Middle River Member in contact with Visean rocks of the Windsor Group. Mapping by Naylor (1990) finds that this boundary represents a fault/modified unconformity. An angular unconformity is exposed at the contact in East River, where Stellarton Formation conglomerates (Pictou/Coal Member) rest on cross-bedded Mabou Group sandstones.

Several fault-bounded slices occur at the north and northwest basin margin. A block of gently dipping redbeds, provisionally assigned to the Skinner Brook Member, is upthrown along the Fletcher Fault against Coal Brook and Thorburn Members. The Fletcher Fault is a high angle, reverse fault, with a throw of at least 100 m (Naylor et al.1990). It is characterized by conglomerates, provisionally assigned to the Middle River Member, overlying deformed siltstones of the Mabou Group. Both these blocks are bounded to the north by the Waters Brook Fault. North of this fault is a slice consisting of Coal Brook Member, bounded to the north by the Pictou Fault, which juxtaposes Coal Brook and Thorburn Group rocks. The basin fill is therefore inferred to infeps the southern basin margin, with higher parts of the Mississippiangroup farther over an adjacent Westphalian upland formed by deformed Mabou and Windsor rocks. In the area of Hazel Glen, Ryan et al.(1991) show the Middle River Member in contact with Visean rocks of the Windsor Group. Mapping by Naylor (1990) finds that this boundary represents a fault/modified unconformity. An angular unconformity is exposed at the contact in East River, where Stellarton Formation conglomerates (Pictou/coal Member) rest on cross-bedded Mabou Group sandstones.

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Structures within the basin fill

The basin fill is tilted broadly toward the northeast, but the structure is complicated by faults and faults. Elevation differences between the Foord seam on the southeast and northwest basin margins, suggest a tilt orientation toward the north margin. Extensional structures (mainly normal faults) strike generally NNW-SE to NNW-SSE.

A major fault system strikes NNW-SE across the basin west of the normal area of Albion coals. Deformed rocks seen in the Westville area are interpreted as part of this fault system. The Foord seam is displaced by several hundred meters in places, records, which suggest that the westernmost fault in the zone (the Acadia Fault of Bell 1940) dips to the northeast and has a stratigraphic throw of about 350 m. An apparent 'rollover' of strata toward this structure, and the change in strike across the fault, suggest that the Acadia Fault is a listric fault, with a dip that flattens with increasing depth. The Acadia Fault (Ralston et al.1989) in inferring that this fault zone can be connected with an exposed structure on East River at Plymouth (the Plymouth fault) where Geo 1987) recorded minor structures indicative of oblique dextral and normal motion.

Other mapped faults within the basin involve smaller offsets. Numerous subsurface faults in the New Glasgow area can be mapped using borehole data. The majority of these faults strike NNW-SE and indicate normal displacement of the Foord seam. Fault throws of 10 m are common, but throws of 30 m are also observed. Many of these faults in the basin few faults are mapped at the surface, but a predominance of NNW strikes is again observed. In the subsurface, seismic reflections are disrupted at the level of the Albion Member, but become more coherent upward. We infer that most faults terminate within the Albion Member, but a few may cut the Foord seam.

Measurable folding of the basin fill increases in intensity toward the northern margin. Several large folds can be traced both from patterns of bedding orientation in scattered outcrop and from subsurface minepilot information (Gillis 1991). Fold axes are generally parallel to the basin margin, suggesting that the synclinal structure may result from ductile movement and other folds Mkm an arcuate pattern, possibly produced by linking of two originally separate folds. Most of the area, correlation of surface and subsurface folds suggests that folds exist surfaces dip steeply north, consistent with inferred fault dip and with the interpretation of the basin as a pull-apart basin.

Farther east in the basin, a complex fold pattern in the Thorburn area involves two structural basins focused on the Marsh and McLellan synclines. The individual basins may be related to NNW-SE shortening but the overall structure appears to be controlled by the shape of the basin margin, suggesting that the synclinal structure may result from ductile movement on nonvertical basin-bounding faults.

EVOLUTION OF THE BASIN

Initiation of the Stellarton basin was preceded by major late Namurian or early Westphalian deformation, which led to the formation of the Mabou Group and the development of the Windsor and Mabou Groups. The Stellarton Formation was deposited with angular unconformity on these units.

The Stellarton Basin was initiated at a releasing bend in the Cobequid-Hollow fault system in early Westphalian time. Stratigraphic analysis of the Stellarton Formation by Naylor et al.(1990) and others has shown that coarse clastic facies (mainly sandstones, local conglomerates) are concentrated at the south and east basin margins. The present structural trend of the basin is NNW-SSE, but the basin may have had a different orientation at the time of sediment accumulation. However, to the southwest, the basin may originally have extended significantly beyond its present enclosed limit.

The thickest coal and all mineable successions are found in the centre of the basin and extend into the highly deformed rocks of the Westville area. This suggests that the centre of the basin, the Albion Syncline, was the area of most rapid accumulation were most rapid at the southern basin margin, interpreted as fault-bounded (Ralston 1989). Fast formation during this interval was concentrated at the north basin margin where overall syndepositional subsidence was slowest. Coal seams are not mineable in the thick fluvial sandstones that occur at the north basin margin. The stratigraphic position of the Albion Member, locally there may be an unconformity at or near the base of the overlying Coal Brook Member. During deposition of the later parts of the formation, the basin floor probably subsided more evenly, with the most rapid subsidence in the centre of the basin. The upper limit of the stratigraphy of the subsidence history is limited, because erosion has removed the youngest units from the west end of the basin.

Significant shortening affected the basin after the deposition of the youngest basin fill (Thorburn Member), and the youngest strata to the north of the basin (Boss Point Formation) both dated as Westphalian C to D. The northwest basin margin was deposited with angular unconformity on these units. The Boss Point Formation is interpreted as a molasse deposit (possibly in a foreland basin) produced by uplift and deposition of molasse which plaqued the Stellarton Basin on a releasing bend. There is no stratigraphic upper limit on the timing of the deformation, on regional grounds it is assumed to have occurred in latest Carboniferous or Permian time.

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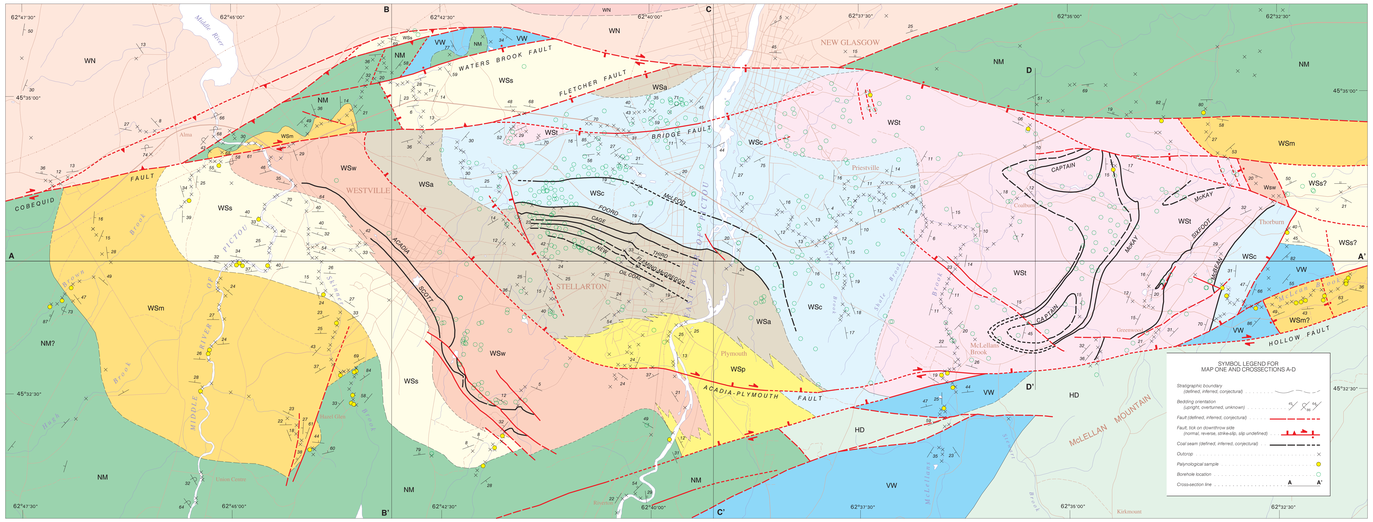


Map 1. Geology and selected coal seams

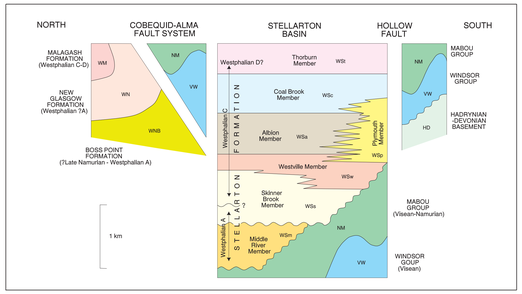
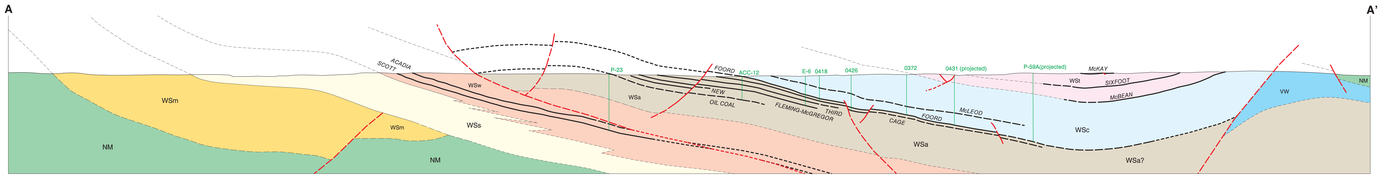
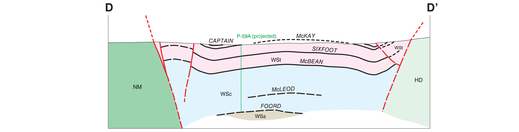


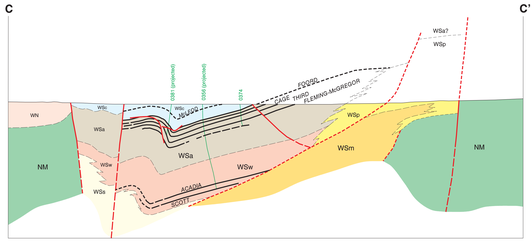
Figure 1. Legend to stratigraphic units



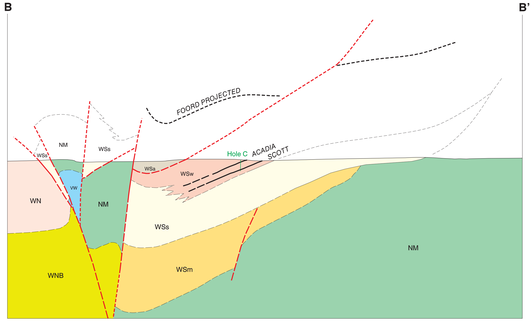
Cross-section along A-A'



Cross-section along D-D'



Cross-section along C-C'



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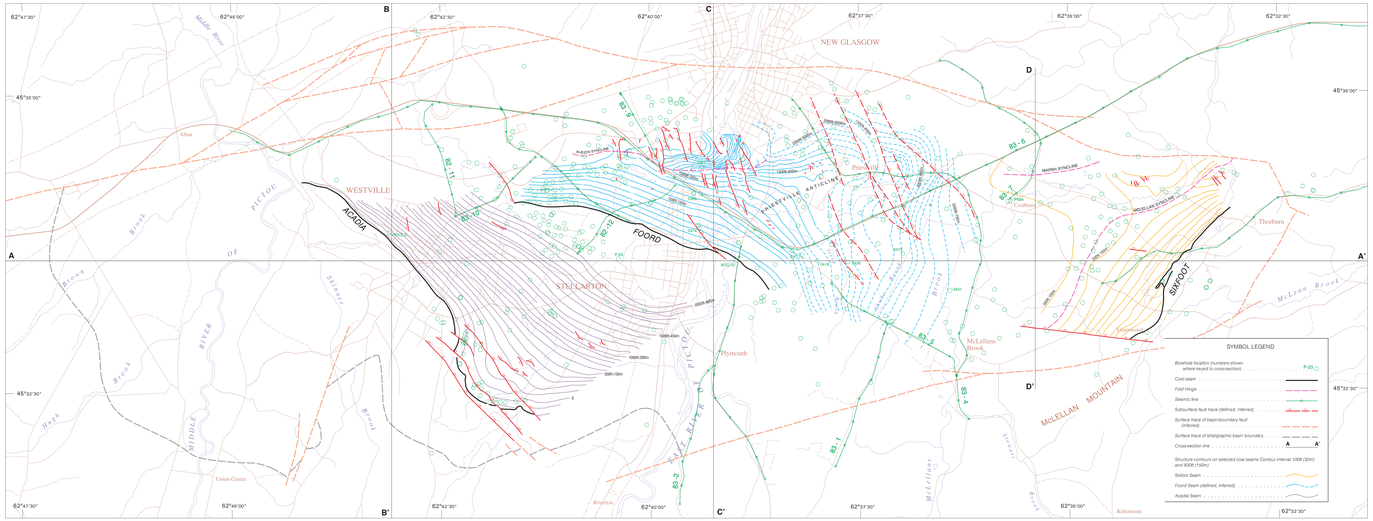

Map 2. Structure contours on selected coal seams

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OPEN FILE 3757

GEOLOGICAL COMPILATION MAP OF THE STELLARTON BASIN

NOVA SCOTIA

Scale 1:25 000 - Échelle 1/25 000

Metres 500 250 0 500 1000 1500 2000 Mètres

Universal Transverse Mercator Projection — Projection transverse universelle de Mercator

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Geology by John W.F. Waldron[1], F.W. Chandler[2], P. Durling[3], K.S. Gillis[4], and R.D. Naylor[5], 1999

[1]Geology Department, Saint Mary's University, Halifax, Nova Scotia
[2]Geological Survey of Canada, Ottawa Ontario
[3]Geological Survey of Canada (Atlantic), Dartmouth, Nova Scotia
[4]Nova Scotia Department of Natural Resources, Stellarton, Nova Scotia
[5]Nova Scotia Department of Natural Resources, Halifax, Nova Scotia

Subsurface borehole data compiled by J.D. Hughes, Geological Survey of Canada

Digital cartography by R.L. Allard, Geoscience Information Division

Electrostatic plot produced by the Geoscience Information Division

Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

Digital base map from data compiled by Geomatics Canada, modified by the Geoscience Information Division

Mean magnetic declination 1999, 31° 21' W, decreasing 12.9' annually

LOCATION MAP

11 E/14	11 E/15	11 E/16
11 E/11	11 E/10 OF 2757	11 E/9
11 E/6	11 E/7	11 E/8

NATIONAL TOPOGRAPHIC SYSTEM REFERENCE

Canada

COPERNICUS — COOPERATION
NATURAL RESOURCES, MINERAL DEVELOPMENT
ENTENTE DE COOPÉRATION
RESSOURCES NATURELLES, MISE EN VALEUR DES MINÉRAUX
Cooperation in Canada-Nova Scotia Cooperation Agreement on Mineral Development 1990-1995 a subsidiary agreement under the Economic and Regional Development Agreement
Coopération à l'Entente de coopération Canada-Nouvelle-Écosse sur la mise en valeur des minéraux 1990-1995, entente de mise en oeuvre subsidiaire de l'Entente sur le développement économique et régional
Canada — Province of Nova Scotia

OPEN FILE
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3757
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
OTTAWA
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