STRUCTURAL GEOLOGY

INTRODUCTION

The major structural feature of eastern Pictou County is the high angle fault which separates the older Paleozoic rocks from the Carboniferous rocks to the north. To the west and southwest, the Carboniferous rocks overlie the older Paleozoic rocks with great unconformity.

The structure within the older Paleozoic sequence consists of folds trending approximately east-west and cut transversely by high angle faults.

The structural geology is presented graphically in the geologic map, fig. 2, and the cross sections, fig. 3.

Many of the important faults of this area are indicated by topographic features. The high angle fault, mentioned above, has a scarp of several hundred feet for much of its great length. Elsewhere, its topographic expression is less striking, but still present in such features as Parks Falls on the Sutherland River. In Antigonish County, the upper reaches of Arisaig Brook and Doctors Brook follow the foot of this scarp. The Marshy Hope Fault[1] is marked by the east-west valley, through which flows the upper part of Barneys River and through which pass Route 4 and the railroad. Farther west, this same fault is followed by an unnamed stream until it intersects the Hollow Fault. The steep northeast face of Irish Mountain is the scarp of an important fault. McLellan Brook flows along the base of this scarp. The upper segment of the French River follows what must be a fault contact between different rock units. Much of the lower portion of Sam Cameron Brook, in the southeast corner of this area, follows a fault, as do two segments of the unnamed brook 2 miles east of Sunnybrae. The numerous small faults and deformation observed in many other streams suggest that their courses also are following a fault or fault zone. Examples of this are Blanchard Brook at Sunnybrae, Sutherland River in the area mapped in detail, and Holmes Brook northeast of Springville. On the French River, and 1½ miles to the west on Telford

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[1]The Marshy Hope Fault is that east-west, high angle fault which extends beyond the Antigonish County line just north of Route 4. It is observed on a tributary from the north of the East French River, in West Barneys River north of Route 4, and in the railroad cut north of Route 4 and east of Barneys River Station, and must be present farther east, separating the Ross Brook Formation from the Browns Mountain Group. This has been named by the present author for the railroad station of that name near the Antigonish County line.

Brook, the presence of a fault is noted by, respectively, the repetition and the absence of strata. In each case, a stretch of flat topography, with no outcrop, is encountered.

These numerous examples indicate the extent to which geologic structure controls the topography. The control of elevation by rock type noted by Bell (1940, p 4), to the northwest, generally holds true in this area as well. With this in mind, the striking pattern of major streams oriented northwest-southeast was noted. Several such streams are among the above examples of fault-controlled stream orientations. These are the upper French River, McLellan Brook, and the unnamed brook 2 miles east of Sunnybrae. This dominant northwest-southeast pattern is taken as representing the major fault pattern. Where no contradiction arises, this pattern has been used to infer directions of faults and to suggest the connection of some faults.

FOLDS

Plunging Anticline

The outcrop pattern in eastern Pictou County indicates that the older Paleozoic rocks are present in an anticline plunging to the west. The older Browns Mountain Group is present in the east central area, with Silurian to the north, south, and west, and Devonian present to the west above the Silurian This anticline is cut off on the north by the Hollow Fault, and plunges under the Mississippian unconformity to the southwest. The anticline is terminated on the west by the unconformity and relatively minor faults.

Superimposed on this anticline are two smaller but persistent folds, a syncline on the northern flank, and a syncline near the axis of the major anticline.

Northern Syncline

In the north, adjacent and sub-parallel to the Hollow Fault, is a syncline about 8 to 10 miles across. This syncline punges to the west south west, gently at its eastern end and more steeply in the west. The lower part of the Browns Mountain Group is present on both flanks. Near its eastern end, the youngest rocks present are of the Ross Brook Formation, while toward the west the remainder of the formations of the northern stratigraphic sequence appear. At the western extreme, the base of the Devonian Knoydart Formation is exposed. At this end, the syncline is cut off by a major transcurrent fault which brings these youngest beds of the syncline in contact with rocks of the Browns Mountain Group.

The dips are shallow in the centre of the syncline, but

become increasingly steep in the older beds on the flanks. Several smaller folds are present near the axis of this syncline, as well as drag folds up to 50 feet wide on its limbs.

Central Syncline

In the center of the major plunging anticline, a second syncline is present, whose axis extends east-west. The transitional facies of the Glencoe Brook Formation and the Kerrowgare Formation are exposed in this structure, flanked on the north by volcanic rocks of the Bear Brook Formation. This syncline is a narrow structure, being only about 3 miles wide. To the east it is terminated by an inferred fault which has brought these beds down against undifferentiated Browns Mountain Group rocks. To the west it is also terminated by a fault. At this end it has been faulted against rocks of the Moydart Formation.

Small areas of Silurian sedimentary rocks are present at two localities, in line with the axis of this central syncline, 2 miles and 5 miles to the east respectively. These are presumably faulted down against the surrounding Browns Mountain Group. In both areas, the transitional facies of the Glencoe Brook and Kerrowgare Formations are exposed. Although no attempt was made to map the structure within the undifferentiated Browns Mountain Group, these younger beds, in line with the axis of the central syncline, may indicate its extension in this direction.

North South Folds

On Cross Brook, and less than a mile to the west, north-south trending synclines are present. The Cross Brook syncline has its east limb overturned, and the more westerly syncline has a vertical east limb. These folds may be essentially drag folds on the steep nose of the anticlinal structure that makes up the older Paleozoic rocks of eastern Pictou County.

Small Scale Folds

Numerous parallel small folds are present at several localities in the Ross Brook Formation. This feature is best developed in Cameron Brook, 1 mile southwest of Parks Falls, and on the French River between Meiklefield and the mouth of Wallace Brook. Small scale folding is also present in the Kerrowgare Formation in the Central Syncline and in the Holmes Brook-Bridgeville-Springville area. However, in the Ross Brook Formation, with its interbedded sandstones, attitudes of the beds frequently can be determined and the small folds mapped, whereas this is not always possible in the Kerrowgare Formation.

The best exposures of these structures are on the French

River, as described above. Outcrops are abundant, and many extend from the stream channel up the bank and into the cliffs on one side of the river. In these excellent exposures, the axes of the small folds are the sites of many very small faults, some with rotational motion resulting in a generally fractured and almost crushed appearance to the mudstones. This fracturing usually destroys all traces of bedding, and the small folds must be recognized by the attitudes of the limbs. Here, in the distance of a mile, are 13 small anticlines and synclines with moderate plunges to the northwest.

On Cameron Brook, 12 small anticlines and synclines are present in a little more than a mile. They plunge gently to both the northwest and the southeast.

These small scale folds in the Ross Brook Formation are present throughout the northern syncline, particularly where this formation lies along the axis of the syncline.

In the Kerrowgare Formation on Holmes Brook, similar structures are observed. In a distance of half a mile, anticlines and synclines are observed plunging gently to the north.

Although these three examples display the same average width or spacing of folds, the individual folds vary from less than 250 feet between axes of consecutive anticlines to almost 2000 feet.

Three areas show complex folding, including the small-scale folds just described. These are the wedge-shaped area between the Hollow Fault and the Marshy Hope Fault, the area south of Parks Falls, which lies between the Parks Falls and the fault zone along the Sutherland River, and the Holmes Brook area between the fault along Holmes Brook and the fault west of Sam Cameron Brook. All three of these areas are wedge-shaped blocks between important faults, and the complex folding is a result of movement along these faults.

FAULTS

Hollow Fault

The major fault that marks the northern boundary of the Devonian, Silurian, and older rocks in eastern Pictou County, extends northeastward through Antigonish County, continuing along the northwest coast of Cape George, and thence out to sea. For most of its length, it is marked by a scarp several hundred feet in height. This was recognized by Fletcher (1887), and named The Hollow, after the valley at the foot of the scarp. This fault also extends southwestward. Beyond the region of exposed older Paleozoic rocks, it can be followed as one or more faults cutting through the Carboniferous rocks. These faults

can be seen on the Geological Survey of Canada Map 616A (Bell, 1940), and include the important "South Fault" shown thereon. The topography continues to reflect this fault or fault zone, though not as strikingly as to the east. Another feature of the Hollow Fault is its straightness throughout its considerable length. With a few changes in direction, of no more than 10°, this fault system can be traced 44 miles from the tip of Cape George to the East River of Pictou. Throughout this length, the rocks on the southeast side are always older than those which they face across the fault. No evidence of strike slip movement was observed. Hence, it is concluded that this is a high angle fault, along which the southeast block has moved up with respect to the northwest block.

Vertical movement is suggested by the presence of small folds adjacent and parallel to the Hollow Fault. Anticlines are present on the south side of this fault at Parks Falls, Telford Brook, "Harri Brook", and the East French River. Synclines are present on the north side on Barneys River, and on the East French River. If these are the result of movement on the fault, they correctly indicate that the south side has moved upward relative to the north side.

In only one place is there any indication that considerable strike slip movement may have occurred. At School Brook Cove, on Cape George, (see fig. 1) Ordovician and lower Silurian rocks of a sandy facies are in fault contact with upper Silurian rocks similar to the Arisaig-northwest Pictou County sequence. The outcrops in this cove resemble a large scale fault breccia in their structural complexity (Boucot, Griffin, and Fletcher, 1959). Some or all of the faults present may be a zone representing the Hollow Fault. The presence of a different sedimentary facies could be the result of a strike-slip movement along the Hollow Fault. However, Cape George is the site of several thrust faults in Mississippian rocks. Such a fault may have carried the rocks of the different facies to this locality. Since rocks of the same age are not represented by two different facies, it is also possible that the anomalous beds are the result of original differences in environment of deposition between this locality and Arisaig, 16 miles to the southwest, that existed during the Ordovician and early Silurian time, but which differences ceased to exist by later Silurian time. It should be noted that this is the situation which exists between the Northeast Pictou County and Southeast Pictou County areas. Here, considerable differences in the sediments existed, until the time of deposition of the Stonehouse Formation, after which the two sequences were similar.

Faults Branching from the Hollow Fault

Several large faults intersect the Hollow Fault at low angles. The clearest example is the fault above Parks Falls

called the Parks Falls Fault by the present writer. This fault trends more southwesterly than the Hollow Fault, and forms the boundary between the older Browns Mountain Group rocks to the north, and the Bear Brook, Beechhill Cove, and Ross Book Formations, respectively from east to west, to the south.

Folds in the rocks on both sides of the fault can be ascribed to a drag effect which agrees, in the sense of the relative movement, with vertical displacement along this fault.

The continuation of this fault is uncertain in the region of scarce outcrops to the southwest. It probably continues as the fault which brings the Browns Mountain Group up against the Knoydart Formation in McLellan Brook.

A second example is the Marshy Hope Fault. The nature of the movement along this fault is uncertain. The contact of the Ross Brook Formation and the older Browns Mountain Group across part of this fault indicates considerable displacement. The rocks to the north are in a wedge-shaped block between this and the Hollow Fault. The strata within this block are complexly folded. In addition, the valley of Barneys River and West Barneys River may be the site of one or more faults not observed in the outcrops.

In the northwestern corner of this area, some outcrops of the Bear Brook, Beechhill Cove and Stonehouse Formations suggest another wedge caught between the Hollow Fault and a fault branching from it. The juxtaposition of Silurian and Carboniferous rocks indicates considerable displacement on both faults.

Another example of this type of fault may exist in the area of Telford Brook and the next small brook to the east. On Telford Brook most of the Stonehouse Formation has clearly been faulted out, but only a swampy region, devoid of outcrop, marks the fault itself. On the next brook to the east, the stratigraphic units are offset and differ in attitude in such a manner as to indicate a fault between these two brooks. These two features can be explained by a fault, as shown in Fig. 2 with relative strike slip displacement of the northwest side to the southwest by about 2000 feet. This fault would intersect the Hollow Fault at an angle of about 35°.

Faults Transverse to the Folds

The Irish Mountain Fault and its extension to the southeast have a north northwest orientation that is paralleled by many of the main streams. In view of the topographic expression of the structure, described above, these streams have been used to infer the orientation of faults otherwise only approximately known. These are high angle faults with vertical displacement. Several of them may prove to have ex-

tensions down some of the stream valleys to the southeast, such as the Kittle River and the Moose River.

In the southwest corner of the area under study are a number of high angle faults with varying orientations, all of which may have only vertical displacement, with the exception of that along Holmes Brook and that at the contact with the Carboniferous on Cross Brook. These last two are of a different age than the others, inasmuch as they displace Carboniferous beds as well, while the former are covered by the Mississippian unconformity. Displacement along the unconformity, for part of its distance north of Springville, probably accurred at the time of this later post-Mississippian faulting.

TECTONIC HISTORY

During the vulcanism accompanying the deposition of the Bear Brook Formation, the underlying Browns Mountain Group sediments were intruded by dikes and sills, as were the Bear Brook sediments themselves. The first structural deformation that these, and the overlying Silurian and Devonian rocks, were subjected to was the compressional folding along approximately east-west axes. As is the case in the rest of the Appalachian Geosyncline, the compressional forces acted in directions perpendicular to the linear basin of deposition. The difference is that in Nova Scotia the axes of the basin of deposition, and the folds, trend east-west. This was accompanied by, or followed by, cross faulting trending north northwest-south southeast with vertical displacement. These faults are overlapped by the Mississippian unconformity in the southwest, and so predate the upper Windsor Group. The folding, and perhaps the cross faulting as well, can be assigned to the Acadian orogeny of Devonian age. After the deposition of the Windsor Group, the Hollow Fault and smaller faults at Cross Brook and Holmes Brook brought Carboniferous rocks down against the older strata. Earlier movements along these faults are suggested by Mississippian basal conglomerates in contact across these faults with Silurian rocks and containing angular pebbles of the same rocks. Movements along these faults, prior to the time of deposition of the Windsor Group, could be a result of the Acadian orogeny. Since the Hollow Fault is later than the folds and transverse faults, it is more likely that any pre-Windsor movement was contemporaneous with that which followed the deposition of the Horton Group of lower Mississippian age. The post-Windsor movement along these faults is of uncertain age. In view of the clastic nature of the post-Windsor Carboniferous sediments, some of these later movements may also have taken place within the Carboniferous. Still further movement may have accompanied the deformation of the Pennsylvanian strata.