Current Research (1994) *Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 94-1, pages 167-174*

FISHER HILLS BLUESTONE: A CARBONIFEROUS FLAGSTONE/LEDGESTONE DEPOSIT

I. Knight
Newfoundland Mapping Section

ABSTRACT

Lower Carboniferous sandstones of the Saltwater Cove Formation are host to a flagstone deposit in the Fisher Hills, near Pynn's Brook, Deer Lake. The Fisher Hills bluestone is a hard, micaeous, blue-grey to green fine-grained sandstone that is dominated by planar to undulating thin stratification and lamination. Micaceous partings allow the sandstone to be quarried for excellent flagstone, and other building stone suitable for landscaping and other natural-stone construction projects. The sandstones were probably deposited at the shallow foreshore of a Mississippian lake.

INTRODUCTION

Lower Carboniferous sandstones and lesser grey shales provide the host for a stone quarry located in a west-trending ridge of sedimentary rocks, in the Fisher Hills, 6.5 km southeast of Pynn's Brook, Deer Lake (Figure 1). The sandstone quarry (Plate 1), the property of J. Tuach Geological Consultants Inc., is in the early stages of development to recover flagstone, ledgestone and blocks for landscaping and other building purposes. The flagstones averaging 2 to 6 cm thick and up to 1.5 m² in area are similiar to flagstones marketed in the United States under the trade names of Pennsylvania Blue and Bergen Blue.

Natural flagstone is perfect for paving stone and patio construction (Plate 2). Cut flagstone can be used for patio blocks and pavers, treads and risers for steps, hearths, floor tiles and a variety of other construction uses. Thicker, planar-bedded slabs and flags can be used for construction of retaining walls, steps, fireplaces, stone furniture and other stone structures. The combination of strength and durability with the aesthetic qualities of natural stones, fresh and weathered colours, surface texture and random shape and line, make the bluestone an eminently suitable substitute for concrete pavers, artifical brick and block and pressure-treated lumber used in landscaping.

HISTORY OF THE DEPOSIT

The deposit was discovered by John Tuach in the fall of 1992 along a woods road in the Fisher Hills during routine prospecting (Figure 1). Sandstone flags and flagstone boulders litter the till of a glacial crag-and-tail structure and can be traced for more than 0.5 km up-ice leading to a west-facing ridge of sandstone. Float and outcrop indicate that flagstone is present over a minimum area of 3.0 by 1.0 km.

Site preparation began in the spring and early summer of 1993 with the issuance of an exploration licence and a quarry permit, the stripping of overburden and the upgrading of a skidder road from the woods road to the ridge. A flat work area was established below the deposit and a ramp and bench constructed to access the deposit. A quarry face, 10 m high, 20 m long and dipping at 50° to the north was established at the north end of the quarry (41 to 49 m interval stratigraphic section, Figure 2). Approximately 2000 to 3000 tonnes of flaggy slabs were loosened by blasting from the dipping face and 1000 tonnes hauled to the quarry floor by excavator. A second, smaller face (up to 3 m interval of the stratigraphic section, Figure 2), located at the south end of the quarry, was loosened using an excavator. The project received funding assistance from the Mining Industry Assistance Program under the current (1990-1994) Federal-Provincial Mineral Development Agreement.

Quarry development will continue in the spring of 1994 and efforts will be made to find local markets and contract local landscape projects.

Figure 2 illustrates the sedimentary section measured through the strata in the quarry.

GENERAL GEOLOGY

The quarry is located in rocks of the Tournaisian Saltwater Cove Formation of the Anguille Group, a

This project is funded by the Canada–Newfoundland Cooperation Agreement on Mineral Development (1990-1994); project carried by Geological Survey Branch, Department of Mines and Energy, Government of Newfoundland and Labrador.

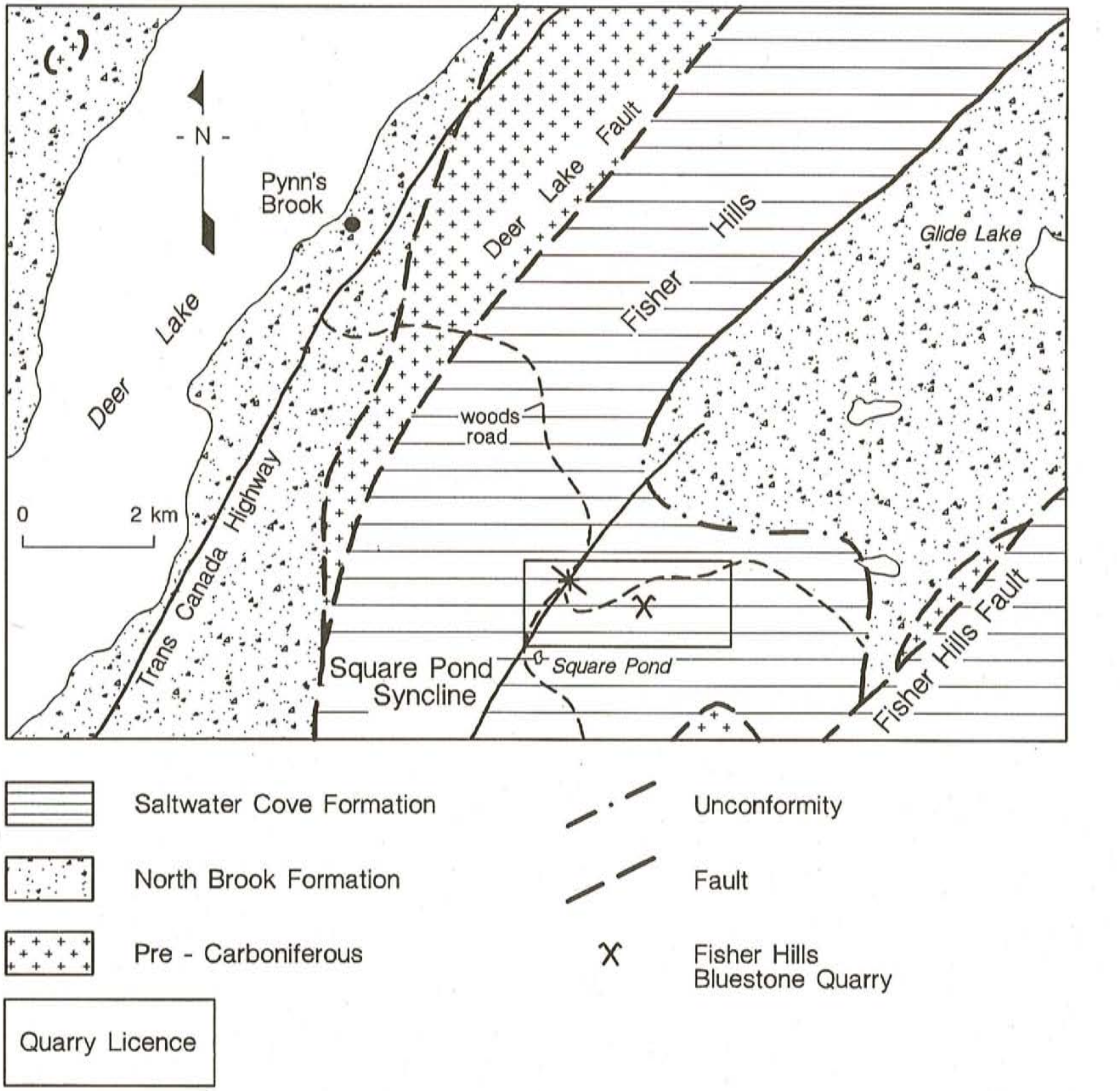

Figure 1. *Simplified geological map of the Pynn's Brook–Fisher Hills area showing the location of the Fisher Hills bluestone quarry (based on Hyde, 1983).*

lacustrine–deltaic sequence deposited in a narrow, northeast-trending Mississippian wrench basin that extended from Grand Lake northeast to White Bay. Hyde (1979, 1983, 1984) described the formation as dark-grey sandstone and siltstone and black carbonaceous shale and mudstone, interbedded with light-grey sandstone, pebbly sandstone and conglomerate. Limestone and dolostone occur locally. These rocks were interpreted to reflect the interaction of fluvial–deltaic–lacustrine processes at the margin of a lake (Hyde, 1979, 1984).

STRUCTURE

The quarry is located in a homoclinal succession (Plate 3) that trends about 280°, dips at 50° to the north and is part of the west limb of the Square Pond syncline (Hyde, 1983). The sedimentary rocks are cut by a number of master and minor joints (Plate 3). At the north end of the quarry, a set of master joints trend at approximately 085° and dip at 25 to 35° south. They are spaced 2 to 5 m apart. A second sub-vertical master joint set, with a spacing of 1 to 3 m, crosscuts this set and trends 190 to 200° and dips between 75° west and 80° east. Locally, these joint sets occur every 10 to 60

Plate 1. *General view looking north at the Fisher Hills bluestone quarry, Fisher Hills.*

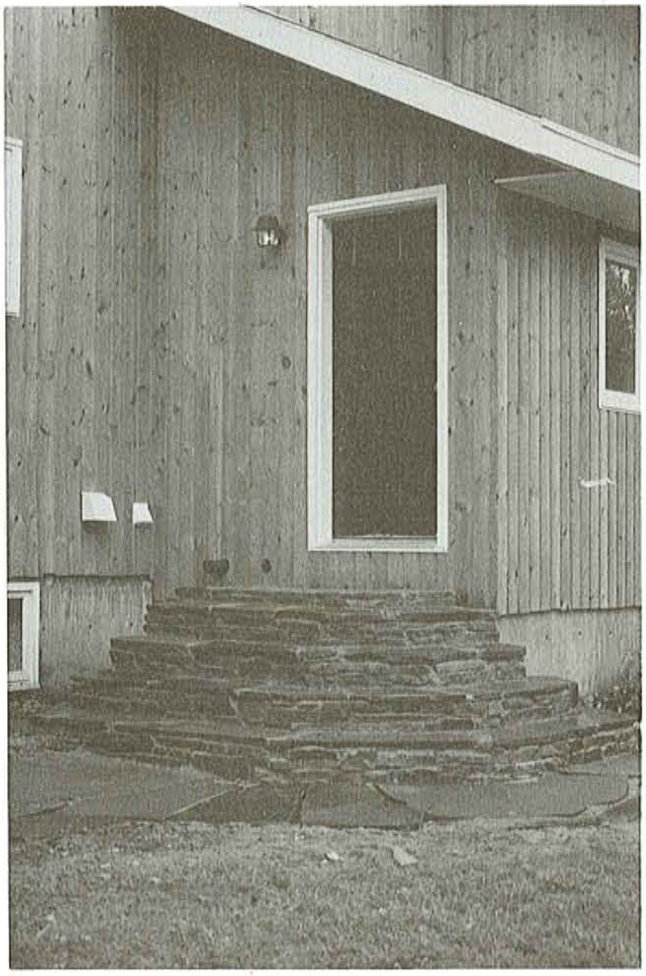

Plate 2. *Flagstone and treadstone from the Fisher Hills bluestone quarry used in the construction of walkways and the entrance steps at a home in Pynn's Brook.*

cm over a distance of about a metre before giving way to much wider spacing. The master joints appear to stop at bedding planes, then follow the bedding plane before restarting a few tens of centimeters beyond the previous termination point. This gives an interlocking geometry to the natural jointing pattern and provides locally for some very large flagstone slabs.

In the middle of the quarry, the main master joint set trends 160° and dips at 65° to the west. They are metre-spaced and are crosscut by decametre- to metre-spaced joints that trend 045 to 070° and dip at 48 to 58° south. In the lowest part of the quarry, the jointing is less pronounced but includes two sets that trend at 192°, dipping at 40° west and at 300°, dipping at 65° north. A minor north-trending subvertical fault offsets the beds approximately 1 m in the same area.

DESCRIPTION OF SECTION AND LITHOFACIES

A section approximately 49 m thick is exposed in the quarry. It is divided into three parts: a lower interval of sandstone and shale of approximately 12 m thick; a middle covered interval of approximately 12 m; and an upper interval of approximately 25 m dominated by sandstone. The sandstone is characterized by overall fine grain size, abundant muscovite content, and good hardness and strength because of its well-cemented siliceous nature. It is mostly blue-grey to green-grey with a green interval low in the section. The sandstone weathers buff to brown. Fossil plant fragments occur in the sandstone and are common as small fragments in the siltstone.

The sedimentary rocks are mostly thinly bedded and laminated sandstone and siltstone with or without parting lineation. The sandstone is readily split into various thicknesses of flagstone because of the well-developed micaceous partings. The thin-bedded sandstone is associated with the following:

1) massive and crossbedded sandstone, locally containing sandstone and shale ripup clasts;
2) ripple crosslaminated sandstone and siltstone with generally thin stratification and shaly partings and thin beds;
3) a dark-grey shale facies with increasing amounts of siltstone upward as overlying sandstones are approached.

Five lithofacies are defined and described below.

Thin-bedded and laminated sandstone and siltstone facies

The thin-bedded and laminated facies (Plate 3) constitutes approximately 44 and 41 percent of the lower and upper part of the section, respectively. There are at least 32 units ranging in thickness from 0.10 to 1.48 m distributed through the section measured. The grain size of the well-sorted sandstone ranges from fine-medium grained through fine grained to very fine grained; coarse-grained siltstone also occurs. Thin bedding having micaceous and locally carbonaceous partings, and in siltstones, shale partings, split at 1 to 10 cm intervals. The thinner scale partings range from 1 to 4 cm and are

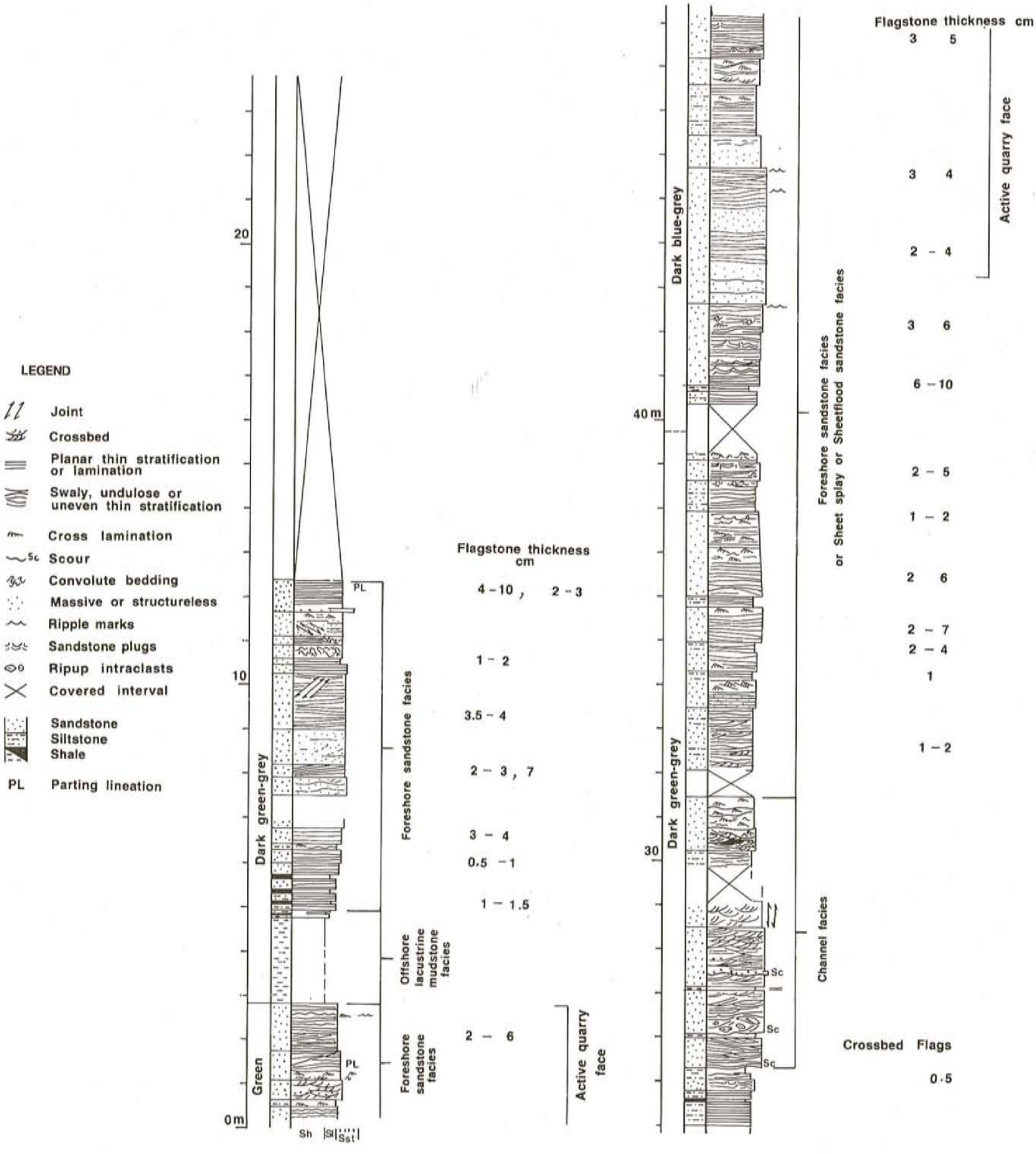

Figure 2. *Stratigraphic–sedimentological section through the Fisher Hills bluestone quarry.*

characterized by micaceous lamination. Partings change thickness when traced laterally in some of the beds. There is some mineral streaming or parting lineation. Bedding and lamination are mostly planar and flat but in some intervals broadly undulating and uneven resembling SCS (swaly cross stratification) (Walker and Plint, 1992). Small areas of convolution that typically resemble plugs locally penetrate a few centimetres of stratification. Oval to scoop-shaped scours and narrow, crudely linear hummocks are exposed on some bedding surfaces. Between 5 to 6 percent of the exposed

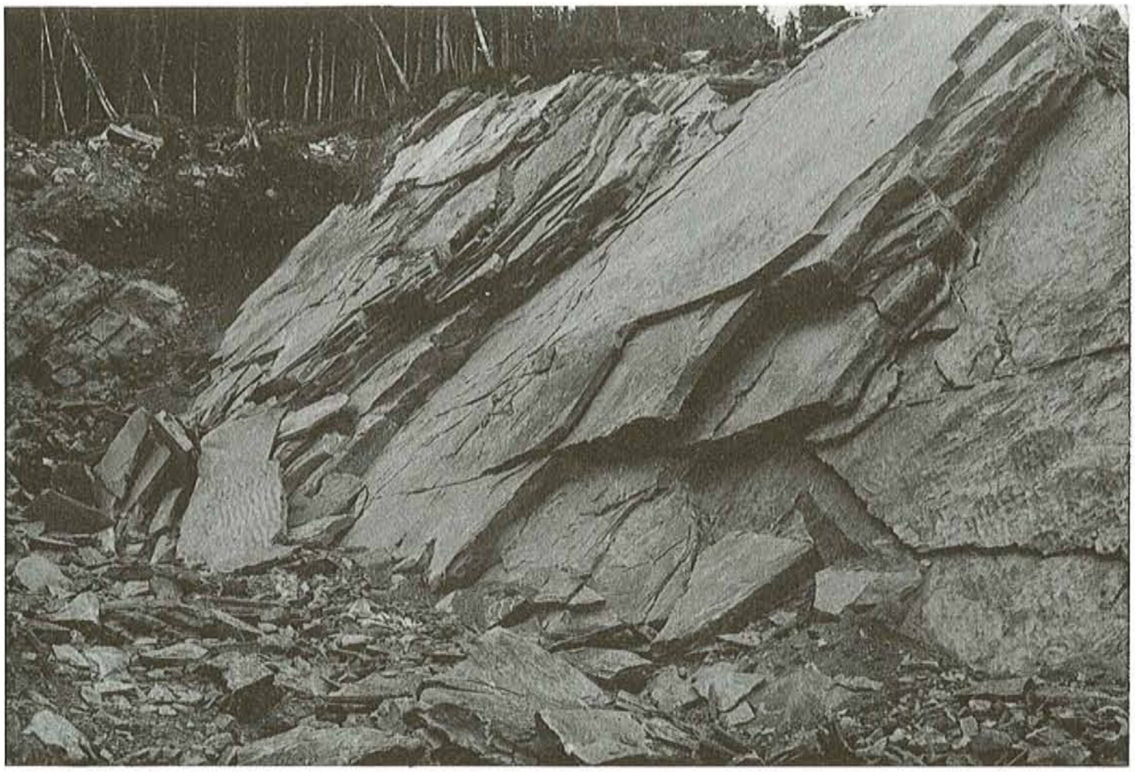

Plate 3. *Flagstones at the 33 to 35 m interval in the Fisher Hills bluestone quarry. Note the master joints, large size of slabs, excellent flaggy nature of the stratification and the dominantly smooth bedding planes. Some ripple-marked surfaces occur and the bedding plane at the far right shows a rippled hummocky topography.*

sections that were measured consisted of thin-covered intervals.

Crossbedded Sandstone Facies

This facies makes up 19 percent of the upper part of the section. It occurs in units ranging in thickness from 0.66 to 1.9 m thick. The crossbedded facies is characterized by the presence of basal and internal scours and trough crossbeds. Ripups of centimetre to decametre size consist of siltstone, shale and rarely sandstone and occur above the scours. Coarse sandstone also locally overlies the scours. Minor lenses and thin beds of dark shale occur in the crossbedded sandstone. The scour-based, crossbeddded sandstone fines upward into rib-and-furrow crosslaminated sandstone.

Massive Sandstone

Massive sandstone makes up 16 and 9 percent of the two exposed parts of the section. Structureless, sandstone beds are commonly interspersed in the thin-bedded and laminated facies and contacts between the two facies are sharp. Natural fracture in these sandstones is rare so that the rock is blocky. Locally, narrow zones of obliquely dipping joints associated with minor faults impart a pseudoflaggy aspect to some beds.

Thin-Bedded, Ripple Crosslaminated Sandstone and Siltstone Facies

Occupying 13 and 23 percent of the lower and upper parts of the exposed section respectively, this facies is mainly very fine-grained sandstone and coarse siltstone with minor thin beds and partings of shale. It generally forms beds 15 to 35 cm thick and is characterized by lamination, crosslamination including rib and furrow and abundant convolution. The facies is intercalated with the swaly thin-bedded and laminated facies.

Symmetrical ripple marks with short to long, sinuous to locally branching crests cover complete bedding planes (Plate 4). The ripple marks have wavelengths of 2 to 4 cm and amplitudes of 1 to 2 cm. Unidirectional internal crosslamination directed toward the northwest and northeast is common. These thin ripple-marked sheets mark thin caps to the swaly stratification of the thin-bedded and laminated facies.

The facies is also found overlying crossbedded sandstone (31 m interval).

Shale and Thin Siltstone Facies

Shale forms 20 and 1 percent of the lower and upper parts of the exposed section. Beds are up to 2.1 m thick in the lower

Plate 4. *A thin sandstone sheet covered by straight, sinuous to branching ripple marks that cover a complete bedding plane. It is associated with the thin-bedded and laminated sandstone (same interval as Plate 3).*

part where shale is most common and occurs only as thin interbeds within the other facies in the upper part of the section. A covered interval of approximately 12 m in the middle of the section perhaps obscures shale. The shales are dark grey, poorly exposed with a locally developed incipient cleavage. Siltstone laminae occur in the upper part of the thick shale unit in the lower part of the section and are gradually replaced by thin beds of laminated siltstone just beneath the overlying sandstone. This suggests an upward-coarsening sequence.

PALEOGEOGRAPHIC INTERPRETATION

Three possible depositional settings may explain the succession in the Fisher Hills quarry. These must account for the dominance of thin-bedded and laminated sandstone facies and the sparce cyclicity over the 40+ m section.

In setting 1, lacustrine muds represented by the shale facies lay offshore of a shoreline consisting of a wave-dominated subaqueous sand flat (thin-bedded and laminated sandstone facies and ripple crosslaminated sandstone and siltstone facies). The lake shore was provided with fine, well-sorted micaceous sand by a nearby river system (crossbedded sandstone facies). The one upward-coarsening shale to sandstone sequence exposed in the lower part of the section represents gradual shallowing-upward associated with a prograding shoreline. Massive-bedded and laminated sandstones just above the shale facies probably represent concentrated bottom-hugging sand flows deposited downslope of the river mouth.

Scour-based crossbedded sandstone with sand and shale ripups and a clear upward-fining trend mark channel deposits. These channels appear to lie above shale units and laminated and broadly swaly thin-bedded sandstone, and beneath more crosslaminated and swaly thin-bedded and laminated sandstone. However, the facies is uncommon and possibly represents an abandoned distributary channel within the lake foreshore.

The swaly bedded sandstones suggest wave-dominated foreshore deposition similiar to that noted in wave-dominated marine shorelines (Walker and Plint, 1992). Although parting lineation occurs in some beds indicating high-flow conditions, its scarcity may reflect low-flow conditions with the abundance of mica inhibiting the formation of ripple marks and thus producing a plane bed (Collinson and Thompson, 1989).

Symmetrical straight ripple marks common in the crosslaminated sandstone facies support the wave-dominated shallow-water sand-flat setting. The thicker crosslaminated sandstone units associated with the swaly sandstone (interval 36 to 39 m, Figure 2) suggests shifting facies belts (offshore swaly to nearshore rippled facies) as lake level fluctuated with shoreline progradation, sediment supply, subsidence and climatic oscillations. Thin ripple-marked sandstone sheets above the swaly sandstone (Plate 4; 34 to 36 m and 44 to

46 m intervals, Figure 2) probably reflects fairweather processes reworking the top of the storm deposits.

In setting 2, lacustrine muds represented by the shale facies lay basinward of a sandy delta and shoreline. The sedimentary succession indicates that the lake shallowed with thinly stratified and massive sands deposited in front of the river mouth succeeded by channelled sandstones. The shallowing continued onto the delta plain where thin-bedded and laminated sandstone overlie the channel sandstone. These sandstones were deposited as sheet splay sands that formed a wide apron marginal to channels but close to the lakeshore. Similiar sheet splay sands described by Galloway (1981) in the fluvially dominated Cenozoic deposits of the Gulf coast of Texas comprise mostly planar thin-bedded and laminated sandstone. The scarcity of channel sands in the quarry succession suggests that the main channel axis lay outside the quarry area.

In setting 3, the importance of the thin-bedded and laminated-facies sandstone in the succession may reflect the deposition by fluvial sheetflood deposits on a lacustrine coastal plain. The planar to undulose stratification with local parting lineation, low angle scours, convolution and fine grain size are similiar to recent and ancient deposits of ephemeral streams (Williams, 1971; McKee *et al.*, 1967; Miall, 1977; Tunbridge, 1981). Such sediments are essentially the deposits of highly sand-rich flashfloods that blanketed the low-lying plain adjacent to the lake. As in the other settings, the lake muds were overlain by the sandy products of the prograding shoreline and local rivers. These deposits are, however, subordinate to those of the sandy coastal plain. The swaly stratification encountered in the thin-bedded and laminated facies may reflect antidune formation in the fluvial setting (Rust and Gibling, 1990).

Model 1 is a novel interpretation of these deposits as SCS (swaly cross stratification) has been only rarely mentioned from lake settings (cf. Eyles and Clark, 1986). They are, however, noted in time equivalent lacustrine rocks of the Horton Bluff Formation, Horton Group of Nova Scotia by Martel and Gibling (1989). The association with wave ripples and the lack of subaerial structures tend to support this interpretation over the other two. Further work is necessary to resolve this question.

STONE PRODUCTS

The thin-bedded and laminated facies and the ripple crosslaminated facies is the source of the flagstone that is quarried at the site. It gives flags of various thickness from 1 to 10 cm. The best flags come from the thin-bedded and laminated facies, giving an excellent blue-grey stone with smooth surfaces afforded by the micaceous partings. Sandstones having less mica and showing a parting lineation provide the flatest stone and are found in the lower part of the section. Sandstones that exhibit parting lineation produce the best flagstone. Rock colour is mostly blue-grey, green-grey and green. It is estimated that between 20 and 25 percent of the section will yield very good quality flagstone. Flagstone from the ripple crosslaminated facies has rougher surfaces resulting from the rib and furrow, ripple marks and scours. These flags make excellent rough-textured pavers and treads.

The dimensions of the flagstone slabs are controlled by the jointing. In general, joints and fractures are infrequent and widely spaced. This results in large slabs in some layers. Locally, closely spaced oblique fractures in the massive sandstones produces a blocky flagstone or building stone. Crosscutting master joints in the upper quarry face yield slabs in excess of 2 by 2 m. In the intervals containing undulating stratification, the maximum size of the flat flags is less in order to eliminate curvature of the flags. The crosscutting sandstone plugs in the flaggy sands serve to pin the natural parting of the flagstone together. Although this may hinder splitting locally, it will probably not be a great hinderance because the plugs are scattered and relatively uncommon.

Flagstone can be recovered from the crossbedded facies since the crossbeds have broad troughs with virtually straight foresets locally. The flags will be smaller than that produced from the thin-bedded facies and the flag itself will be wedge-shaped.

Besides flagstone, the quarry will produce good building stone because of its commonly blocky nature when quarried. Massive and crossbedded sandstones can all contribute to this product. In addition, large natural slabs have a potential market as rip-rap and erosion liners.

The lack of closely spaced joints, the competence and the fine grain size combined with the excellent colour suggest that the massive intervals in this quarry have potential for polished slabs, tile and cladding. Blocks up to 2 by 2 by 1 m in size should be readily extracted. The flags could also be cut and graded to uniform thickness for tile. As such it compares to, although it is darker than, Pietra Sierra, a sandstone dimension stone produced in Italy.

ACKNOWLEDGMENTS

John Tuach encouraged the author to look at the deposit and is thanked for his advice, discussion, Plates 2 to 4 used in this report and a review of this article. Jamie Meyer provided Plate 1. David Liverman and Jamie Meyer reviewed the article.

REFERENCES

Collinson J.D. and Thompson, D.B.
1989: Sedimentary structures, 2nd edition. Unwin Hyman, Boston, Sydney, Wellington, 207 pages.

Eyles, N. and Clark, B.M.
1986: Significance of hummocky and swaly cross-stratification in late Pleistocene lacustrine sediments of the Ontario basin, Canada. Geology, Volume 14, pages 679-682.

Galloway, W.E.
1981: Depostional architecture of Cenozoic Gulf coastal plain fluvial systems. *In* Recent and Ancient Nonmarine Depostional Environments: Models for Exploration. *Edited by* F.G. Ethridge and R.M. Flores. SEPM Special Publication 31, pages 127-155.

Hyde, R.S.
1979: Geology of Carboniferous strata in portions of the Deer Lake Basin, western Newfoundland. Newfoundland Department of Mines and Energy, Report 79-6, 43 pages.

1983: Geology of the Carboniferous Deer Lake Basin. Newfoundland Department of Mines and Energy, Map 82-7, scale 1:100 000.

1984: Geological history of the Carboniferous Deer Lake Basin, western Newfoundland, Canada. *In* Atlantic Coast Basins, Paleogeography and Paleotectonics, Sedimentology and Geochemistry, Volume 3. *Edited by* H.H.J. Geldsetzer, W.W. Nassichuk, E.S. Belt and R.W. MacQueen. 9th International Congress of Carboniferous Stratigraphy and Geology, Southern Illinois University Press, Carbondale, Illinois, pages 85-104.

Martel A.T. and Gibling, M.R.
1989: Shoreline model for the lacustrine Horton Bluff Formation: implications of wave attenuation, oscillatory groove casts and sediment starved hummocky cross stratification. Abstracts, Atlantic Geoscience Society—1989 Colloquium, Atlantic Geology, Volume 25, No. 2, page 164.

Mckee, E.D., Crosby, E.J. and Berryhill, H.L.
1967: Flood deposits, Bijou Creek, Colorado, June, 1965. Journal of Sedimentary Petrology, Volume 37, No. 3, pages 829-851.

Miall, A.
1977: A review of the braided river depositional environment. Earth Science Review, Volume 13, pages 1-62.

Rust, B.R. and Gibling, M.R.
1990: Three dimensional antidunes as HCS mimics in a fluvial sandstone: the Pennsylvanian South Bar Formation near Sydney, Nova Scotia. Journal of Sedimentary Petrology, Volume 60, No. 4, pages 540-548.

Tunbridge, I.P.
1981: Sandy high-energy flood sedimentation—same criteria for recognition with an example from the Devonian of S.W. England. Sedimentary Geology, Volume 28, pages 79-95.

Walker, R.G. and Plint, A.G.
1992: Wave- and storm-dominated shallow marine systems. *In* Facies Models: Response to Sea Level Change. *Edited by* R.G. Walker and N.P. James. Geological Association of Canada, pages 219-238.

Williams, G.E.
1971: Flood deposits of the sand-bed ephemeral streams of central Australia. Sedimentology, Volume 17, pages 1-40.