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A. A. Ruttenberg, S. R. McCutcheon et D. V. Venugopal

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The Soil Column

Recent Gravity Sliding and Coastal Erosion, Devil's Half Acre, Fundy Park, New Brunswick: Geologic Explanation of an Old Legend

A. A. Ruitenberg, S. R. McCutcheon and D. V. Venugopal
Department of Natural Resources
P.O. Box 1519
Sussex, New Brunswick E0E 1P0

Devil's Half Acre is situated on a sandstone promontory along Herring Cove in Fundy National Park, about 2.5 km southwest of Alma, New Brunswick. The area has long been known for unusually large blocks of rock that periodically tumble from the promontory into the bay. An old legend attributed this phenomenon to an angry devil, who attempted to prevent some sturdy Yorkshiremen from settling in the area (Steeves, 1974). Devil's Half Acre was believed to be spared from complete destruction by the sprinkling of holy water brought along by the faithful Yorkshiremen.

Devil's Half Acre forms part of a northeast trending belt of Carboniferous sedimentary rocks, which is separated, to the northwest, by a major fault from late Precambrian volcanic rocks (stratigraphic equivalents of the Coldbrook Group). The bedrock geology has been mapped by Kindle (1958) and Ruitenberg *et al.* (1975). The Chief Naturalist at Fundy National Park requested the writers to investigate the effects of unusual rapid erosion that is affecting this scenic part of the park.

The nature and disposition of geologic strata and structures that have given rise to this phenomenon are described in this report.

Bedrock Geology

The oldest rocks in the area (Fig. 1) are Late Precambrian felsic and mafic tuffs, flows, and volcanogenic sedimentary rocks. The latter consist mostly of silt and sand-sized tuffaceous material, presumably derived from the weathering of adjacent volcanic terrain. The entire volcanic sequence has been subjected to intense cataclastic deformation accompanied by low grade greenschist metamorphism, that has resulted in a well-developed penetrative cleavage (Ruitenberg *et al.*, 1973; 1975).

The Carboniferous sequence at Herring Cove (Figs. 1 and 2) comprises the Hopewell Group and the overlying Boss Point Formation. Rocks of both units have been weakly deformed, except in the proximity of major faults.

The basal section of the Hopewell Group is composed of red to purplish red, poorly sorted, conglomerate with minor sandstone and siltstone. The conglomerate contains numerous highly deformed fragments of Late Precambrian rocks. The basal conglomerate grades upwards into purplish red sandstone and silty shale. The silty shale predominates in the upper three m of the section where it forms an excellent marker horizon.

Careful examination of the Hopewell Group, in the Cape Enragé and New Horton areas (Flaherty and Norman, 1931), demonstrated that this particular shale member occurs only in the Maringouin Formation. In that area, the Maringouin Formation is the oldest rock unit within the Hopewell Group.

At Herring Cove, the purplish red silty shale member of the Maringouin Formation is conformably overlain by grey, well-sorted, sandstone, quartz-pebble conglomerate and minor shale of the Boss Point Formation. Carbonized plant fragments and thin coal seams are common in these rocks. Mud-pebble conglomerate is locally abundant. Cross bedding is generally well developed. Parting along bedding and two sets of steeply dipping joints are well developed in these rocks (Fig. 4). The Shepody and Enragé Formations that overlie the Maringouin and underlie the Boss Point Formation, in the Cape Enragé and New Horton areas (Flaherty and Norman, 1931), are absent at Herring Cove.

Gravity Slides

Gravity sliding surfaces at Devil's Half Acre and other localities to the southwest along Herring Cove are best developed in the purplish red shale member of the Maringouin Formation (Fig. 3), and to a lesser extent along parting surfaces parallel to the gently dipping bedding in the overlying Boss Point Formation (Fig. 4). The rate of movement along the sliding surfaces is not well known. The amount of bending, and pulling apart of recently built stone walls, wooden structures and disruption of vegetation (Figs. 3 and 5), along the coast at Devil's Half Acre, indicates relative displacement of at least 20 cm/year between adjacent joint-bound blocks in the Boss Point Formation. The overall rate of movement of the sliding blocks could well be greatly in excess of 20 cm/year.

Gravity sliding and associated accelerated coastal erosion at Devil's Half Acre results from a unique disposition of strata and structures combined with active wave erosion. The following factors are involved:

1) The purplish red shale member of the Maringouin Formation has low shear resistance and low permeability in comparison to the underlying and overlying rocks (sandstone member of the Maringouin Formation, and quartzose sandstone and conglomerate of the Boss Point Formation).

2) The steeply dipping joints, and parting surfaces (parallel to bedding) that divide the Boss Point Formation into large blocks has greatly enhanced the permeability and lowered the tensile strength of this rock unit. Freezing and thawing, as well as expanding tree root systems have been effective in the initial separation of these joint blocks (Figs. 4 and 5).

3) A highly productive aquifer has formed along the contact zone of the purplish red shale member of the Maringouin Formation (low permeability) and the overlying Boss Point Formation (high permeability resulting from well developed joints). This has further decreased the shear resistance of the purplish red shale member of the Maringouin Formation.

4) The shale member of the Maringouin Formation erodes readily where it is exposed to wave action. At Devil's Half Acre, this has resulted in undercutting of the Boss Point Formation.

5) Gravity slides occur mainly where the contact between the Maringouin and Boss Point Formations dips towards Herring Cove.

Discussion

An unusual disposition of strata and geologic structures, combined with intense wave action, has given rise to active gravity sliding and accelerated coastal erosion in the Devil's Half Acre area. Slides occur mainly along a thin shale member of the Maringouin Formation, which conformably underlies the Boss Point Formation in this area. This shale member has low shear resistance and low permeability. Surface water entering through the well-developed joint system in the overlying Boss Point Formation is impounded by this same shale unit, resulting in the formation of a highly productive aquifer and further reduction in the shear resistance of the Maringouin shale member.

The tensile strength of the Boss Point Formation has been reduced as a result of the well-developed vertical joint system and bedding parting, which divide these rocks into large blocks. Undercutting by wave action of the underlying Maringouin shale activates sliding of large blocks of Boss Point rocks (over the Maringouin shale) towards Herring Cove. It is possible that minor seismic shocks, that are common along the Bay of Fundy may also help to initiate sliding.

Although the stratigraphy and structure of the Devil's Half Acre area uniquely favour gravity sliding, this same phenomenon can be expected in other conglomerate-sandstone-shale sequences along the Bay of Fundy. This is particularly the case where aquifers have developed.

Acknowledgements

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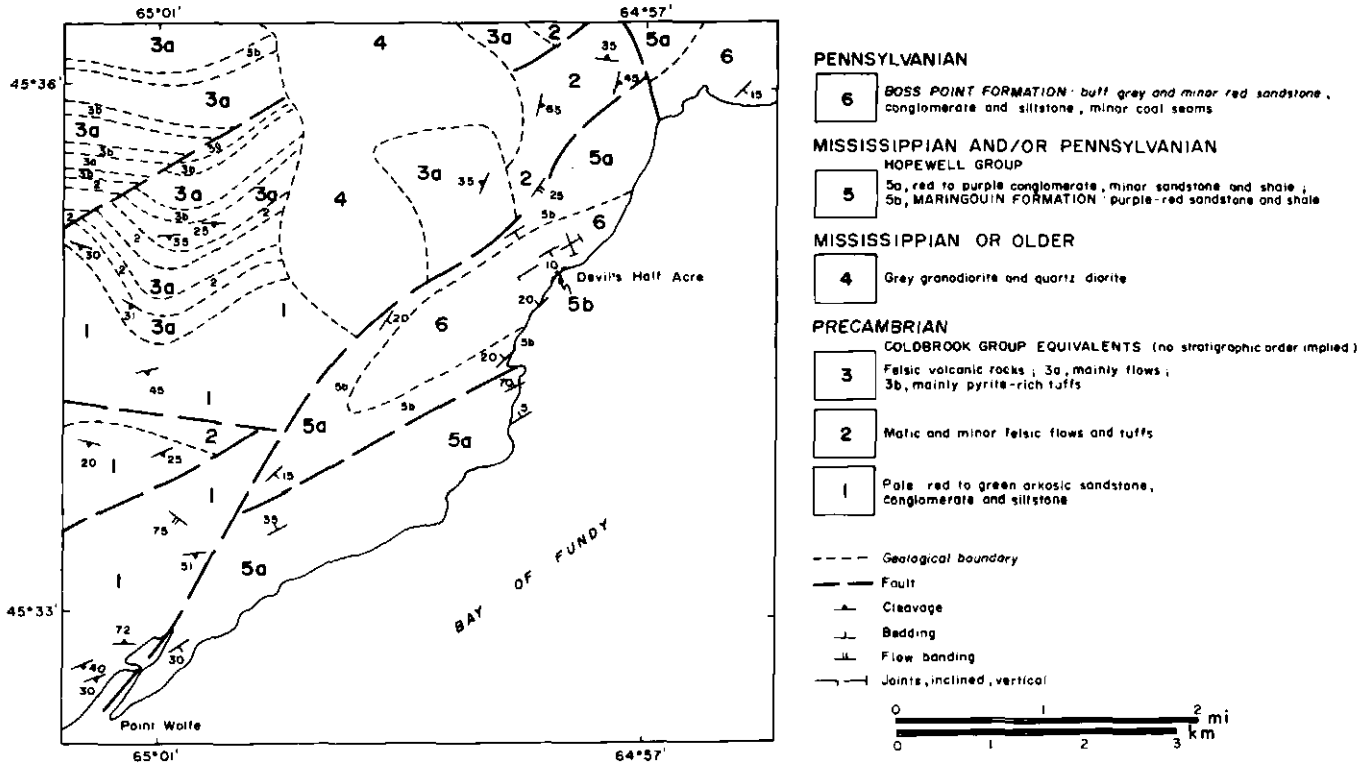

Figure 1
Geological sketch map, Devil's Half Acre area (modified after Kindle, 1958 and Ruitenberg et al., 1975).

Figure 3
Gravity slide along purplish red shale member of Maringouin Formation, severely affected by marine erosion. The recently constructed wooden walk-way has in part been pulled apart as a result of sliding towards the bay.

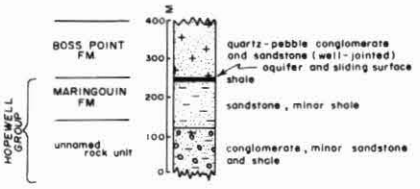

Figure 2
Stratigraphic column, Herring Cove area.

Figure 5
Effects of gravity sliding on vegetation.

Figure 4
Effects of gravity sliding along parting surfaces (parallel to bedding) and offsets across joints, in Boss Point Formation.