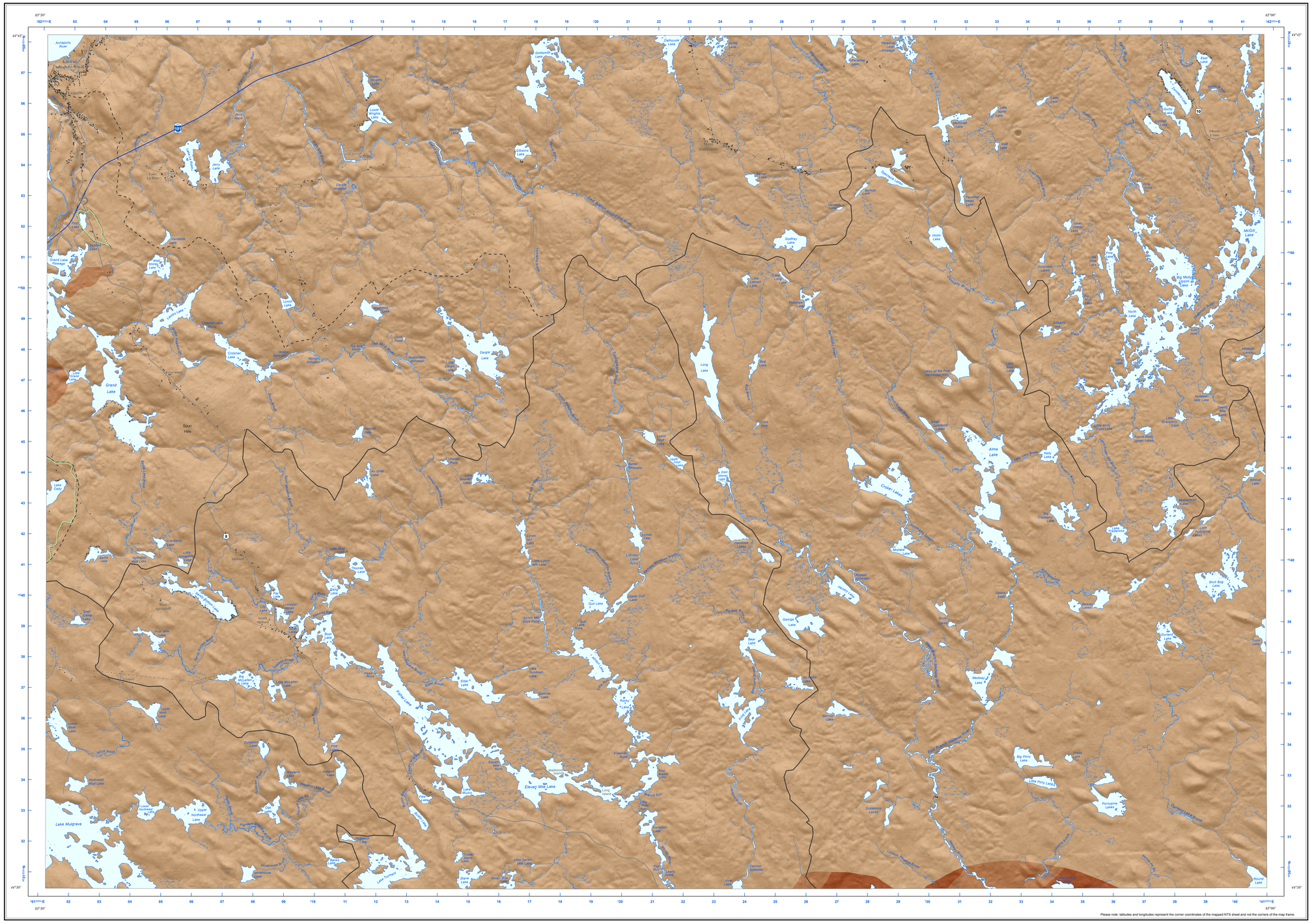


Bedrock Potential for Acid Rock Drainage

Introduction

The purpose of this map is to inform landowners, developers and municipal planners about the geological hazard of acid rock drainage (ARD) and to identify where the bedrock in southwestern Nova Scotia is potentially sulphide-bearing and may develop ARD if physically disturbed or exposed. Disturbing the bedrock refers to activities that physically alter and/or expose the bedrock, such as drilling, blasting and excavation. This map is intended to be used as a tool for making land-use and environmental planning decisions by indicating where precaution is needed, or further lithogeochemical analysis is likely required, before engaging in activities that disturb or expose bedrock.

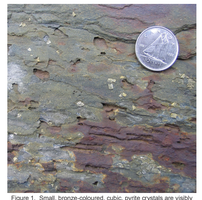


Figure 1. Small, bronze-coloured, cubic, pyrite crystals are visibly embedded in this slate. The rusty-coloured iron staining indicates ongoing sulphide oxidation and ARD (photo by G. Prime, NSDNR).

Figure 2. Sulphide mineral oxidation of the surrounding pyritic-slate bedrock discharges iron-oxides into this stream, discolouring it red (photo by G. Prime, NSDNR).

Overview of Acid Rock Drainage

ARD is a phenomenon that occurs when naturally occurring sulphide minerals in rocks are exposed to air and water, and react in a chemical weathering process called sulphide mineral oxidation. During sulphide mineral oxidation, pyrite (and other sulphide-bearing minerals) react with oxygen and water to produce iron-oxides and sulphuric acid, which discharge into groundwater and streams, rivers or lakes. Waterbodies impacted by ARD typically have higher acidity (pH levels between 2 and 4), making them corrosive and unable to support many forms of aquatic life. Acidic waterbodies can negatively impact potable and industrial water supplies and can cause excessive corrosion in metal and concrete infrastructure (White and Goodwin, 2011; Fox *et al.*, 1997). Furthermore, through a process called metal leaching, the acidic waters may break down other metal-bearing minerals in the rock, causing the release of dissolved metals (e.g. iron, aluminum, manganese, copper, zinc, cadmium, lead and other heavy metals), which can have adverse effects on human health. ARD can render municipal or domestic water supplies unusable and unpalatable, or aesthetically unpleasant. The oxidation of sulphide-bearing rocks tends to produce elevated iron concentrations, leaving an orange discoloration on rocks (Fig. 1), in stream beds (Fig. 2), and when in water supplies, discolouring laundry and porcelain fixtures.

ARD occurs naturally at slow rates; exposing or breaking up sulphide-bearing bedrock, however, can accelerate the sulphide mineral oxidation process. Human activity such as highway construction, quarrying, excavating, as well as natural events (e.g. washouts) are activities that can physically disturb and expose sulphide-bearing bedrock.

Acid Rock Drainage Potential in Nova Scotia

Recent bedrock mapping in the Goldenville and Halifax groups in southern Nova Scotia (White and Goodwin, 2011; White et al., 2012) has shown that some bedrock formations have the potential to generate ARD. Sulphide-bearing slate from the Cunard and Acadia Brook formations have the highest potential of generating acidic runoff because these formations contain abundant pyrite, pyrrhotite and other sulphide-bearing minerals. Pieces of the weathered sulphide-bearing bedrock may be incorporated into the overlying loose surface material. Exposing this type of till or soil can also initiate the process of ARD.

If disturbance in unavoidable, then potentially acid-generating bedrock (and other sulphide-bearing materials) must be managed in accordance with the Sulphide Bearing Material Disposal regulations (made under Section 66 of the Nova Scotia Environment Act 1995; Province of Nova Scotia 1995).

Classification of Acid Rock Drainage Potential

Recently published digital data and geological maps of southwestern Nova Scotia (White et al., 2012), combined with unpublished lithogeochemical data, were used as the base for ARD prediction. Rock formations were assigned to one of the following three acid-generating potential categories:

- High potential that bedrock will generate ARD
- Moderate potential that bedrock will generate ARD
- Low potential that bedrock will generate ARD

The ARD potential categories were established on legislative standards for identifying sulphide-bearing material using a similar lithogeochemical method (White and Goodwin, 2011) as the British Columbia Research Initial Test (BC-RIT).

The overall potential of a rock to generate acid is determined by the ratio of minerals that produce acid, such as sulphides, known as the acid-producing potential (APP), to the minerals that are able to neutralize it, such as carbonates, known as the acid-consuming ability (ACA) (White and Goodwin, 2011). Samples from the Bridgewater area (NTS 21A/07) were analyzed to determine their overall potential to generate acid by calculating the APP/ACA ratio. These results were extrapolated to the geological units in southwestern Nova Scotia. Rock samples above the 1:1 ratio were classified as acid-producers or high potential to generate ARD; samples within the 1:1 and 1:2 ratios have moderate potential to generate ARD; samples below the 1:2 ratio are considered as a non-acid producers or low potential to generate ARD. Whole-rock data were used to classify the bedrock units into acid-generating potential categories on the map based on the method outlined in White and Goodwin (2011).

Summary

The intention of this map is to provide information about the geological hazard of ARD and its associated risks, and to identify where sulphide-bearing, potentially acid-generating bedrock is located in southwestern Nova Scotia.

Physically disturbing and exposing sulphide-bearing rocks can accelerate ARD. Determining if sulphide-bearing bedrock is present should to be considered during the planning stage of development and construction in order to avoid negative environmental and human health effects as well as to reduce costly remediation. The best way to prevent ARD is knowing where sulphide-bearing bedrock is located and to avoid disturbing and/or exposing it.

Additional Information

For more information about ARD, please refer to Information Circular ME 067. Additional information includes the factors that influence ARD, the human activities that initiate ARD, and the effects of ARD that impact human health, the environmental and infrastructure.

Legend*

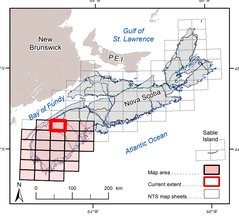
Potential for acid rock drainage (ARD) from bedrock that is exposed or physically disturbed

- High potential that bedrock will generate ARD. . . . . .
- Moderate potential that bedrock will generate ARD . . . . . .
- Low potential that bedrock will generate ARD . . . . . .

Symbols*

- Building . . . . . .
- Rock in water . . . . . .
- Municipal drilled well . . . . . .
- Arterial highway . . . . . .
- Trunk highway . . . . . .
- Collector highway . . . . . .
- Hard surface road . . . . . .
- Loose surface/resource access road . . . . . .
- Trail, footpath, cart track . . . . . .
- Railway (active, inactive) . . . . . .
- Coastline . . . . . .
- River, stream . . . . . .
- Municipal boundary . . . . . .
- Watershed (primary, secondary) . . . . . .
- Transmission line (multi, single line) . . . . . .
- Municipal surface water supply area . . . . . .
- National Park . . . . . .
- Wetlands . . . . . .
- Lake/ocean . . . . . .

* **Note:** Compiled legend and symbols list for Open File Maps ME 2013-003 to 2013-027. All symbols may not appear on each map.



Descriptive Text

This map represents the second in a series of 25, 1:50 000 scale maps, highlighting the acid-generating potential of bedrock in southwestern Nova Scotia if exposed and/or physically disturbed. A corresponding digital product (DP ME 484) and an information circular (IC ME 067) are available on the DNR website.

This map is part of an undergraduate Honours thesis project with Dalhousie University School of Planning, examining how to make geologic information accessible to an audience of planners and non-geologists.

Disclaimer

The information on this map may have come from a variety of government and nongovernment sources. The Nova Scotia Department of Natural Resources does not assume any liability for errors that may occur. Site specific lithogeochemical analyses are necessary to confirm the occurrence of acid-generating bedrock.

Map Notes

GIS databases, cartography and reproduction by Laura Trudell, Angie Ehler, Brian Fisher and Jeff McKinnon of the Nova Scotia Department of Natural Resources, 2013. The GIS databases and map were developed using ArcGIS® 10.

Universal Transverse Mercator Projection (UTM), Zone 20, Central Meridian 63°00' West. North American Datum (NAD) 1983 Canadian Spatial Reference System (CSRS) 98.

Base and digital data derived from the Nova Scotia Topographic Database (NSTDB). Copyright Her Majesty the Queen in Right of the Province of Nova Scotia. The NSTDB is available from Service Nova Scotia and Municipal Relations (SNSMR), Land Information Services Division (LIS), Nova Scotia Geomatics Centre (NSGC), Armherst, Nova Scotia.

Shaded relief image derived from a 25 m Digital Elevation Model of the Province of Nova Scotia, DP ME 56, version 2, 2006. Azimuth of 0°, sun angle of 45° and a vertical exaggeration of 5.

Nova Scotia Department of Natural Resources
Mineral Resources Branch

Open File Map ME 2013-004

Bedrock Acid Rock Drainage Potential Map of the Milford Area, NTS Sheet 21A/11, Annapolis County, Nova Scotia

L. L. Trudell and C. E. White

Scale 1:50 000

1 0 1 2 3 4 km

Halifax, Nova Scotia
2013

Acknowledgments

We thank Nova Scotia Department of Natural Resources for the permission to use unpublished data. Dr. Patricia Manuel, Dalhousie University School of Planning professor, is thanked for her advice and guidance with the undergraduate thesis project. We thank the participating planners for their helpful comments throughout the map production process, which led to the publishing of this derived map product.

Recommended Citation

Trudell, L. L. and White, C. E. 2013: Bedrock acid rock drainage potential map of the Milford Area, NTS Sheet 21A/11, Annapolis County, Nova Scotia; Nova Scotia Department of Natural Resources, Open File Map ME 2013-004, scale 1:50 000.

Selected References

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Health Canada 2010: Guidelines for Canadian Drinking Water Quality, Summary Table. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2010-sum_guidelines_recom/index-eng.php Date accessed: January 2013.

Nova Scotia Environment 2007a; updated 2010: Primary and secondary watersheds; Nova Scotia Environment, Water Resources Management Unit, scale 1:10 000.

Selected References (continued)

Nova Scotia Environment 2007b: Natural watershed municipal surface water supply areas; Nova Scotia Environment, Water Resources Management Unit, scale 1:10 000.

Nova Scotia Environment, Water and Wastewater Branch and Nova Scotia Department of Natural Resources, Mineral Resources Branch 2006; Municipal Water Supply Wells Database

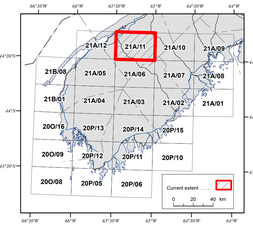
Province of Nova Scotia 1995. Environment Act: Sulphide-bearing Material Disposal Regulations. Retrieved from http://gov.ns.ca/just/regulations/regs/envp795.htm. Date accessed: January 2013.

Trudell, L. L. and White, C. E. 2013: Digital Bedrock Acid Rock Drainage Potential Data for the Southwestern Area of Nova Scotia; Nova Scotia Department of Natural Resources, Digital Product ME 484; http://www.gov.ns.ca/natr/meb/download/dp484.asp [ISN:23257][1]

White, C. E. and Goodwin, T. A. 2011: Lithogeochemistry, petrology, and the acid-generating potential of the Goldenville and Halifax groups and associated granitoid rocks in metropolitan Halifax Regional Municipality, Nova Scotia, Canada; Atlantic Geology; v. 47, p. 158-184.

White, C. E., Fisher, B. E., McKinnon, J. S., and Ehler, A. L. (compilers) 2012: Digital Geological Data Generated as Part of Geological Mapping of the Meguma Terrane of Southwestern Nova Scotia (1998-2010), Shelburne, Digby, Yarmouth, Annapolis, Queens, and Lunenburg Counties, Nova Scotia; Nova Scotia Department of Natural Resources, Digital Product ME 127; http://www.gov.ns.ca/natr/meb/download/dp127.asp [ISN:23256]

[1] Internal Search Number (ISN) is a unique identifier used in NovaScan - the Nova Scotia Geoscience Maps and Publications Database. The ISN can be used to retrieve a digital version of the listed citation - http://www.gov.ns.ca/natr/meb/default.asp



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Jul 31, 2013