Current Research (2023) Newfoundland and Labrador Department of Industry, Energy and Technology Geological Survey, Report 23-1, pages 23-29

THE GEOSCIENCE ATLAS AND GEOSCIENCE DATA UPDATES IN 2022

S. Jenkins, P. Honarvar, G. Roberts, D. Taylor, L. Crisby and G. Kilfoil
Terrain Sciences and Geoscience Data Management Section

ABSTRACT

The Geological Survey of Newfoundland and Labrador performed two updates on the Geoscience Atlas in 2022, comprising new data additions, and updates to existing data and help files. The most significant additions included several new geophysical products for Newfoundland, and newly digitized surficial geology and landforms from the historical map archives. In addition, the Survey received a report from Novacene AI (Ontario, Canada) that addresses the readiness of our datasets and infrastructure to meet the emerging demands of exploration in today's data-rich ecosystem. A review of the report is discussed. Finally, planned Geoscience Atlas enhancements in 2023 are presented: a new Drill Hole layer and a compiled Lithogeochemistry layer.

INTRODUCTION

The Terrain Sciences and Geoscience Data Management Section of the Geological Survey of Newfoundland and Labrador (GSNL) is tasked with maintaining and updating our online geoscience data portal – the Geoscience Atlas – with new and newly digitized or compiled archival data, as well as enhancing the organization's geoscience data strategy and implementation. This report describes updates to the Geoscience Atlas completed in 2022, discusses the recommendations from an external assessment of the current GSNL digital infrastructure and datasets with respect to emerging requirements for data-driven mineral-exploration technologies, and presents planned enhancements to our geoscience data inventory.

THE GEOSCIENCE ATLAS

The Geoscience Atlas (Atlas) is a web-accessible interface to a geographic information system (GIS) that provides Newfoundland and Labrador geoscience datasets (*e.g.*, geology maps, mineral occurrences, map staked claims information, geochemistry data, geophysical images and links to reports) to clients, such as prospectors, mineral-exploration companies and the general public. Annually, the Atlas logs over 44 000 sessions, comprising visits from more than 9600 clients worldwide. Most of our Atlas clients are in Newfoundland and Labrador, followed by Eastern and Atlantic Canada (Figure 1). The Atlas functionality (*e.g.*, query, download, print, help files; *see* Figure 2) is described in previous Current Research reports (Honarvar *et al.*, 2015, 2022).

The Geoscience Atlas connects the user to more than 180 geoscience data layers and more than 200 unique data visualizations (*e.g.*, geochemistry dot plots for individual elements). The Atlas also displays ancillary data layers generated by other provincial and federal government agencies to aid in decision making, such as the locations of transmission lines, municipal and planning area boundaries, and staked claims.

The Atlas is updated regularly; the update frequency varies by type of information. Foundational geoscience information (*e.g.*, *Geochemistry, Surficial Geology* and *Geophysics*) is updated annually or bi-annually. Other layers that pertain to mineral rights and mineral exploration (*e.g.*, *Mineral Occurrences, Map Staked Claims* and *Quarry* layers) are automatically updated daily or in real-time. Linked help files and metadata pages are updated on an "as needed" basis.

UPDATES

Updates to the Geoscience Atlas occurred in March and October, 2022. These updates, listed below, included newly compiled data, updated or appended data, and links to reports by GSNL personnel and exploration companies. The list below does not include those layers updated in real time (*i.e.*, *Map Staked Claims*) or daily (*e.g.*, *Mineral Occurrences, Historical Claims* and *Quarry* layers).

- Coastal Monitoring Group: Updated the *SE Labrador Coastal Indices* and *Coastal Characterization* layers.

- Indexes Group: Added links to new map and report releases in the layers *Bedrock Geology Maps, Surficial Geology Maps, Geochemical Surveys* and *Airborne Geophysical Surveys*.

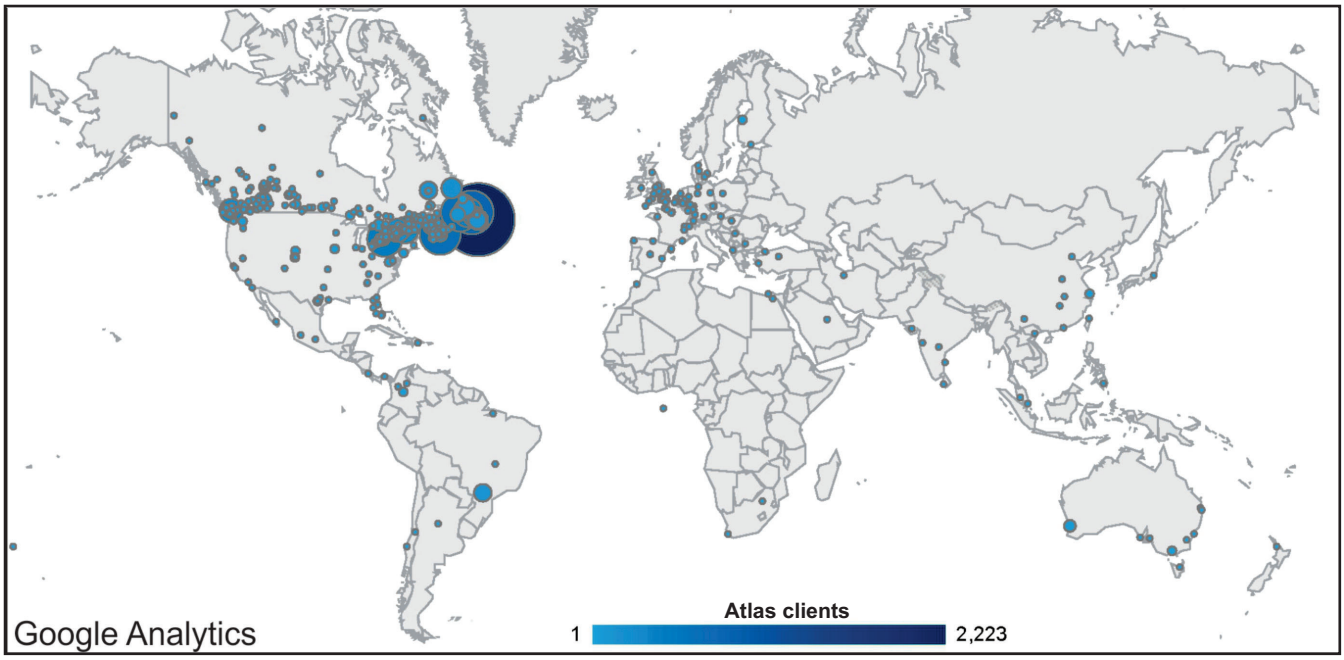

Figure 1. *Location and relative proportion of clients who used the Geoscience Atlas between October 2021 and October 2022. Data provided by Google Analytics.*

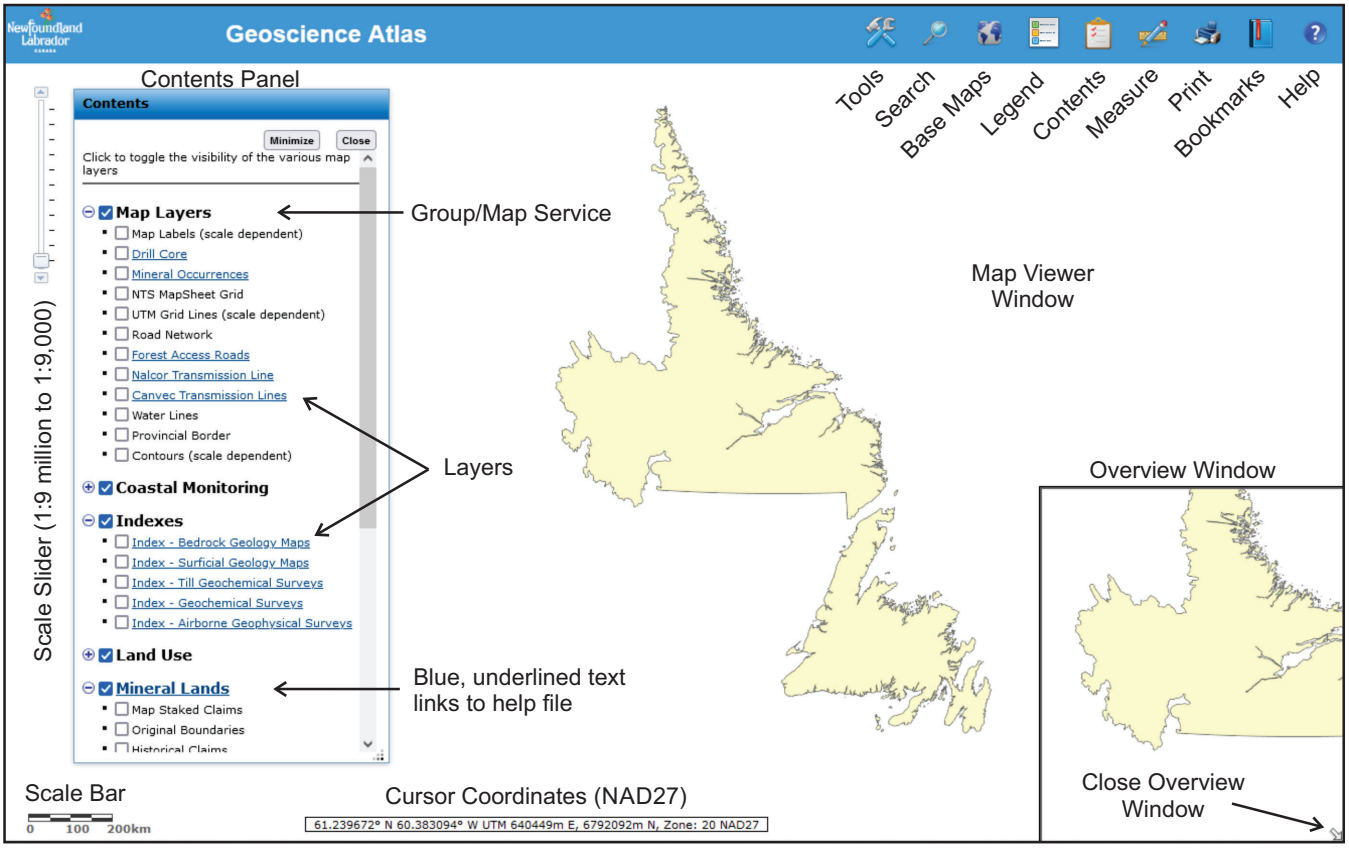

Figure 2. *The Geoscience Atlas webpage layout. The scale slider and contents panel are located on the left side. The scale bar, cursor coordinates (based on the North American Datum of 1927 (NAD27)) and overview window are located along the bottom. Tools, Base Map options, Legend generator, Print, Help file links and additional function buttons are located in the menu bar across the top right.*

- Land Use Group: Updated the *Public Water Supplies* (as of January 2022) and the *Municipal Boundaries and Planning Areas* (as of 2021) [these data are provided by other Provincial departments].

- Geochemistry Group: New records added to the *Detailed Stream Sediment Geochemistry* layer in the Labrador Seal Lake area and along the south coast of Newfoundland

- Surficial Geology Group:
  - Updated the attribute fields for *Carbon-14 Age Dates* and *Striations* layers.
  - Added newly digitized information to the *Landforms* and the *Detailed Surficial Geology* layers for NTS sheets 01M/05, 12, 03D/04, 05, 11P/08, 09, 12P/09, 10, 15, 16, 13A/01, 07, 08, 09, 16, 13J/01, 02, 13, 13N/10, 14, 15, 13O/03, 14C/05 and 14D/08.
  - Added a new thematic layer: *Peatland Maps of Newfoundland* (*see* below for further information) plus the help file, which contains a link to the Humber River Basin digitized Peatland shapefile.

- Geophysics Group:
  - Split the Group into *Geophysics - Labrador* and *Geophysics - Newfoundland*.
  - Added to the *Geophysics - Newfoundland* Group: Burin - 2022 (21 raster surveys), Twillick Brook - 2019 (22 raster surveys), Compilation - North-Central Newfoundland (4 raster compilations), and Compilation - West-Central Newfoundland (8 raster compilations).

- Updated Help Files and Metadata:
  - Metadata, compliant with the ISO 19139 standard, were added to most of the GSNL geoscience files. The metadata include the layer title, description, use limitations, keyword tags and thumbnail image of the dataset.
  - The What's New (list was updated with the new 2022 Atlas updates as well as providing direct links to relevant help files, contact information for Atlas questions and comments, and a link to the Atlas REST services (*see* Highlight section, below, for more information).

ATLAS HIGHLIGHT REVIEW: REST SERVICES

The Atlas provides a download tool so clients can add geoscience datasets to their own GIS programs, such as ArcGIS, MapInfo, or QGIS. For those Atlas layers that are updated often, such as the *Map Staked Claims* layer (updated in real time) or the *Mineral Occurrences* layer (updated every evening), frequently downloading the most recent version can be time consuming. For these and all other Atlas layers, clients can view and query the latest Atlas data directly through their desktop GIS software or web GIS API using the representational state transfer (REST) service, without downloading and storing the data locally.

The server address for Atlas REST services is https://dnrmaps.gov.nl.ca/arcgis/rest/services/GeoAtlas. A username and password are not required. The methods for loading REST services will vary by desktop software or web API provider and version. Clients are encouraged to search for help on the internet about how to access REST services for their specific GIS solution. Once loaded, the services are grouped in the same manner as the Atlas layers; for example, a user interested in viewing the distribution of our coastal monitoring sites would load the "Coastal Monitoring" group service, and expand it in the table of contents to turn on the *Coastal Monitoring Sites* layer. The displayed layer is not editable; users can query the data but cannot adjust the symbols or labels. The projection of the REST layer is based on its projection in the Atlas, *e.g.*, UTM or geographic coordinates (Latitude-Longitude). All Atlas layers use the NAD27 datum, therefore the client should ensure that the correct geographic transformation is loaded to project the REST services correctly on-the-fly if their GIS project is based on the NAD83 or WGS84 datum.

Other data providers' REST services can be also added to the Geoscience Atlas using the Tools > Add Map Service procedure. For example, users can load ESRI basemap services from https://services.arcgisonline.com/arcgis/rest/services (*see* Figure 3). Click 'Get Services', pick one of the 25

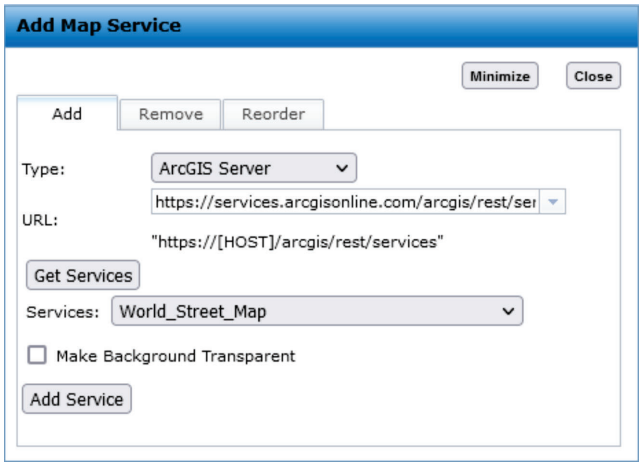

Figure 3. *Screenshot of the "Add Map Service" window showing the settings to add an ESRI ArcGIS basemap to the Geoscience Atlas. Users are cautioned that the Atlas cannot reproject ESRI basemaps; map offset relative to the Geoscience Atlas features may be visible at large map scales.*

services in the list provided (*e.g.*, World_Street_Map) and click 'Add Service'. The layer will load over all the Atlas layers, but the layer drawing order can be adjusted in the 'Reorder' tab. Users are cautioned that the Atlas cannot project external services on-the-fly. For example, the datum for ESRI basemaps is WGS84, therefore, users will notice spatial discrepancies between Atlas data and ESRI basemaps at zoom levels larger than 1:150 000.

NEW THEMATIC DATASET: SURFICIAL GEOLOGY GROUP – PEATLAND MAPS OF NEWFOUNDLAND

Peatlands, collectively encompassing types of wetland bogs, fens and other organic matter-rich soils, are a subject of recent global interest for their vital role in postglacial carbon sequestration (*e.g.*, Yu *et al.*, 2010; Amesbury *et al.*, 2019). As such, peatland restoration may play a key role in climate change mitigation (*e.g.*, Leifeld and Menichetti, 2018). Besides being significant biological carbon sinks, peatlands and other types of wetlands provide sites for groundwater recharge, stabilize coastlines and provide other erosion control, prevent floods, purify both surface water and groundwater, provide habitat to support a rich biodiversity, and provide a basis for agricultural, horticultural and oil-absorbent products. Historically, peat was a valuable fuel source in mid- to high latitudes (*e.g.*, Ireland), or was drained for agricultural land development (*e.g.*, Newfoundland regional pastures program, 1950s to present).

Peat is considered a quarry material in Newfoundland (*see* Quarry Materials Act 1998: Mineral Lands Division, 2006). There are about 1.3 million hectares of peatlands and bogs with a size of over 30 hectares in Newfoundland (Peatland Development, Department of Fisheries, Forestry and Agriculture). In 2020, 17 companies listed peat as a quarry material of interest. Of those, 10 companies quarried peat with a production total of over 15 000 m^3 (A. Grant, personal communication, 2022). Hi-Point Industries Ltd. is currently the largest producer in Newfoundland, with products consisting of horticultural peat moss and oil response products.

A peatland inventory of the Island of Newfoundland was carried out from 1978 to 1983 by Northland Associates Ltd. The purpose of the inventory was not defined but there was considerable interest at the time in peat as a growing medium for agricultural and horticultural products, for landscaping sod, and as a fuel source. Peatland areas were delineated on colour aerial photographs. Information on the type of peat, water content, areal extent, volume and slope were collected. This information was transferred to orthophoto Mylar maps based on three scales: 1:50 000 (1:50k), 1:15 840 (1:15k) and 1:12 500 (1:12k). Most of the sheets were produced at the 1:15k scale.

In the late 1980s, the Mylar maps were transferred to the Geological Survey of Newfoundland and Labrador. From 2010 to 2015, the maps were scanned, georeferenced, clipped, processed and compiled into an ArcGIS raster catalogue. Select scanned maps from the Humber River Basin were digitized with ancillary data including the peatland type, area, volume, depth, percent water, pool pattern and slope and aspect. This vector dataset is in ESRI shapefile format, along with a colour map and report.

Due to renewed interest in the national peatlands database by the Canadian Wildlife Service's Wetlands Inventory and other groups, scanned peatland maps from Geological Survey's archival collection were made available on the Geoscience Atlas in 2022 (Figure 4). At present, this compilation consists of the Peatland Map catalogue as well as an associated help file describing the inventory methods and legend information, a downloadable ZIP archive containing the Humber River Basin data (shapefiles), and links to the Northland reports from 1978 to 1983.

If the Geological Survey continues to receive interest in this dataset, efforts may be made to provide the Peatland Maps of Newfoundland collection as vector data.

DATA READINESS FOR NEW EXPLORATION TECHNOLOGIES

Newfoundland and Labrador is a highly competitive jurisdiction for mineral resource development, despite challenges such as poor bedrock exposure, a relatively short field season and a lack of access in remote areas. Recent advancements in machine-assisted data analysis, such as predictive mapping and deposit modelling, may alleviate some of these challenges. However, incomplete data coverage, legacy metadata and complex data-sharing portals can hinder the application of emerging technologies for mineral exploration and discovery in the future. These challenges are not singular to this Province; a framework for geoscience data enhancement across Canada has recently been put forward by the National Geological Surveys Committee of Canada (NGSC) Pan-Canadian Geoscience Strategy (NGSC, 2022).

In early 2022, Novacene AI Corp. (Toronto, ON), in partnership with NCD Consulting Limited (Paradise, NL) completed a review of GSNL data and data portals for the application of advanced analytics in mineral exploration. The project team evaluated the current status and provided preliminary recommendations across three interrelated topics: 1) the suitability of GSNL geoscience data for the application of advanced data analytics (AI) for mineral exploration and predictive mapping (*i.e.*, data readiness assessment); 2) the suitability of GSNL metadata for the same,

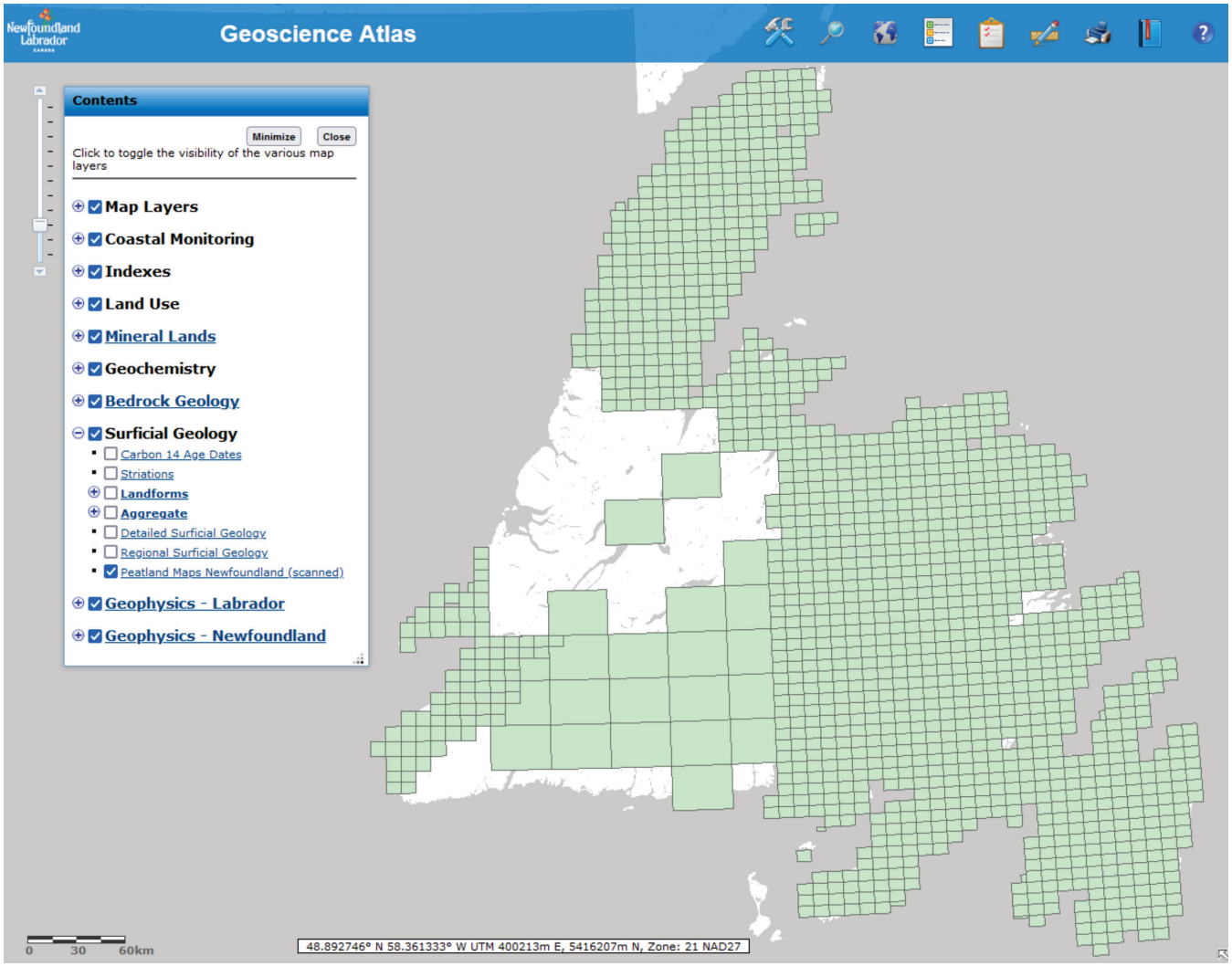

Figure 4. *Footprints of the scanned peatland maps comprising the new Peatland Maps of Newfoundland hosted on the Geoscience Atlas. Map outlines are replaced by scanned map images at the three largest zoom levels.*

with a focus on machine readability and compliance with accepted international standards; and 3) the efficacy of data delivery through our primary portal (the Atlas) using the FAIR guiding principles for data (Wilkinson *et al.*, 2016; *e.g.*, Findable, Accessible, Interoperable, Reusable).

The scope of the assessment was necessarily limited as the first effort of its kind; a comprehensive review of data readiness for all advanced analytics techniques employed by the geoscience community was not possible within the project timeframe. The team approached the project from the viewpoint of a company using GSNL public geoscience data to generate greenfield gold-exploration targets using techniques such as prospectivity modelling. It should be noted that targets were not generated from this effort. To this end, only a subset of GSNL datasets relevant to this exercise were reviewed. These layers comprised surficial geology, bedrock geology, geochemical and geophysical data in both raster (grids or images) and vector (points, lines, polygons) formats. Together, these datasets represent the complete range of data types and formats in the GSNL public data catalog.

The Novacene AI assessment is a valuable resource for continuous improvement to public geoscience data quality and delivery. Key recommendations for clients engaged in advanced analytics with GSNL public geoscience data are presented in the following sections, and current solutions to challenges identified by the project team are discussed where possible.

DATA READINESS

Conversion from the shapefile format downloaded from the Atlas into delimited text files (*e.g.*, CSV) may introduce errors during data ingestion into the machine-learning ecosystem. Specifically, commas in feature attributes may be read in as delimiters if the attribute strings are not parsed correctly during conversion. The GSNL recommends that clients use the preferred software (ESRI ArcGIS) for conversions between shapefile and text formats for point datasets; if this is not possible, the conversion process should be followed by a thorough review of data quality.

The NAD27 datum employed by the Atlas may present a challenge for some clients. We recommend that clients use the NTV2 Transformation Binary Grid Shift File provided by Natural Resources Canada for conversion between the Atlas NAD27 datum and the newer NAD83 datum; the transformation can be downloaded from the Canada Open Government portal.

The concept of "whole data", *i.e.*, purpose-ready datafiles that combine multiple thematic datasets into a single file using a common key value such as location, was presented. This would allow the data scientist to load data into their programming environment more efficiently (Novacene AI Corp, 2022). The GSNL data catalogue uses a variety of spatial geometries that are currently not well suited to whole data delivery; GSNL data are currently optimized for integration with industry-standard GIS systems.

Low-data density in some datasets may be a challenge for machine learning operations. Data skew and, for geochemical data, negative values, zero values, and/or variable detection limits, can be similarly problematic for data modelling. The GSNL recommends that clients perform data preconditioning to optimize data for their preferred analytical routines. The ability to offer different representations of below-detection-limits value, negative values and zeroes for geochemical data could add value for our clients.

'No data' values in GSNL geospatial datasets are represented by a NULL value that may produce errors in data ingestion and modelling. A suitable global NULL replacement value was not determined. Instead, the project team recommended that domain experts should carefully consider the impacts of NULL replacement on model performance before defining a replacement value.

METADATA

The GSNL metadata should comply with current industry standards. The project team recommend adding JSON-compliant metadata in addition to updated XML standards. Rich metadata should be easily-accessible and non-embedded. Furthermore, recommendations for data and metadata standardization from future developments of the Pan-Canadian Geoscience Strategy (NGSC, 2022) should also be considered.

DATA DELIVERY

Novacene AI recommended that any new GSNL applications and data portals be designed to be compliant with all modern browsers, be mobile-responsive and conform to the Web Content Accessibility Guidelines (W3C, 2022). They also recommended that the GSNL offer additional training sessions to review our current data catalog and Geoscience Atlas functionality. In-person training sessions have been offered previously, but these activities were necessarily curtailed since the beginning of the Covid-19 pandemic.

The project team suggested improving the search experience by, for example, developing a global search utility for GSNL datasets that would allow the user to perform queries across multiple data layers and conduct full-text searches. For accessibility, they recommended adding application programming interface (API) services and access control framework for GSNL data integration with client applications. Interoperability could be improved by providing data in non-proprietary formats such as text files (CSV, TXT) or GeoJSON to encourage broader use by clients employing advanced analytics outside of industry-standard GIS environments.

PLANNED ENHANCEMENTS IN 2023

The current Atlas interface, developed to leverage the ESRI ArcGIS Server technology, was launched in March of 2014. As this is an invaluable tool in its current configuration, the GSNL is committed to ensuring that data delivery is aligned with the requirements of the current and future exploration industry, and other clients. Efforts to develop and implement a modernized version of the Atlas that leverage the ESRI cloud-based platform, ArcGIS Online, are ongoing in 2023. In this new format, clients will access the full geoscience data catalog on their browser or through their desktop GIS, add their own data to the web interface, or access thematic information through custom web apps designed to deliver answers to our most common client requests quickly.

Two new layers are presently being compiled for release in 2023: a *Drill Hole* database, containing the location and ancillary information for all drillholes, starting from the most recent exploration company assessment reports (including compiled datasets), and a *Lithogeochemical* database, consisting of a compilation of reputable lithogeochemical analy-

ses from GSNL research as well as exploration company assessment reports. The latter will focus first on the most recent digital data (including compiled datasets) due to more complete data documentation.

The *Drill Hole* database will be included in the *Map Layers* group and the *Lithogeochemical* database will be included in the *Geochemistry* Group. The *Plutonic Rock Geochemistry* and *Volcanic Rock Geochemistry* layers will be removed from the *Geochemistry Group* once they are incorporated into the more comprehensive *Lithogeochemical* database. This new layer will provide more efficient access to a comprehensive catalog of litho-geochemical data, particularly for clients who use advanced analytical methods.

ACKNOWLEDGMENTS

The authors thank the project team at Novacene AI Corp. (Marcelo Bursztein and Hengameh Hajipour) and NCD Consulting, Ltd. (Brad Dyke) for their insight into the application of advanced analytics to geoscience data. Dorothea Hanchar is thanked for a helpful review of this manuscript.

REFERENCES

Amesbury, M.J., Gallego-Sala, A., Loisel, J.
2019: Peatlands as prolific carbon sinks. Nature Geoscience, Volume 12, pages 880-881. doi.org/10.1038/s41561-019-0455-y

Department of Fisheries, Forestry and Agriculture
2023: Peatland Development, Agrifoods Land Use Program, accessed 9 January, 2023, https://www.gov.nl.ca/ffa/faa/agrifoods/land/land-use/peatland/

Honarvar, P., Nolan, L.W., Crisby-Whittle, L., Roberts, G. and Duquet, S.
2015: The New Geoscience Atlas. *In* Current Research. Government of Newfoundland and Labrador, Department of Natural Resources, Geological Survey, Report 15-1, pages 287-294.

Honarvar, P., Taylor, D. and Roberts, G.
2022: The Geoscience Atlas: Optimization and updates. *In* Current Research. Government of Newfoundland and Labrador, Department of Industry, Energy and Technology, Geological Survey, Report 22-1, pages 203-209.

Leifeld, J. and Menichetti, L.
2018: The underappreciated potential of peatlands in global climate change mitigation strategies. Nature Communications, Volume 9, Article number 1071. doi.org/10.1038/s41467-018-03406-6

National Geological Surveys Committee of Canada (NGSC)
2022: Pan-Canadian Geoscience Strategy: Enhancing geoscience data, knowledge and access for a stronger future. Natural Resources Canada, General Information Product 131e, 24 pages. doi.org/10.4095/329347

Novacene AI Corp.
2022: AI readiness assessment: Geological Survey of Newfoundland and Labrador. Report, 70 pages.

Mineral Lands Division
2006: Quarry Materials Act, SNL1998 Chapter Q-1.1. Government of Newfoundland and Labrador, Department of Natural Resources, Mineral Lands Division. www.assembly.nl.ca/Legislation/sr/statutes/Q01-1.htm

W3C World Wide Web Consortium
2022: "Web Content Accessibility Guidelines 2.2," W3C World Wide Web Consortium Recommendation. Last update: 06 September, 2022 (retrieved January, 2023). www.w3.org/TR/WCAG20/

Wilkinson, M.D., Dumontier, M., Aalbersberg, I.J., Appleton, G., Axton, M. (+ 48 authors)
2016: Comment: The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data, Volume 3, Article 160018. doi.org/10.1038/sdata.2016.18

Yu, Z., Loisel, J., Brosseau, D.P. and Beilman, D.W.
2010: Global peatland dynamics since the last glacial maximum. Geophysical Research Letters, Volume 37, Article L13402. doi.org/10.1029/2010GL043584