DIGITAL MAPPING TECHNIQUES 2019

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(May 19 – 22, 2019 - Montana Technological University)

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2019)

http://ngmdb.usgs.gov/info/dmt/

Digital Geological Mapping: from the Field to Interoperable Geospatial Web Services

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Different classification systems and terminology are commonly used to capture geology and mineral occurrence data, causing difficulties in data sharing, data exchange, and data integration. At the British Columbia Geological Survey (BCGS), we carry out field-based digital geological mapping and integrate data not only from our mapping projects, but also from other groups such as the Geological Survey of Canada and universities. Inconsistent and incompatible geological data will prevent advanced computation including machine learning based on data from multiple jurisdictions. To address these issues, the International Union of Geological Sciences (IUGS), through its sub-committee Commission for the Management and Application of Geoscience Information (CGI), developed international geoscience standard Geoscience Markup Language (GeoSciML) and adopted vocabularies to describe bedrock geology.

The BCGS is in the process of reviewing and implementing the international geoscience standard to deliver geoscience data via interoperable geospatial web services. As a first step, we transformed our province-wide bedrock geology to be compliant to the 'Lite' model of the standard, and matched our bedrock geology classification and terminology to the vocabularies adopted by IUGS/CGI. These data are available as OGC Web Map Service (WMS) and Web Feature Service (WFS), accessible through OneGeology, the portal for worldwide geoscience data. From our limited experience, we recognized that significant effort and time are required to make our data fully compliant to the GeoSciML models and the CGI vocabularies. Some of our data lack certain features set out in the international geoscience standards. Similarly, the simplified 'Lite' models and CGI vocabularies lack terminology to adequately represent all our data. While WMS is useful, WFS and WCS require significant technical capability on the client side to build sophisticated information systems to benefit. There are many challenges to exchanging data at the feature or coverage levels, including impediments in web-based authentication. Currently the OneGeology Portal is rudimentary in functionality and performance. Most geological maps available on OneGeology are at scales of 1:1 million or smaller, which are of limited use to most applications for the mineral exploration and mining industry.

At the BCGS, our geological mapping has evolved from traditional map compilation for cartographic representation (e.g., as hardcopy maps or in PDF format), to digital geology that is ready for spatial and non-spatial analyses (Figure 1). We define 'digital geology' as: 1) the authoritative data source for deriving map products, 2) containing all available details (e.g., from 1:20,000 to 1:250,000), 3) seamless digital coverage and updatable, and 4) consistent nomenclature and encoding to support computations. At the core of this evolution is the implementation of the Geospatial Frame Data (GFD) model, a data 'checkout' process and 'anchoring' mechanism to 1) simplify the capture, compilation and integration of digital geology, and 2) manage digital mapping's lifecycle from field to corporate GFD database. To have consistent and GeoSciML compliant data, we are expanding data capture in the field and have designed a simplified graphic user interface to efficiently enter essential data on digital devices, followed by consistent encoding of lithology, event process and environment, and a new scheme for bedrock unit labels in map compilation.

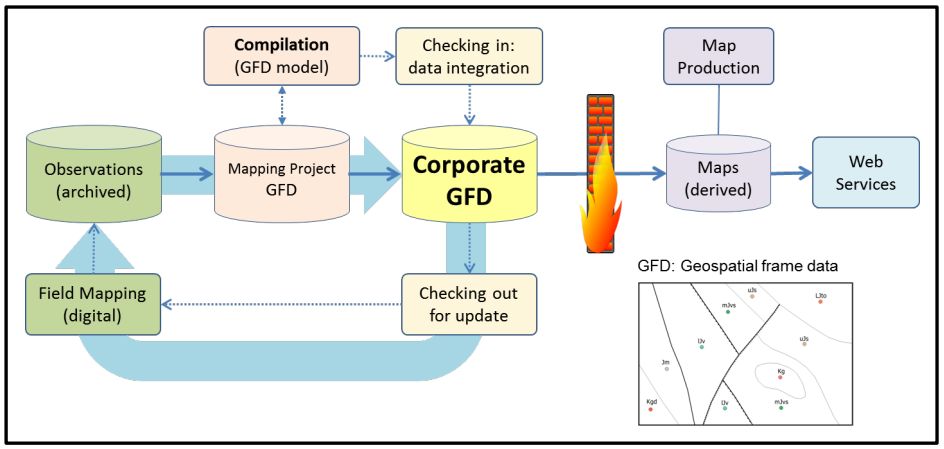


Figure 1. Lifecycle of digital mapping and treatment of digital geology and derived geological maps.

To support our clients in the mineral exploration and land use management sectors, the BCGS will continue to provide digital geology as data download (including in the new open data format GeoPackage, more details at https://www.geopackage.org) and make it available on MapPlace 2, our geospatial web services. MapPlace 2 not only allows visualization, but also has advanced spatial and non-spatial functions for query and analysis of province-wide bedrock geology in the context of other geoscience, mineral titles, land ownership, natural resource and topographic base maps (Figure 2). MapPlace 2 is available as a desktop application, and has versions for tablet and mobile devices as well. The application database system behind MapPlace 2 makes extensive use of Foreign Data Wrapper to integrate data sourced from various external databases such as Oracle, SQL Server, and PostgreSQL/PostGIS that are maintained by other government agencies.

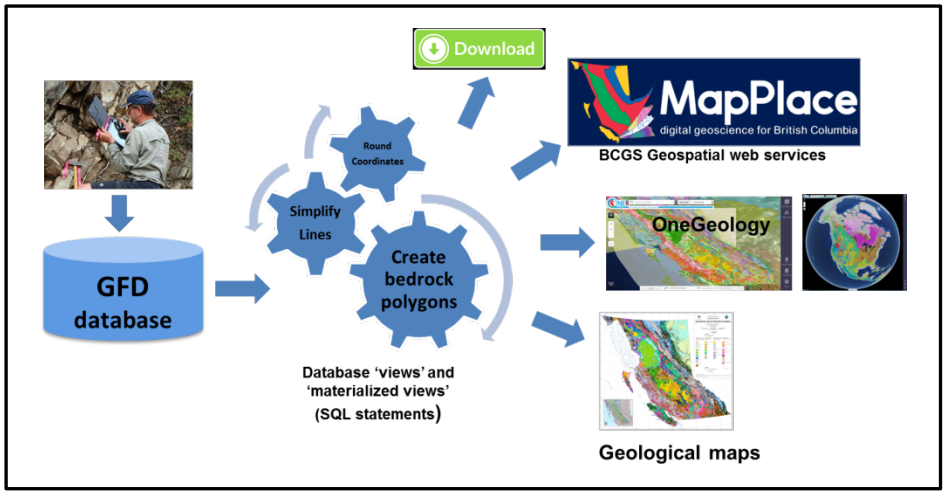


Figure 2. High level view from field survey, map compilation, to geospatial web services.

The British Columbia Geological Survey follows closely the progress in the international geoscience standard and the Deep-Time Digital Earth program. We take these developments as opportunities to update our data models and specifications in digital geology to produce consistent data. We also encourage others to adopt our GFD model, data checkout process, and anchoring mechanism, to not only simplify map compilation data integration of digital geology, but also to resolve data boundaries crossing jurisdictional borders, to eventually enable interoperability in data sharing and data exchange.

Digital Geological Mapping
from the field to interoperable geospatial web services

Yao Cui, P.Geo.
British Columbia Geological Survey

Digital Mapping Techniques Workshop
Butte, Montana
May 19-22, 2019

Geological **maps**

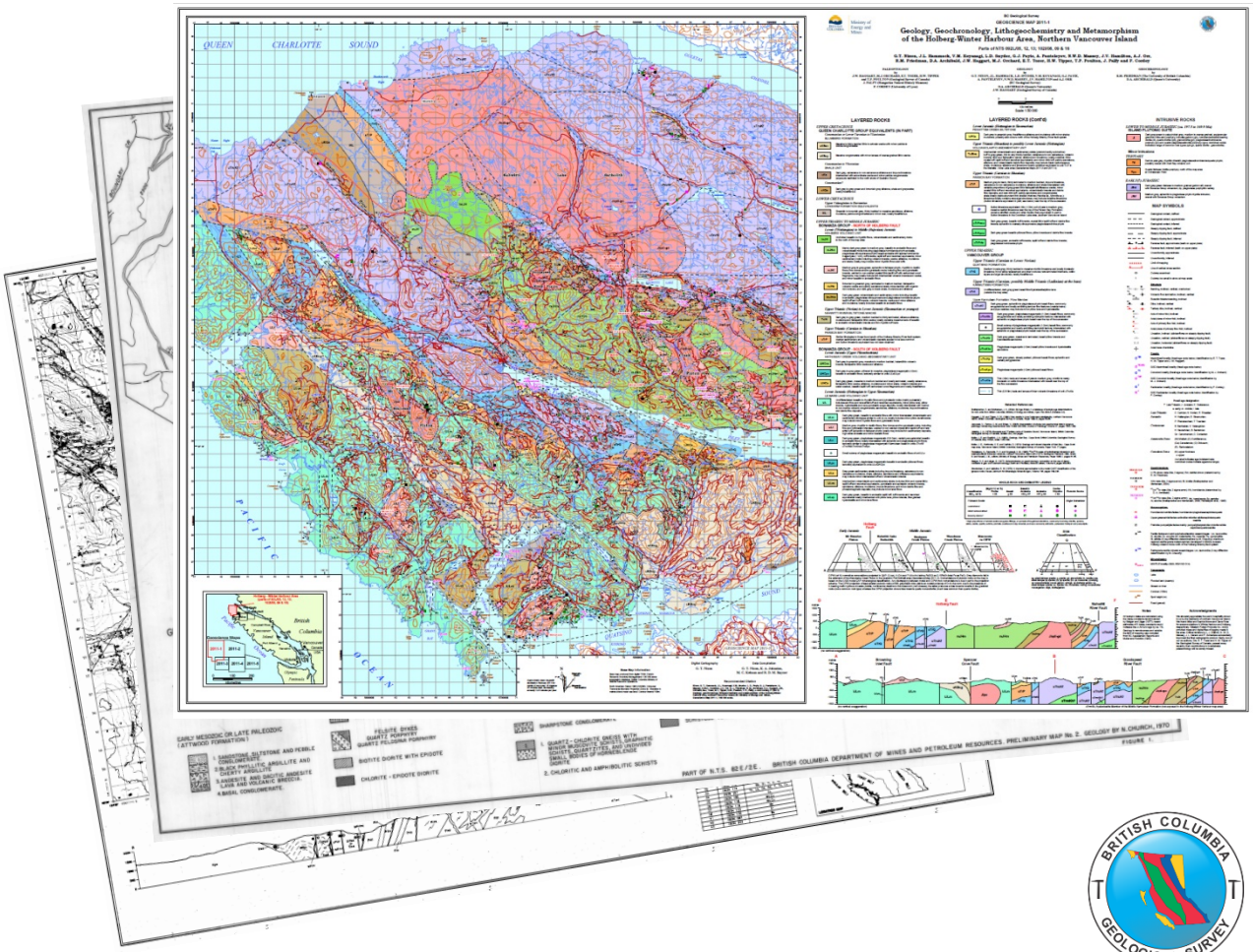
Cartographic representation of bedrock geology as **maps**

Colours
Symbols

- title
- authors (entire map)
- legend
- coordinate system
- scale bar
- cross section
- references of data sources
- northern arrow

Maps can be in digital media (e.g., PDF, DWG)

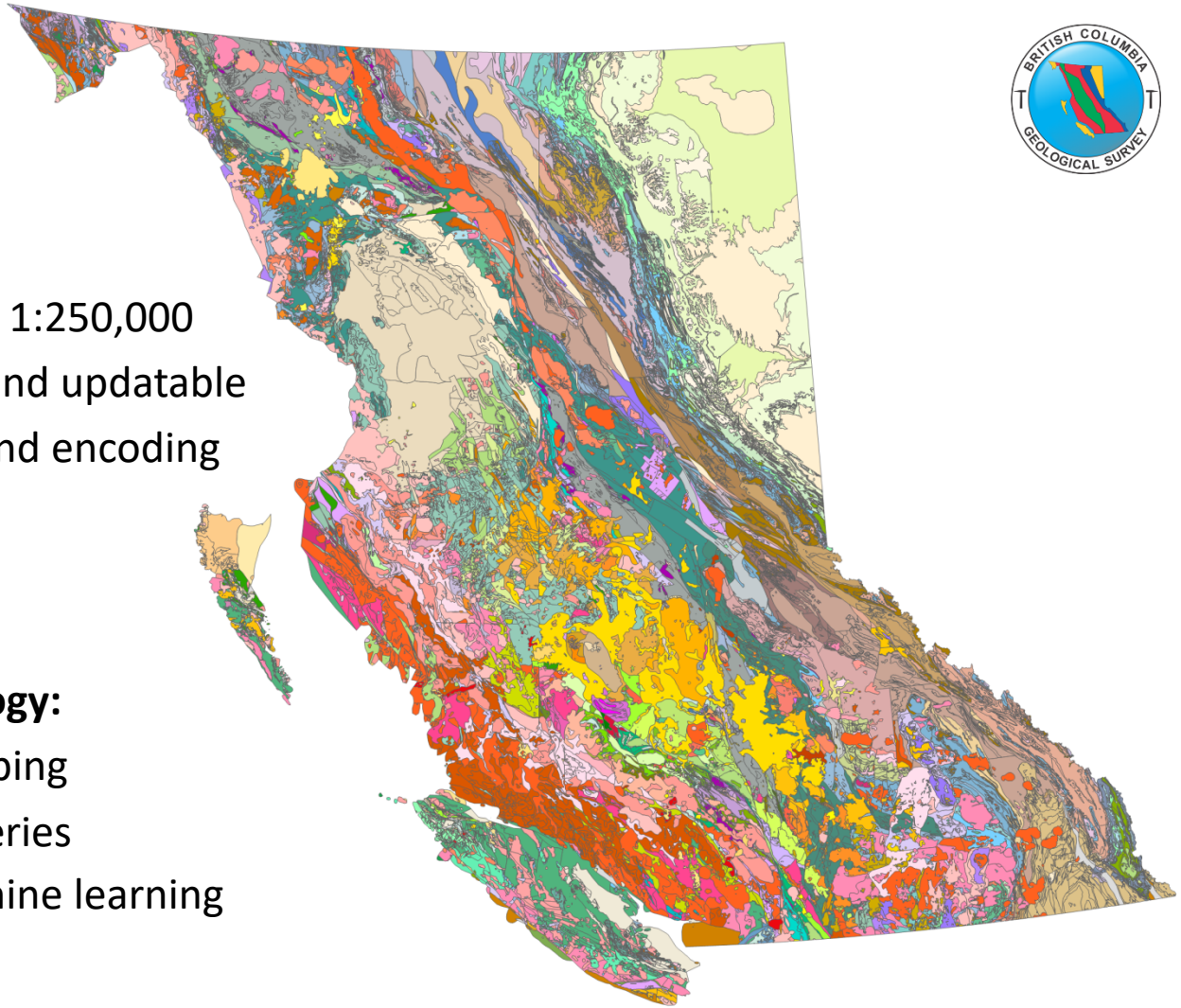
Contents may not be digitally interoperable.



British Columbia

Digital Geology

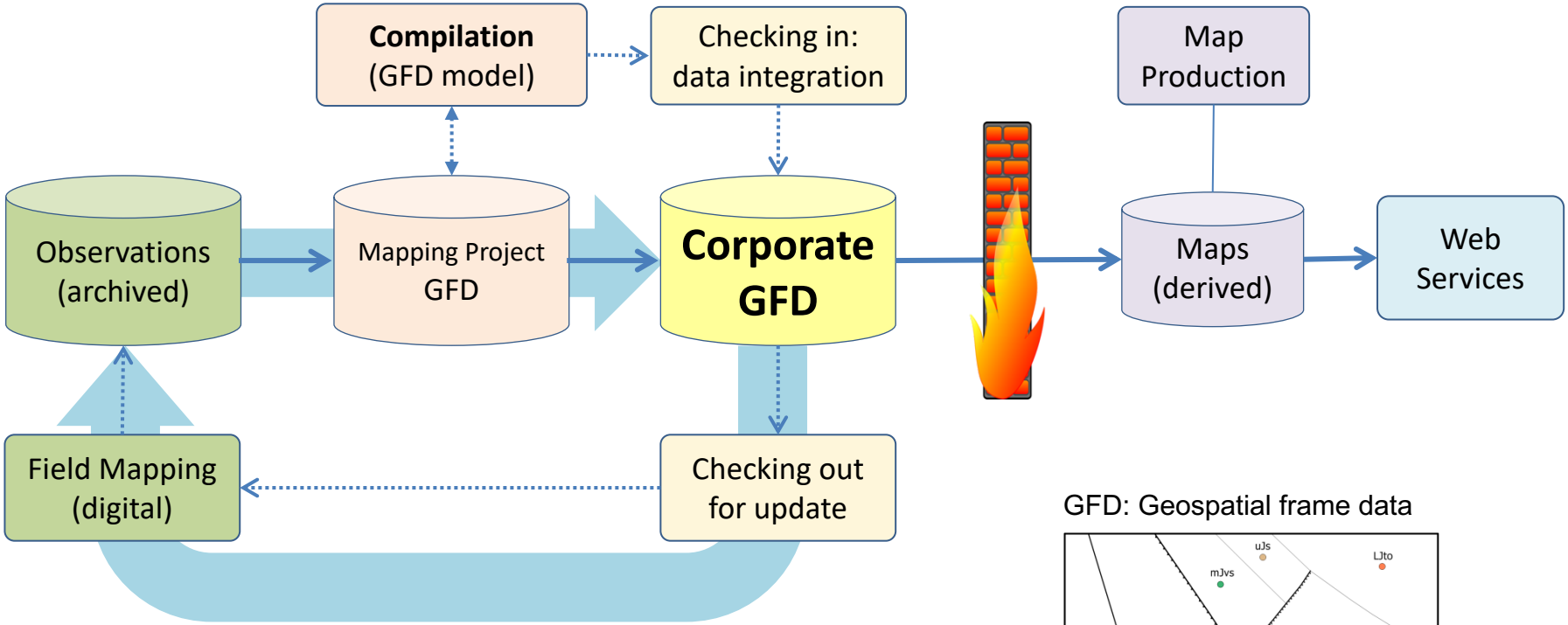
- authoritative data source
- all details from 1:50,000 to 1:250,000
- seamless digital coverage and updatable
- consistent nomenclature and encoding to support **computation**



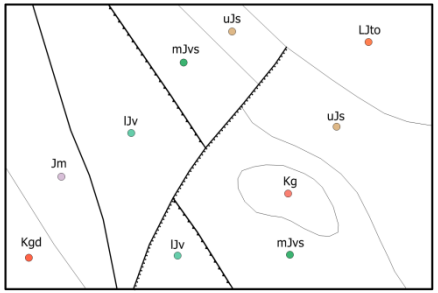
Why do we need digital geology:

- mineral prospectivity mapping
- spatial and non-spatial queries
- GeoSciML to support machine learning

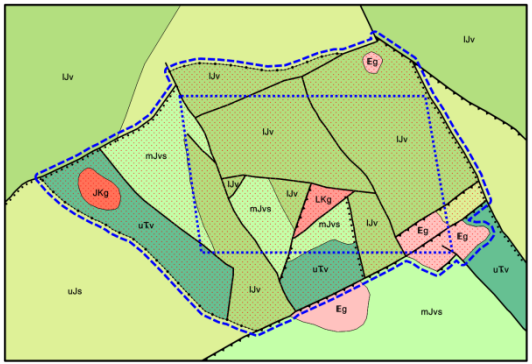
Lifecycle of geospatial data



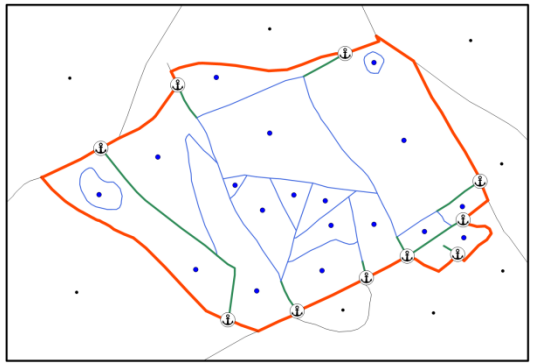
GFD: Geospatial frame data



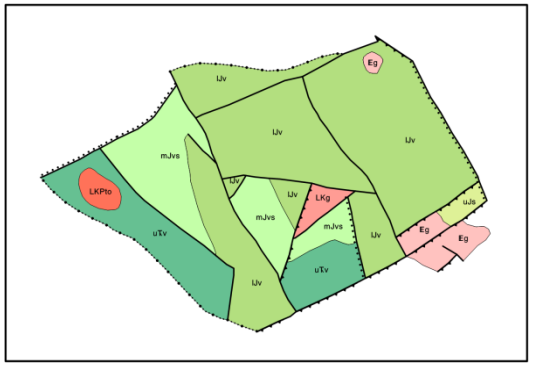
GFD checking out and checking in to update and integrate



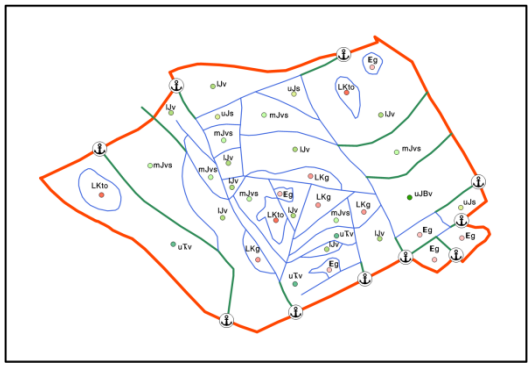
1) Data selection: extended to include entire units



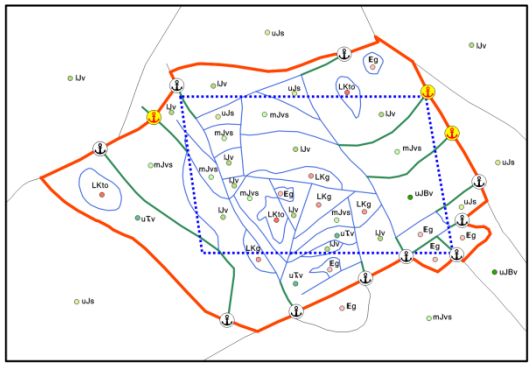
2) Anchoring: guarded boundaries and intersections



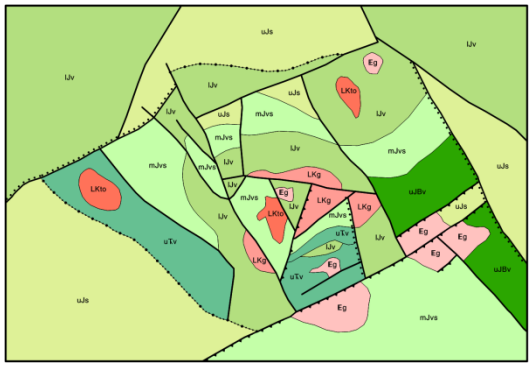
3) Checked out: complete package ready for field mapping



4) Updated project GFD from field mapping and compilation



5) Check in and update corporate GFD



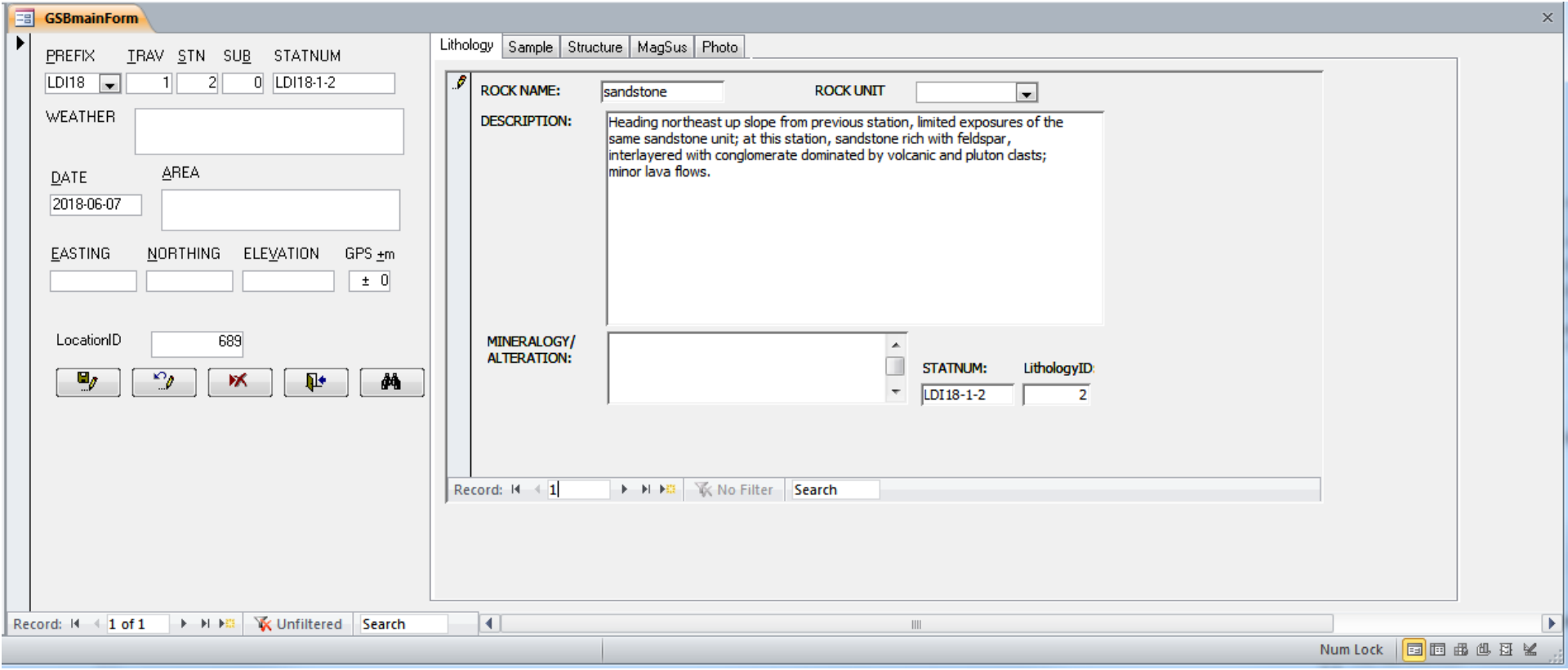
6) Derived geological map

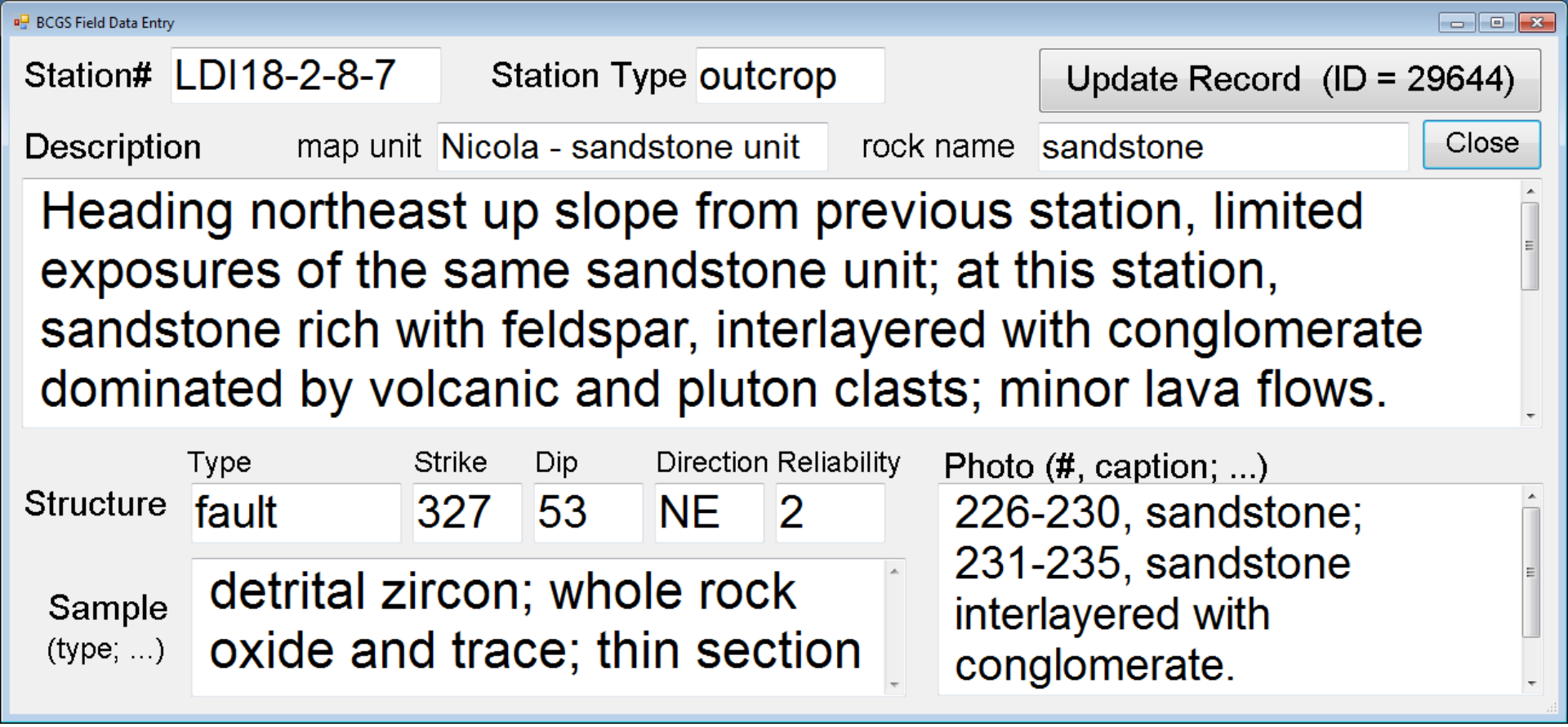
Field mapping

Digital data captured to observation database

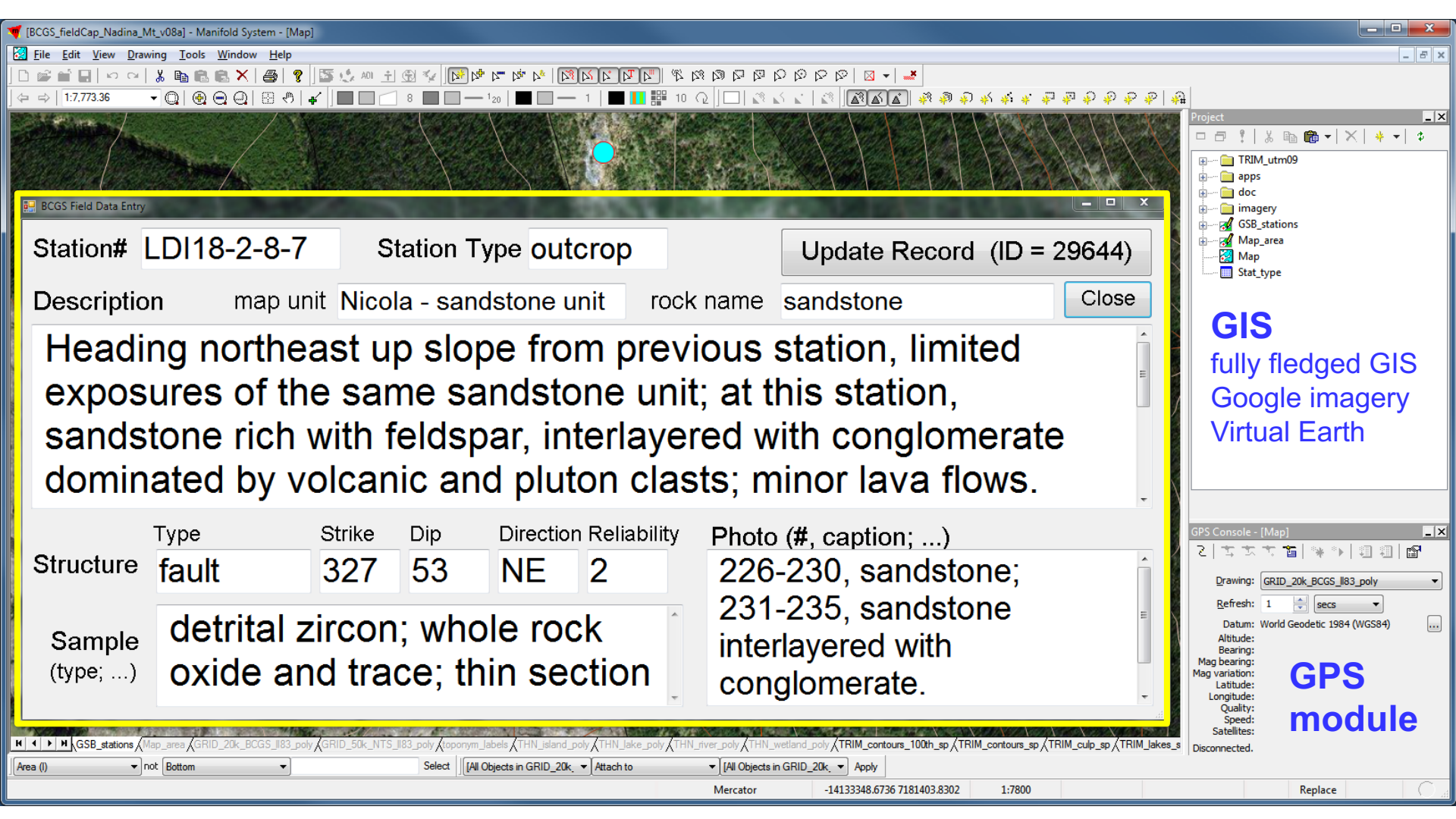
- outcrop descriptions
- structural measurements
- samples: hand specimen, age dating, assay, fossils
- alternation and mineralization
- magnetic susceptibility
- photos

Inexpensive tablets
Inexpensive software


GSBmainForm
PREFIX
TRAV
STN
SUB
STATNUM
LDI18
1
2
0
LDI18-1-2
WEATHER
DATE
2018-06-07
AREA
EASTING
NORTHING
ELEVATION
GPS ±m
± 0
LocationID
689
Lithology
Sample
Structure
MagSus
Photo
ROCK NAME:
sandstone
ROCK UNIT
DESCRIPTION:
Heading northeast up slope from previous station, limited exposures of the same sandstone unit; at this station, sandstone rich with feldspar, interlayered with conglomerate dominated by volcanic and pluton clasts; minor lava flows.
MINERALOGY/ ALTERATION:
STATNUM:
LithologyID
LDI18-1-2
2
Record:
1
No Filter
Search
Record:
1 of 1
Unfiltered
Search
Num Lock



- Quick data entry, extra-large font to read, semi-colon to parse entries
- Local map unit and rock name (field interpretation) to style stations


[BCGS_fieldCap_Nadina_Mt_v08a] - Manifold System - [Map]
File Edit View Drawing Tools Window Help
BCGS Field Data Entry
Station# LDI18-2-8-7
Station Type outcrop
Update Record (ID = 29644)
Description
map unit Nicola - sandstone unit
rock name sandstone
Close
Heading northeast up slope from previous station, limited exposures of the same sandstone unit; at this station, sandstone rich with feldspar, interlayered with conglomerate dominated by volcanic and pluton clasts; minor lava flows.
Structure
Type
Strike
Dip
Direction
Reliability
fault
327
53
NE
2
Photo (#, caption; ...)
226-230, sandstone;
231-235, sandstone interlayered with conglomerate.
Sample (type; ...)
detrital zircon; whole rock oxide and trace; thin section
Project
TRIM_utm09
apps
doc
imagery
GSB_stations
Map_area
Map
Stat_type
GIS
fully fledged GIS
Google imagery
Virtual Earth
GPS Console - [Map]
Drawing: GRID_20k_BCGS_ll83_poly
Refresh: 1 secs
Datum: World Geodetic 1984 (WGS84)
Altitude:
Bearing:
Mag bearing:
Mag variation:
Latitude:
Longitude:
Quality:
Speed:
Satellites:
Disconnected.
GPS module
GSB_stations Map_area GRID_20k_BCGS_ll83_poly GRID_50k_NTS_ll83_poly toponym_labels THN_island_poly THN_lake_poly THN_river_poly THN_wetland_poly TRIM_contours_100th_sp TRIM_contours_sp TRIM_culp_sp TRIM_lakes_s
Area (I) not Bottom Select [All Objects in GRID_20k_ Attach to [All Objects in GRID_20k_ Apply
Mercator -14133348.6736 7181403.8302 1:7800 Replace

Better way to label bedrock units?
BCGS label format, meaningful and scalable?

1) Bedrock age (Epoch, in uppercase for lithodemic or lithotectonic units) or position (Series, in lowercase for lithostratigraphic units);
2) Group|Suite, Formation|Lithodeme|_*member names*, in uppercase
3) Lithology code, in lowercase
4) Extension code (designative/diagnostic/characteristics), in lowercase, following a dot (.)

uTrVK_*F*vb.tfh ➡ uTrVKvb.tfh ➡ uTrVKvb ➡ TrVv

Upper Triassic Vancouver Group – Karmutsen Formation
– *flow member*; basalt, hyaloclastic flow

Lithologic code and extension code: mapping to GeoSciML / CGI vocabulary

Simplified lithology and code (partial…)

rock_class	rock_subclass	rock_type	rock_code
sedimetary_rock	clastic	clastic	sc
sedimetary_rock	clastic	arenite	sa
sedimetary_rock	chemical	limestone	sl
sedimetary_rock	chemical	dolomite	sd
volcanic_rock	flows	undivided, lava flows	vf
volcanic_rock	pyroclastic	undivided, pyroclastic rocks	vpy
volcanic_rock	compositional	rhyolite or acidic rock	vr
volcanic_rock	compositional	dacite	vd
volcanic_rock	compositional	basalt or basic rock	vb
intrusive_rock	granitic	granite	gg
intrusive_rock	granitic	granodiorite	gd
intrusive_rock	dioritic	diorite	d
intrusive_rock	dioritic	gabbro	dg
intrusive_rock	Alaskan type	pyroxenite	up
metamorphic	contact	skarn / calc-silicate	skm
metamorphic	barrovian	marble	lm
ultramafic	mantle tectonite	peridotites	updm
structural	dynamic	mylonite	my
hydrothermal	dynamic	imbricate zone	imy

Designative/diagnostic/characteristic extension code (partial…)

ext_rock	ext_type	ext_sub_type	ext_character	f_code
sedimentary_rock	conglomerate	distinctive_clasts	chert	.cc
volcanic_rock	pyroclastic	size_classification	lapilli tuff	.pl
volcanic_rock	pyroclastic	resedimented	debris flow / lahar	.pd
volcanic_rock	pyroclastic	flow	ignimbrite/ash-flow tuff	.pi
volcanic_rock	analyzed	composition	calc-alkaline	.aca
volcanic_rock	flow_texture	autoclastic_submarine	hyaloclastite	.tfh
volcanic_rock	flow_texture		amygdaloidal	.tfa
volcanic_rock	flow_structure	submarine	pillows	.tp
volcanic_rock	pyroclastic_texture		welded / eutaxitic	.tw
volcanic_rock	intrusive_texture		megacrystic	.tm
volcanic_rock	intrusive_texture		trachytic	.tt
intrusive_rock	texture		pegmatitic	.tpe
metamorphic_rock	texture		gneissic	.tg
sedimentary_rock	environment	marine	shelf	.emsh
sedimentary_rock	environment	terrestrial	fluviatile	.etf
volcanic_rock	environment	volcanic	subaerial	.evs
tectonic	environment	tectonic	island arc	.etia
sedimentary_rock	diagnotic_feature	cement	calcareous	.dca
	diagnotic	mineral	apatite	.xap
metamorphic_rock	Barrovian (regional)		zeolite facies	.z
metamorphic_rock	Barrovian (regional)	mafic volcanic	greenschist facies	.g
metamorphic_rock	Barrovian (regional)	pelite	amphibolite	.au
metamorphic_rock	mineral		chlorite	.xchl
metamorphic_rock	index mineral-pelite	blueschist faces	lawsonite	.xlws
alteration			serpentinized	.sp

uTrVKvb.tfh

BCGS stratigraphic unit label specification

age::{epoch::uppercaseLetter | **position::**{epoch::lowercaseLetter)} {period | {range}}::uppercaseLetter} | **unitName::**{<<*lithostratigraphic*>> {supergroup {group {formation {*member* {bed}}}}} | lithodemic {complex {supersuite {suite {lithodeme (pluton) { _intrusion {zone | dyke | sill | plug | vent}}}} | composite-genesis {<<metamorphic>> | *cataclastic}*::uppercaseLetter | {<<*and*>> | - | } | {<<*or*>> | / | }} | **lithology::**{<<*rockClass*>> {igneous {intrusive {sub-volcanic} | volcanic { explosive | flow | impact}} | sedimentary {clastic | chemical | biogenic} | metamorphic {dynamic | regional | contact | metasomatic | impact | cataclastic | composite-genesis | hydrothermally altered}} | **rockTypeCode** {composition {non-silicate | silicate {acidic | intermediate | basic | ultramafic}}} | . | **extensionCode** {texture | fabric | alteration | alteration | mineralization | structure | colour | fossil content}}::lowercaseLetter

<<*metaclass*>>

Expressed in extended 'Backus–Naur form' notation (BNF)

Bedrock geology: field mapping to web services

GFD database

Round Coordinates

Simplify Lines

Create bedrock polygons

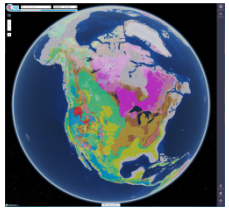
Database ‘views’ and ‘materialized views’ (SQL statements)

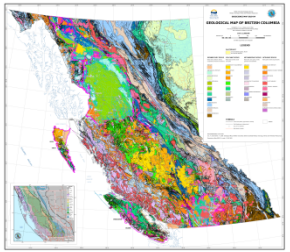
Download

MapPlace digital geoscience for British Columbia

BCGS Geospatial web services

OneGeology



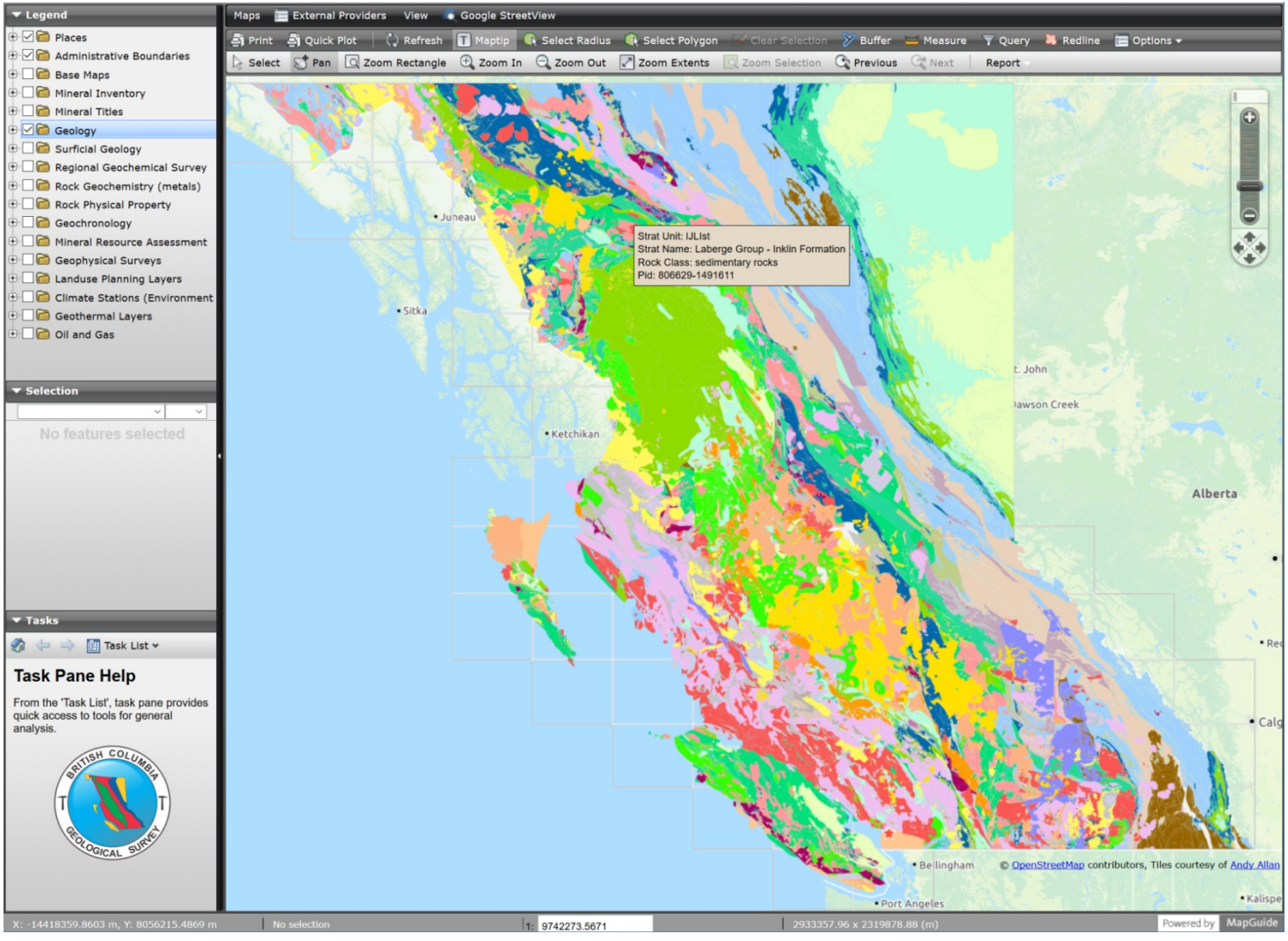


Geological maps

MapPlace 2

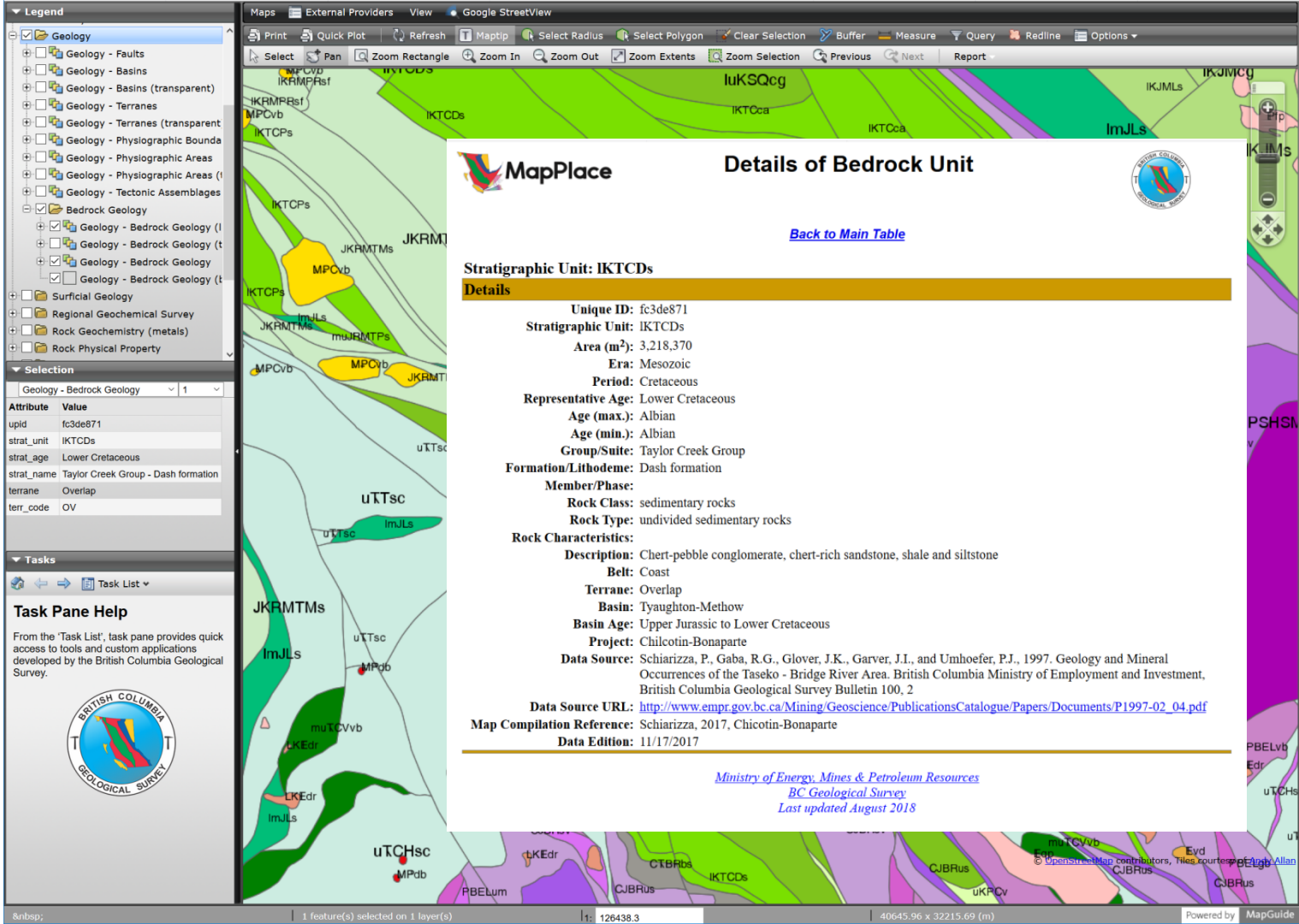
Geospatial web services

Data mining platform to all geoscience and mineral exploration related databases in British Columbia



Bedrock geology
>33,000 units
>110,000 lines

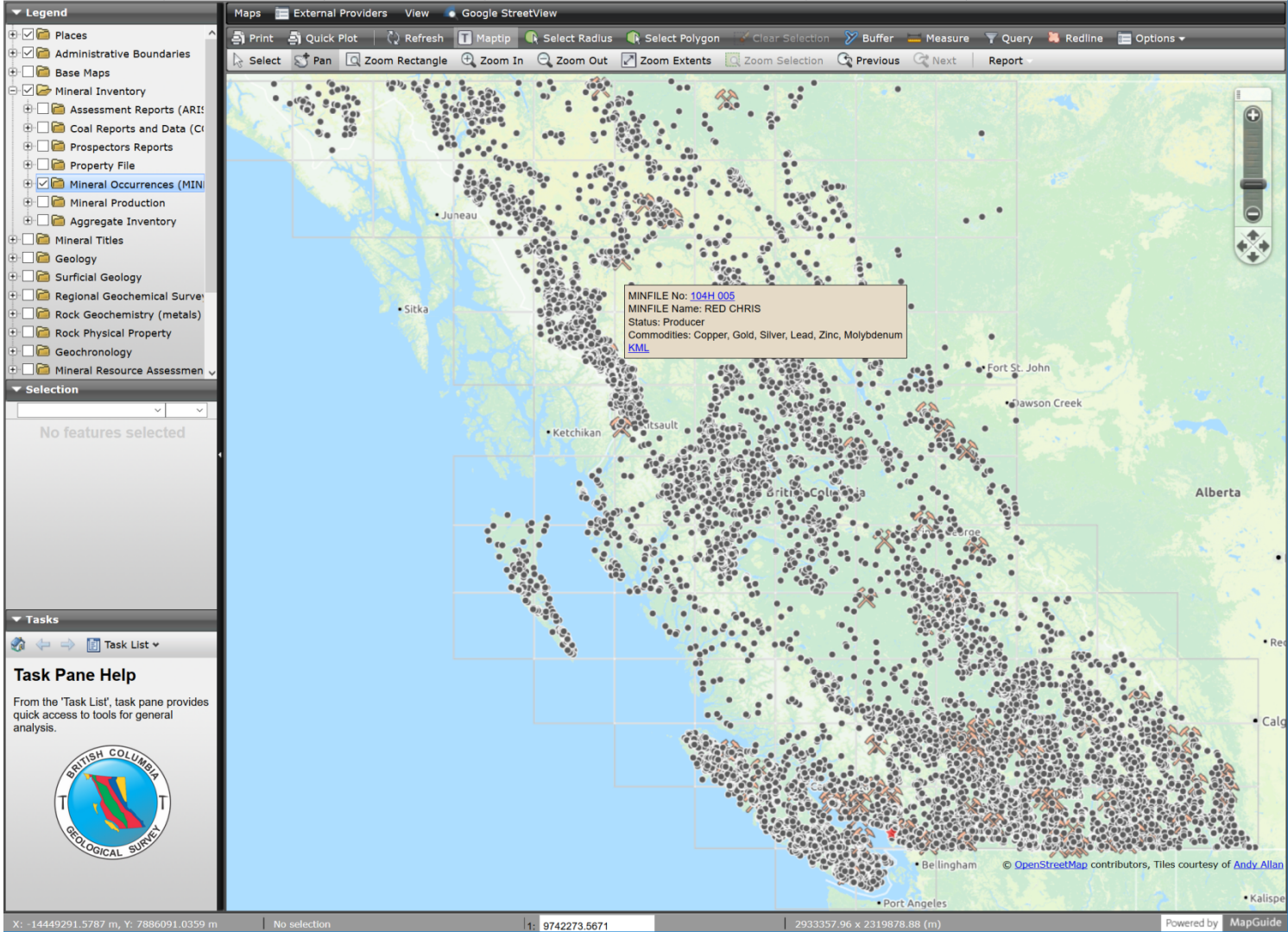
API to details



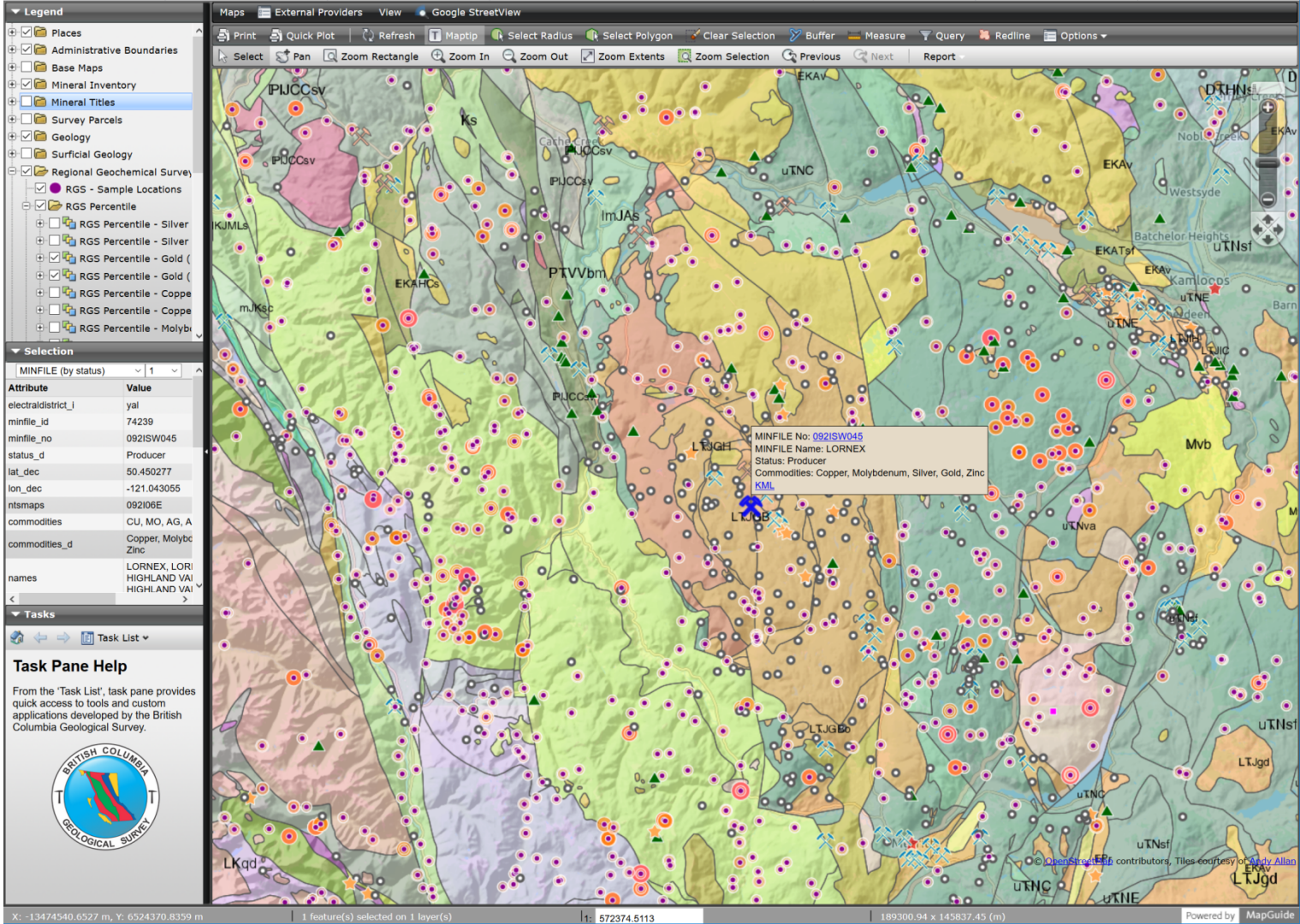
Bedrock geology

Mineral occurrences

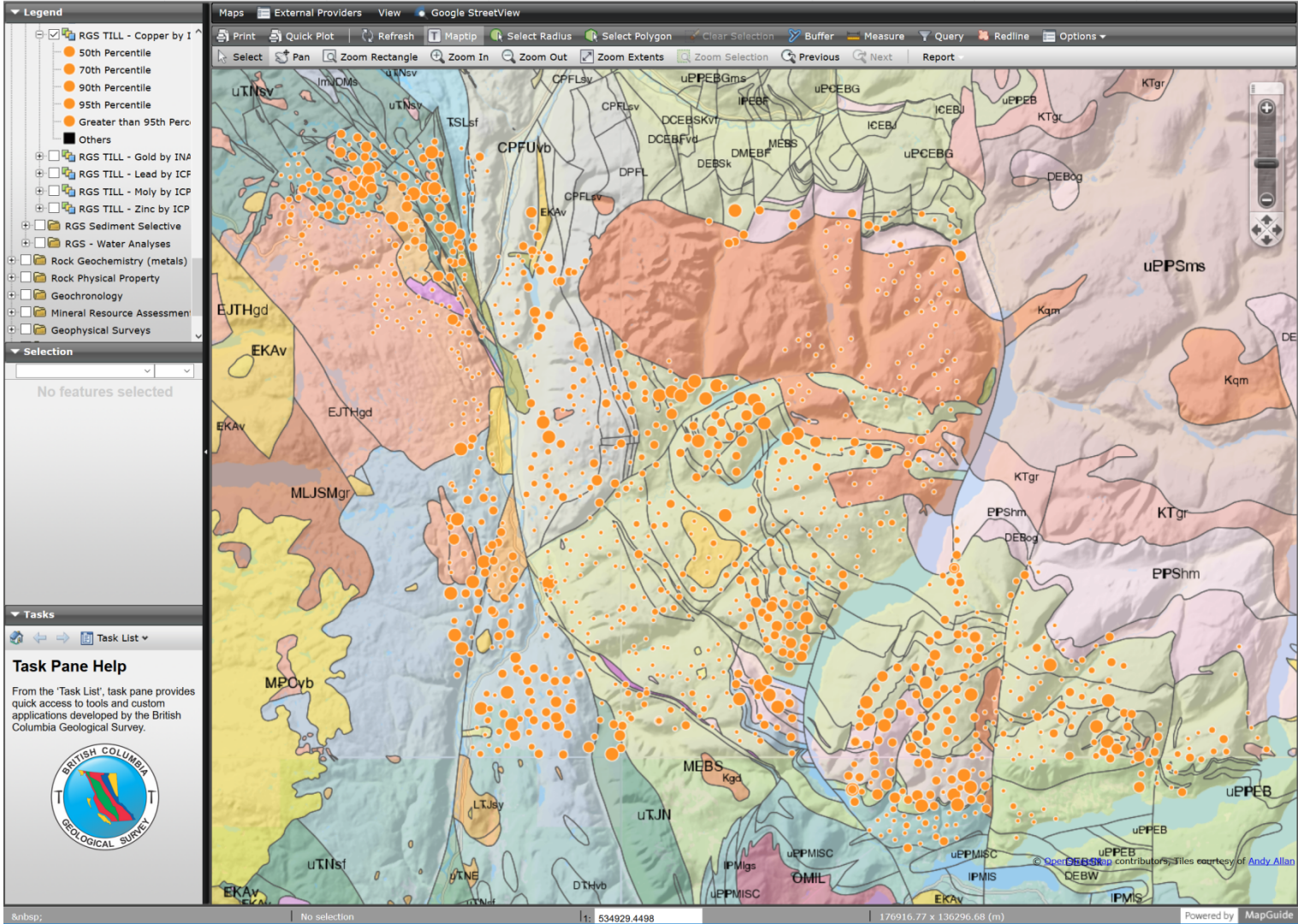
>14,650



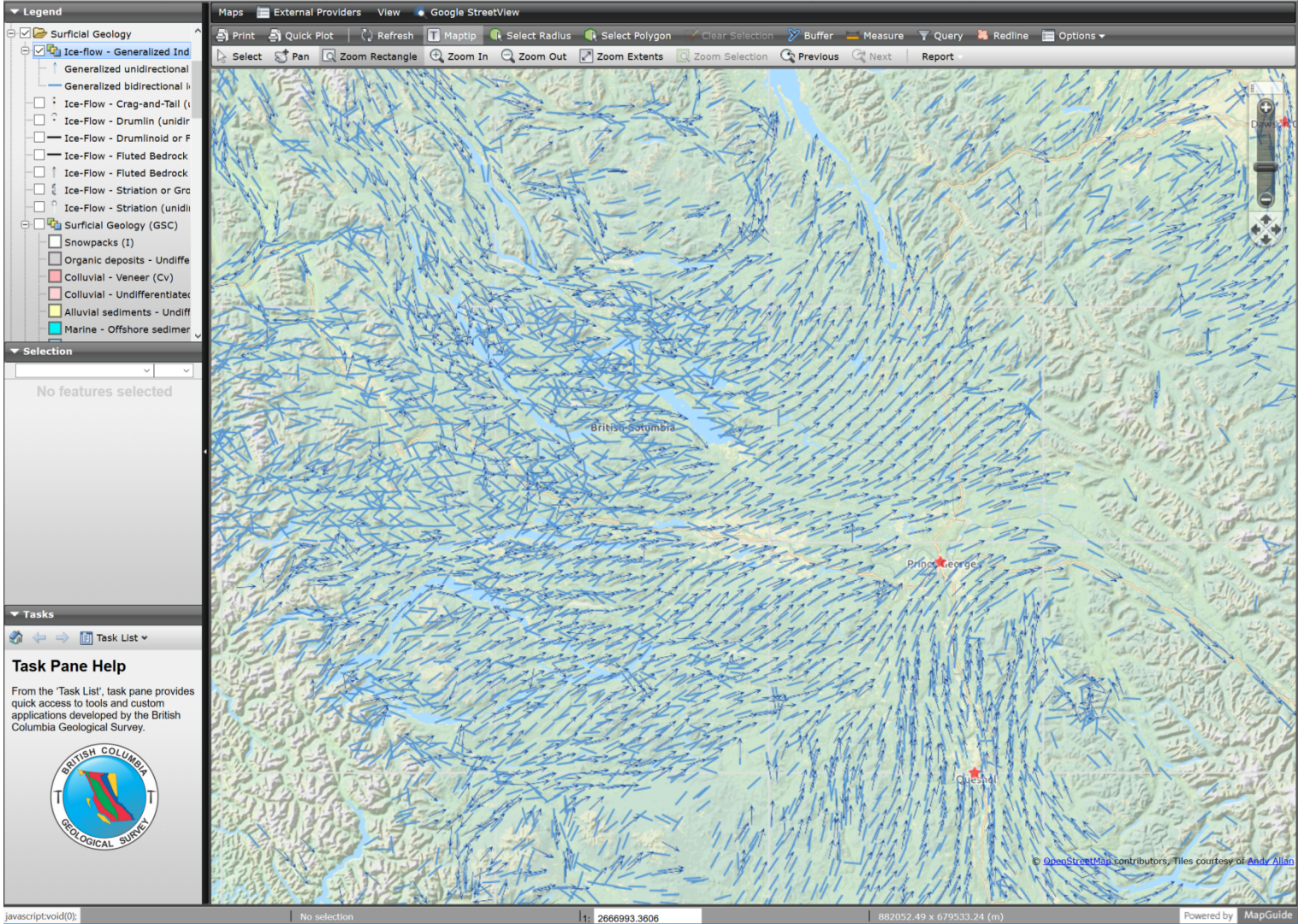
Bedrock geology
Mineral occurrences
Geochemical data
> 60,000 sites



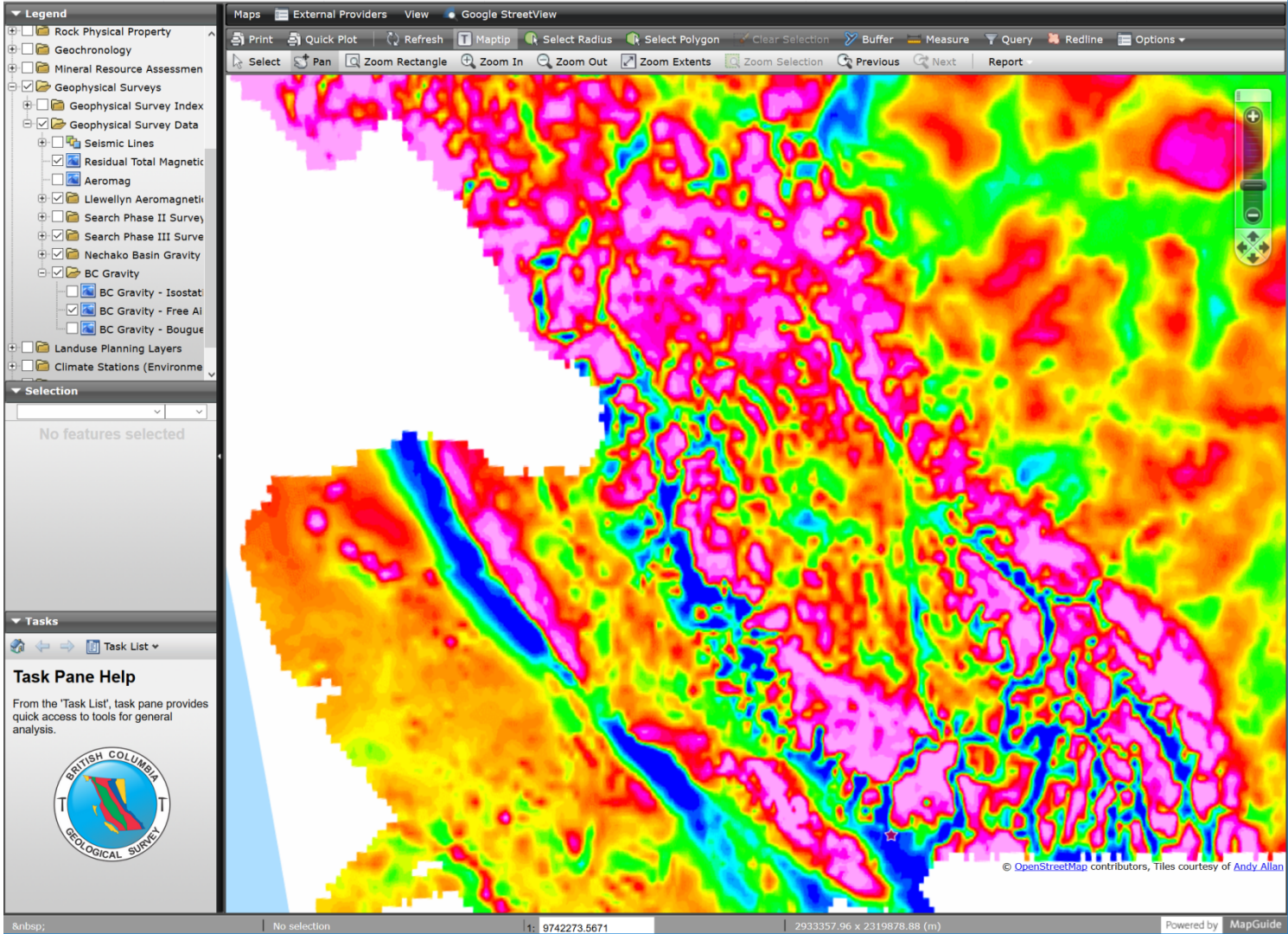
Bedrock geology
Mineral occurrences
Geochemical data
Till geochem
focus areas



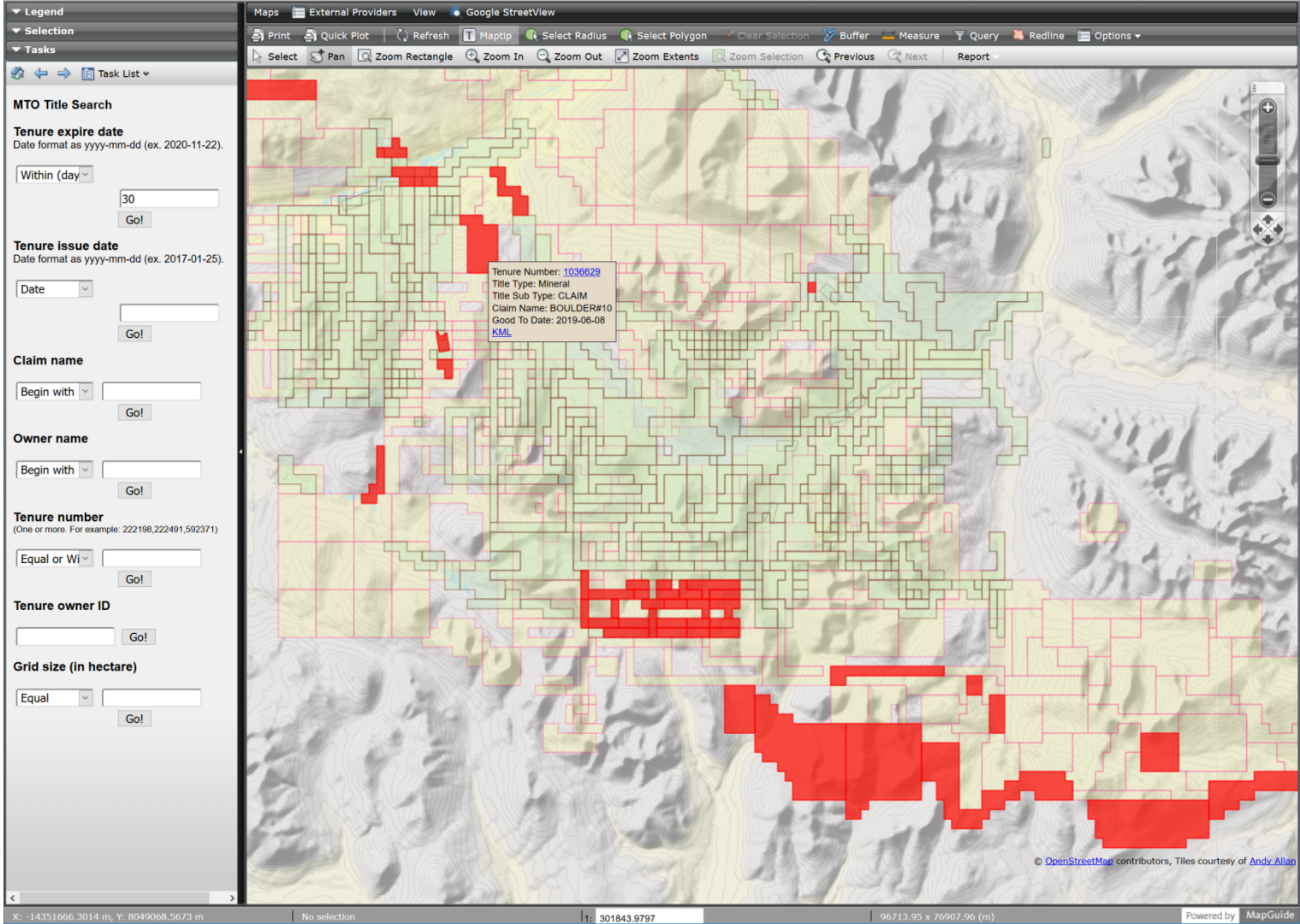
Bedrock geology
Mineral occurrences
Geochemical data
Till geochem
Ice flow indicators
> 130,000



Bedrock geology
Mineral occurrences
Geochemical data
Till geochem
Ice flow indicators
Geophysical surveys

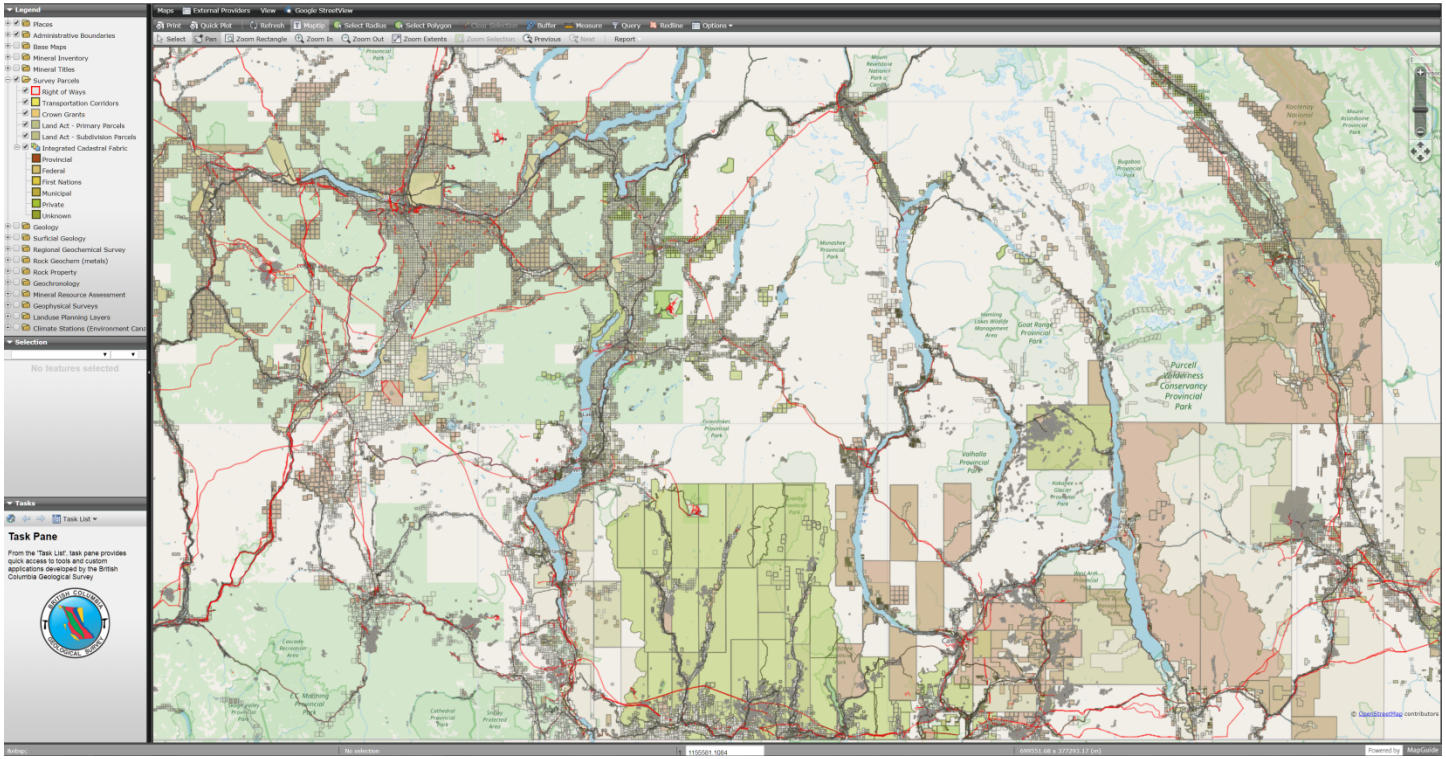


Bedrock geology
Mineral occurrences
Geochemical data
Till geochem
Ice flow indicators
Geophysical surveys
Mineral titles



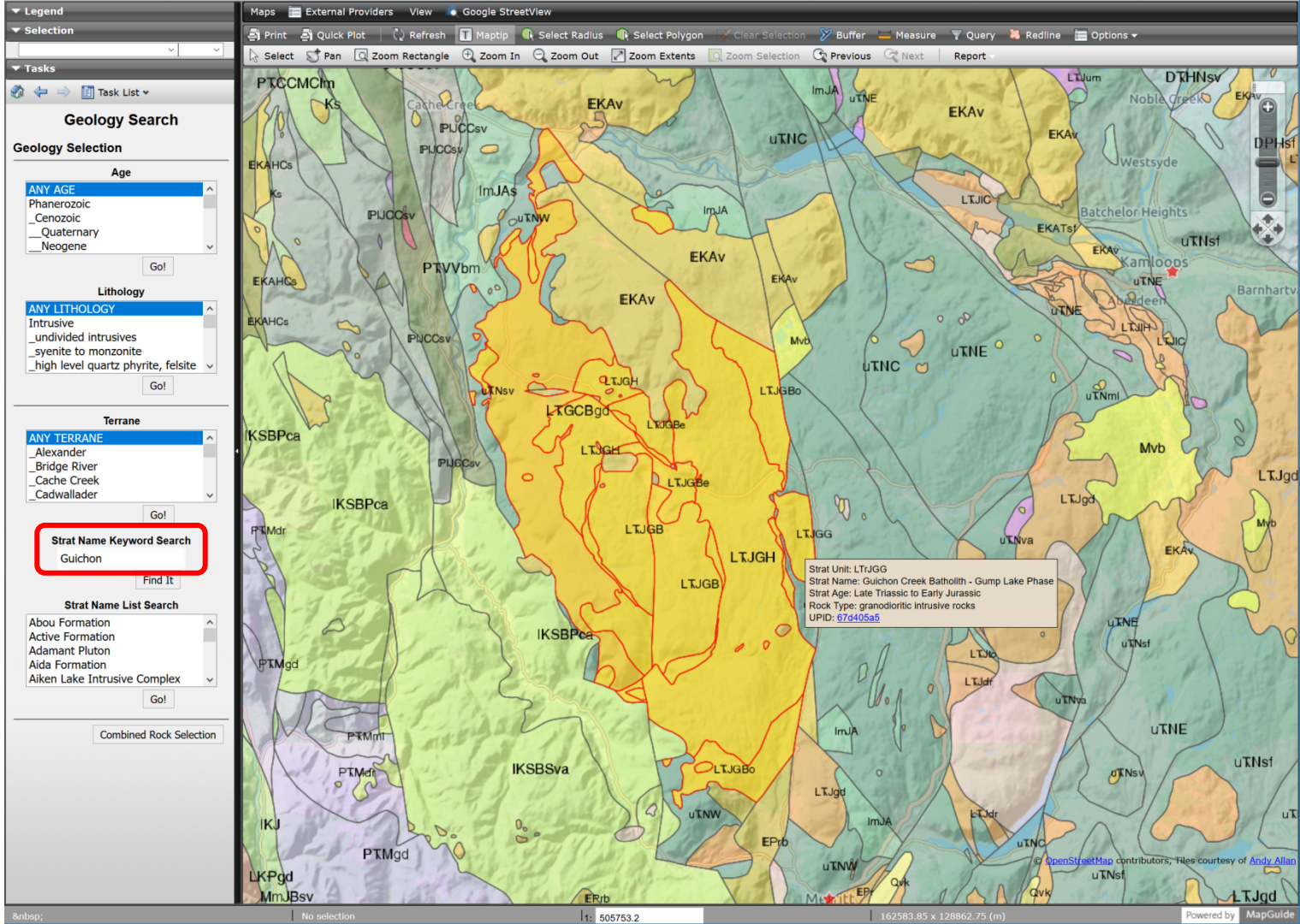
Bedrock geology
Mineral occurrences
Geochemical data
Till geochem
Ice flow indicators
Geophysical surveys
Mineral titles
Land parcels

Tectonic assemblages
Lithogeochem
Rock physical property
Geomorphology
Publications
Mineral resource assessment



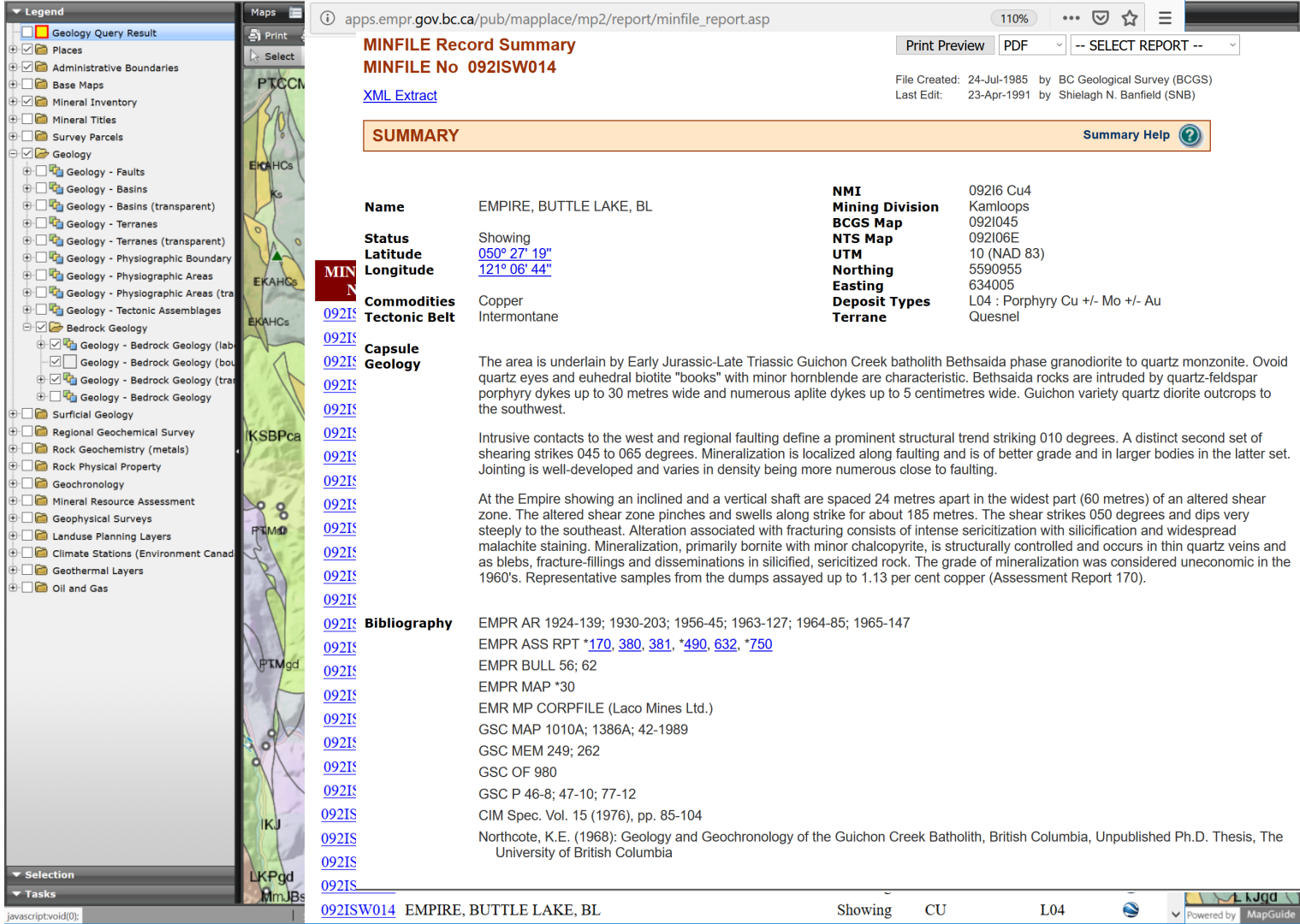
Data mining tool

Search bedrock Units by spatial or non-spatial query



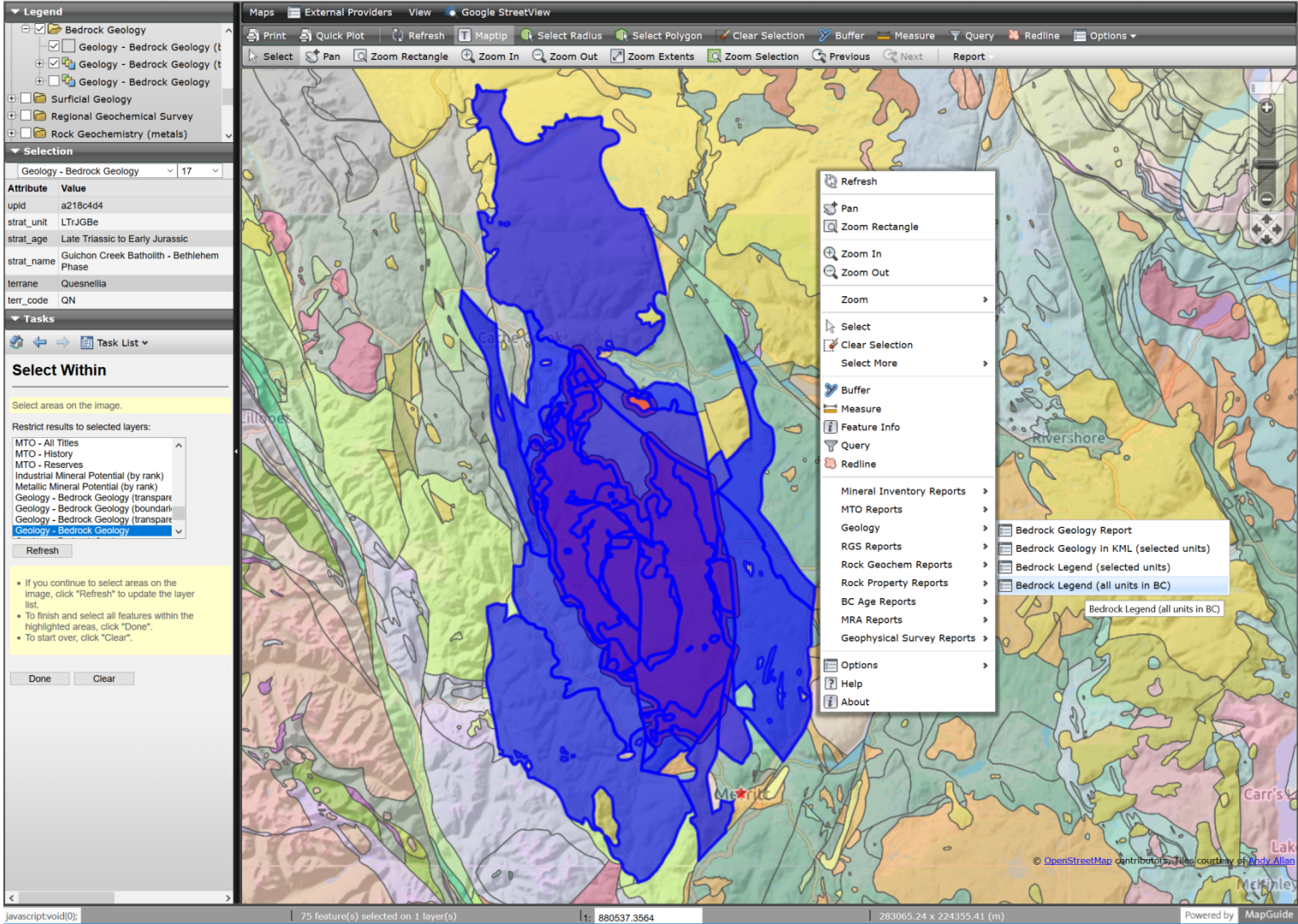
Data mining tool

Getting mineral occurrences within a formation and reporting results.



Data mining tool

Search bedrock units in the buffer, report results, download as KML, and generate legend.



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MapPlace

Geology Legend

Geology Legend (all units in BC)

Back to Main Table

Miocene

Mivb — basaltic volcanic rocks

Eocene

Kamloops Group

EKAv — undivided volcanic rocks

EKAs — undivided sedimentary rocks

EKav — undivided volcanic rocks

EKAv — undivided volcanic rocks

Princeton Group

EPrb — andesitic volcanic rocks

Efp — feldspar porphyritic intrusive rocks

Lower Cretaceous

Spences Bridge Group

lKSBPca — **Pimainus Formation:** calc-alkaline volcanic rocks

lKSBPva — **Pimainus Formation:** andesitic volcanic rocks

lKSBSva — **Spius Creek Formation:** andesitic volcanic rocks

Lower Jurassic to Middle Jurassic

lmJAs — **Ashcroft Formation:** undivided sedimentary rocks

lmJA — **Ashcroft Formation:** mudstone, siltstone, shale fine clastic sedimentary rocks

Late Triassic

Guichon suite

LTrGCBgd — **Guichon Creek batholith - Border phase:** granodioritic intrusive rocks

LTrGCSqm — **Guichon Creek batholith - Spatsum quartz monzonite:** quartz monzonitic intrusive rocks

Late Triassic to Early Jurassic

Guichon Creek Batholith

LTrJGBe — **Bethlehem Phase:** granodioritic intrusive rocks

LTrJGG — **Gump Lake Phase:** granodioritic intrusive rocks

LTrJGH — **Highland Valley Phase:** granodioritic intrusive rocks

LTrJGqp — high level quartz phyric, felsitic intrusive rocks

LTrJGBo — **Border Phase:** quartz dioritic intrusive rocks

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MapPlace

Summary of Bedrock Geology

Download in KML

Bedrock legend (selected units)

Bedrock legend (all units in BC)

Click on UPID for more information.

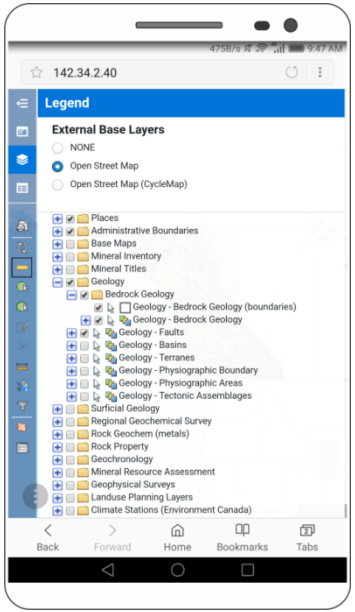
Click column headings to sort results.

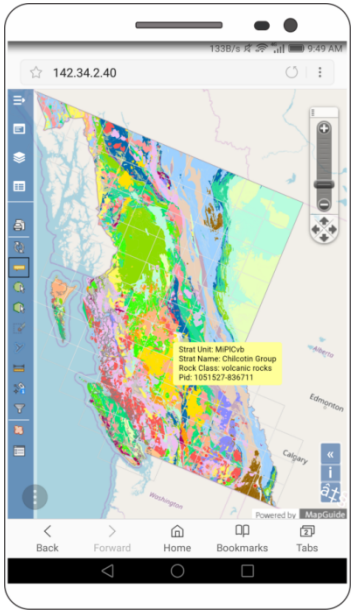
UPID	Strat Unit	Strat Name	Period	Strat Age	Rock Class	Rock Type	Age (maximum)	Age (minimum)	Terrane	Project	Google Earth	Bedrock Colour
0205a972	EKAv	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
05d21ff2	LTrJGBo	Guichon Creek Batholith - Border Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	quartz dioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
0811ddc2	EKAv	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
109a299d	EKAv	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
1361bcc4	LTrJGBe	Guichon Creek Batholith - Bethlehem Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
16475f9e	EPrb	Princeton Group	Paleogene	Eocene	volcanic rocks	andesitic volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
18b1a4f0	LTrJGBe	Guichon Creek Batholith - Bethlehem Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
1dfd60e3	lKSBSva	Spences Bridge Group - Spius Creek Formation	Cretaceous	Lower Cretaceous	volcanic rocks	andesitic volcanic rocks	Albian	Albian	Overlap	Okanagan		
1f2cbb4f	PTrVVbm	Venables Valley assemblage	Permian to Triassic	Upper Permian to Middle Triassic	volcanic rocks	bimodal volcanic rocks	Upper Permian	Middle Triassic	Cache Creek	Chilcotin-Bonaparte		
1f7860f1	lmJAs	Ashcroft Formation	Jurassic	Lower Jurassic to Middle Jurassic	sedimentary rocks	undivided sedimentary rocks	Lower Jurassic	Middle Jurassic	Quesnellia	Chilcotin-Bonaparte		
1fae0621	LTrJGBo	Guichon Creek Batholith - Border Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	quartz dioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
2166e8bc	LTrGCSqm	Guichon suite - Guichon Creek batholith - Spatsum quartz monzonite	Triassic	Late Triassic	intrusive rocks	quartz monzonitic intrusive rocks	Late Triassic	Late Triassic	Quesnellia	Chilcotin-Bonaparte		
23f08685	EKav	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Chilcotin-Bonaparte		
28b4a45c	Efp		Paleogene	Eocene	intrusive rocks	feldspar porphyritic intrusive rocks	Eocene	Eocene	Post Accretionary	Cariboo		
2b74d298	EKAv	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
30a7a195	uTrN	Nicola Group	Triassic	Upper Triassic	volcanic rocks	undivided volcanic rocks	Upper Triassic	Upper Triassic	Quesnellia	Okanagan		
36d10bb0	uTrNC	Nicola Group - Central Volcanic Facies	Triassic	Upper Triassic	volcanic rocks	andesitic volcanic rocks	Upper Triassic	Upper Triassic	Quesnellia	Okanagan		
3899742f	EKav	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Chilcotin-Bonaparte		
3dc06eb3	uTrNW	Nicola Group - Western Volcanic Facies	Triassic	Upper Triassic	volcanic rocks	undivided volcanic rocks	Upper Triassic	Upper Triassic	Quesnellia	Chilcotin-Bonaparte		
3e7f0233	EPrb	Princeton Group	Paleogene	Eocene	volcanic rocks	andesitic volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
42a18d63	LTrJGB	Guichon Creek Batholith - Bethsaida Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	quartz monzonitic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
431477bd	LTrJgd		Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
474d44d9	EKAv	Kamloops Group	Paleogene	Eocene	volcanic rocks	undivided volcanic rocks	Eocene	Eocene	Overlap	Okanagan		
4974fd08	LTrGCBgd	Guichon suite - Guichon Creek batholith - Border phase	Triassic	Late Triassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Late Triassic	Quesnellia	Chilcotin-Bonaparte		
4d42ae4f	LTrJGBo	Guichon Creek Batholith - Border Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	quartz dioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
517c1bbe	LTrJGH	Guichon Creek Batholith - Highland Valley Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
546dc02f	uTrNW	Nicola Group - Western Volcanic Facies	Triassic	Upper Triassic	volcanic rocks	undivided volcanic rocks	Upper Triassic	Upper Triassic	Quesnellia	Chilcotin-Bonaparte		
60776e95	LTrJGH	Guichon Creek Batholith - Highland Valley Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		
646d859b	LTrJGBe	Guichon Creek Batholith - Bethlehem Phase	Triassic to Jurassic	Late Triassic to Early Jurassic	intrusive rocks	granodioritic intrusive rocks	Late Triassic	Early Jurassic	Quesnellia	Okanagan		

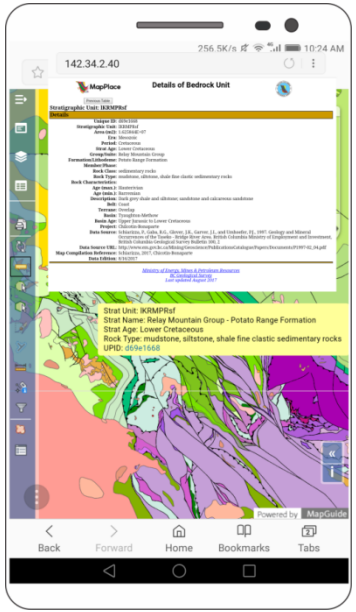
BRITISH COLUMBIA GEOLOGICAL SURVEY

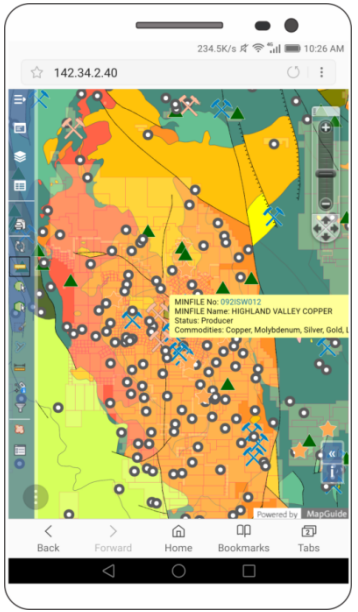
MapPlace 2 for mobile devices

- Simple queries
- API to details



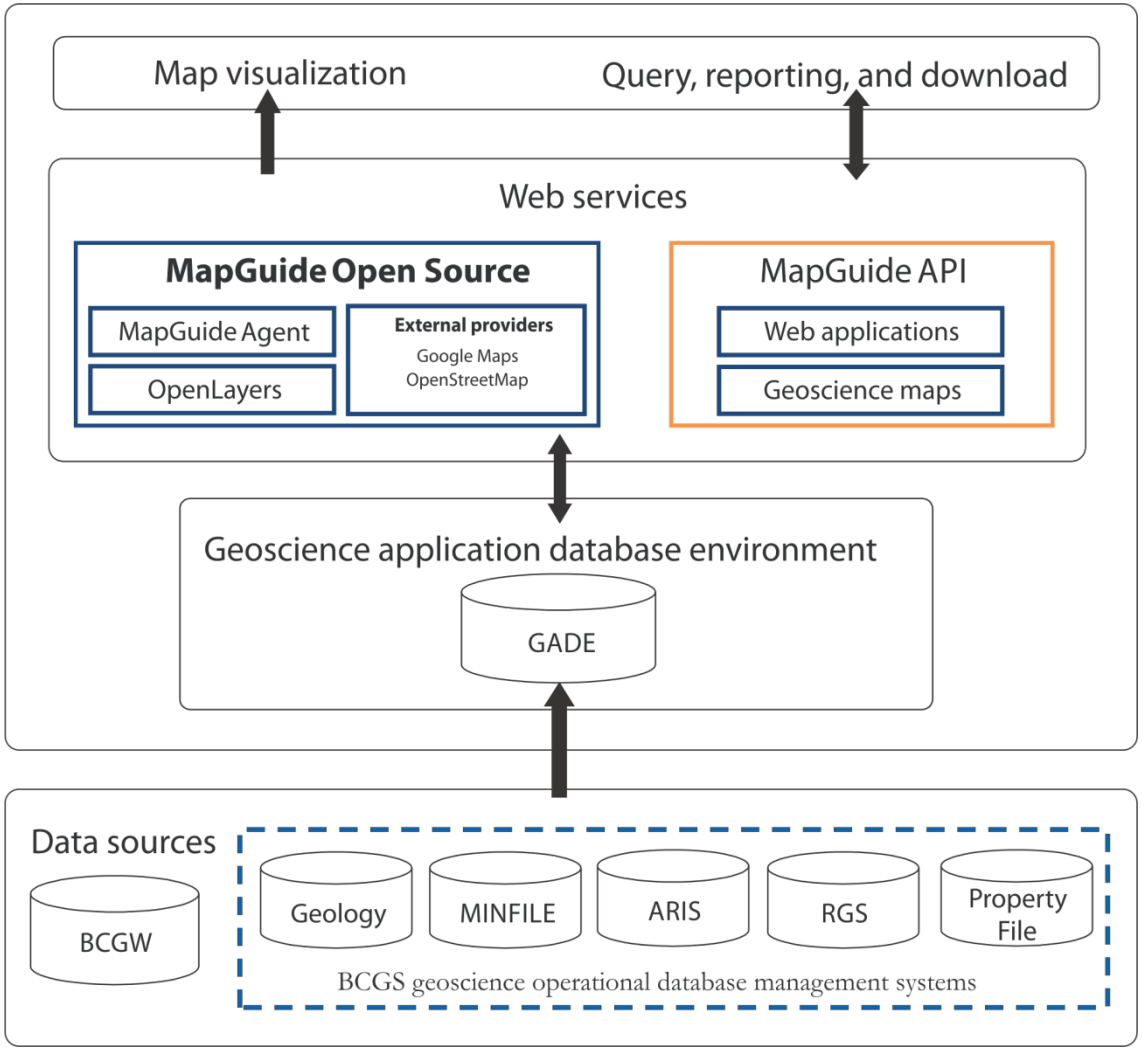






MapPlace 2 system view

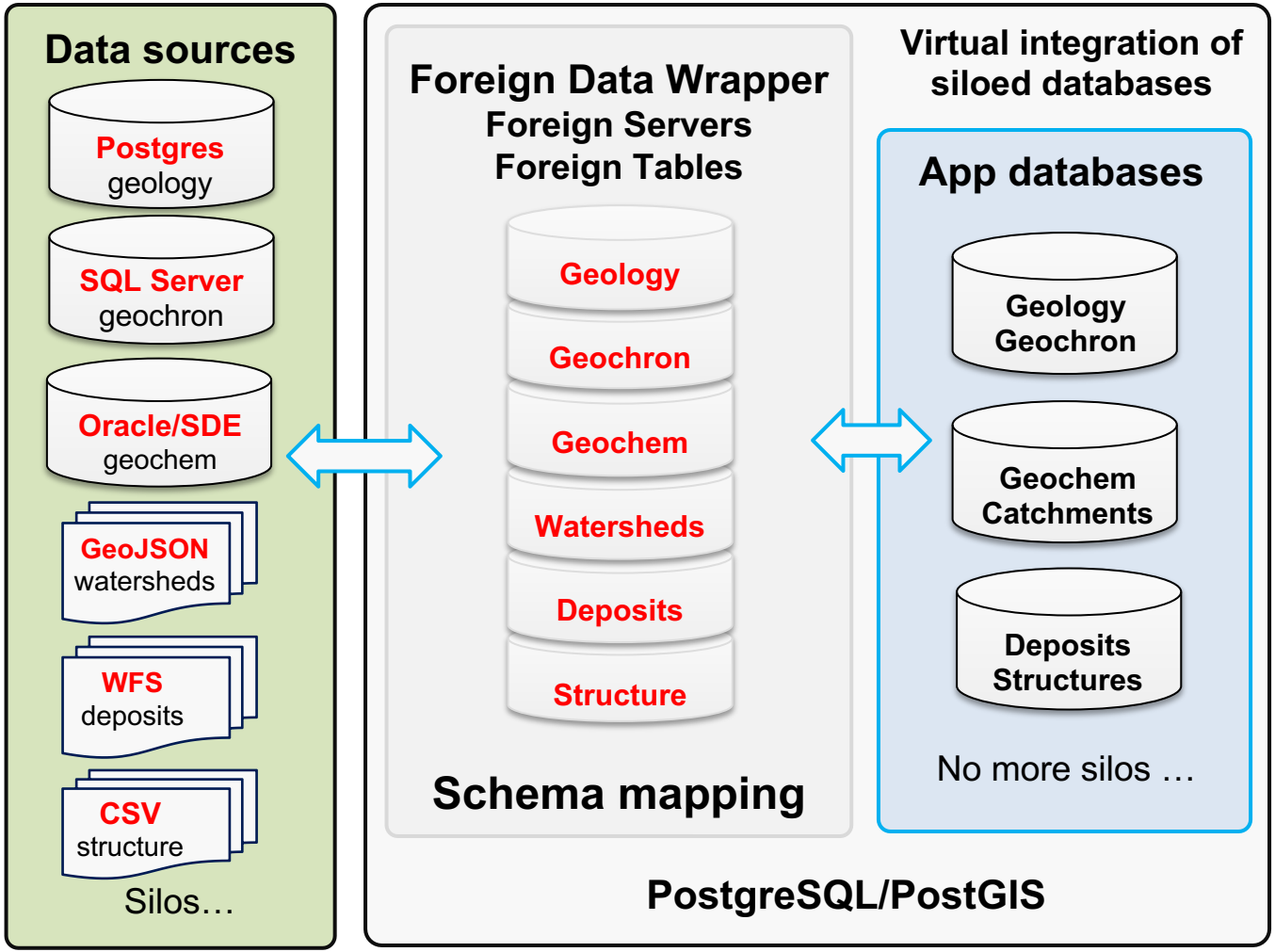
Build on open source software for geospatial



Foreign Data Wrapper

Extensively used to build the MapPlace 2 application databases to virtually integrated data from various data sources.

Database silo is a reality and not necessary a negative thing. It means data are maintained at the sources by the people who understand the data.



Foreign Data Wrapper

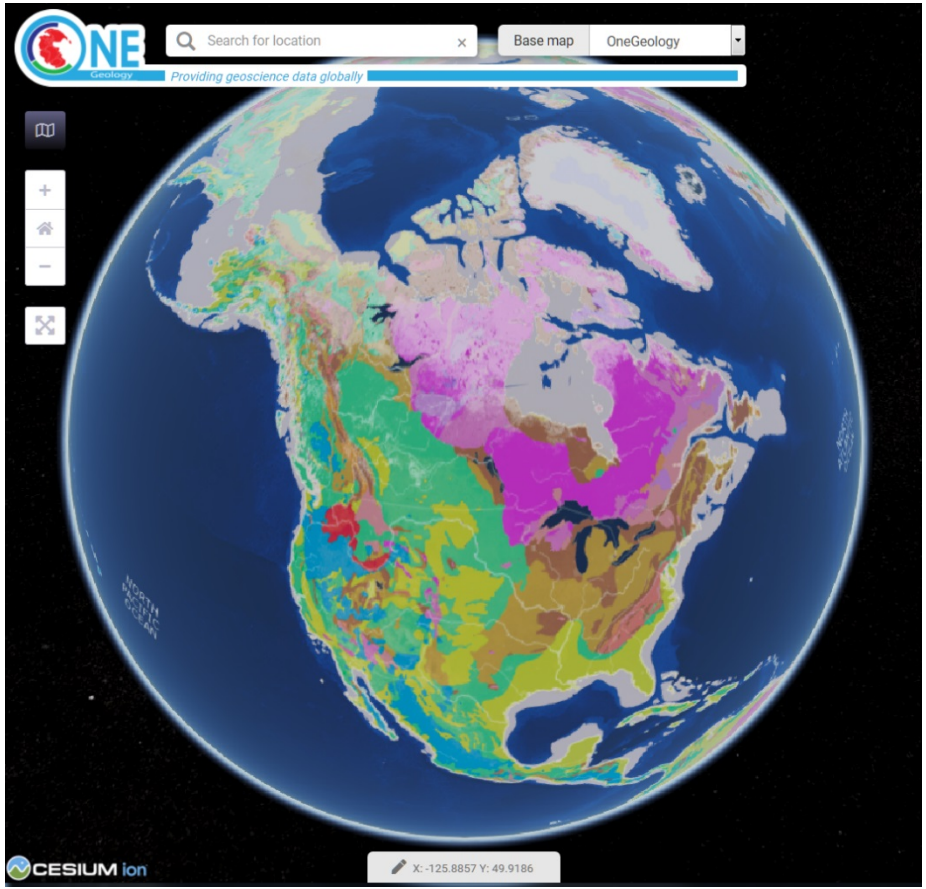
Added to SQL standard in 2003: SQL Management of External Data (SQL/MED)

- **Geo wrappers**: GDAL/OGR, Geocode/GeoJSON, OSM PBF
- **Specific SQL database wrappers**: Oracle, MS SQL Server
- **Generic SQL database wrappers**: ODBC, JDBC
- **NoSQL database wrappers**: Cassandra2, CouchDB
- **File wrappers**: CSV, pg_dump, JSON, XML, TAR, ZIP files
- **LDAP wrappers**: LDAP
- **Generic web wrappers**: Git, ICAL, IMAP, RSS, www
- **Specific web wrappers**: Face, Google, Twitter, DynamoDB
- **Big data wrappers**: Elastic Search, Hadoop, Hive, HDFS, Impala
- **Column-oriented wrappers**: Columnar Store, MonetDB
- **Scientific wrappers**: Ambry, ROOT files, VCF files
- **Operating system wrappers**: Dockers, Log file, OS Query, Passwd
- **Exotic wrapper**: fdw_fdw, PPG, Open Civic Data, Random Number

International Geoscience Standard

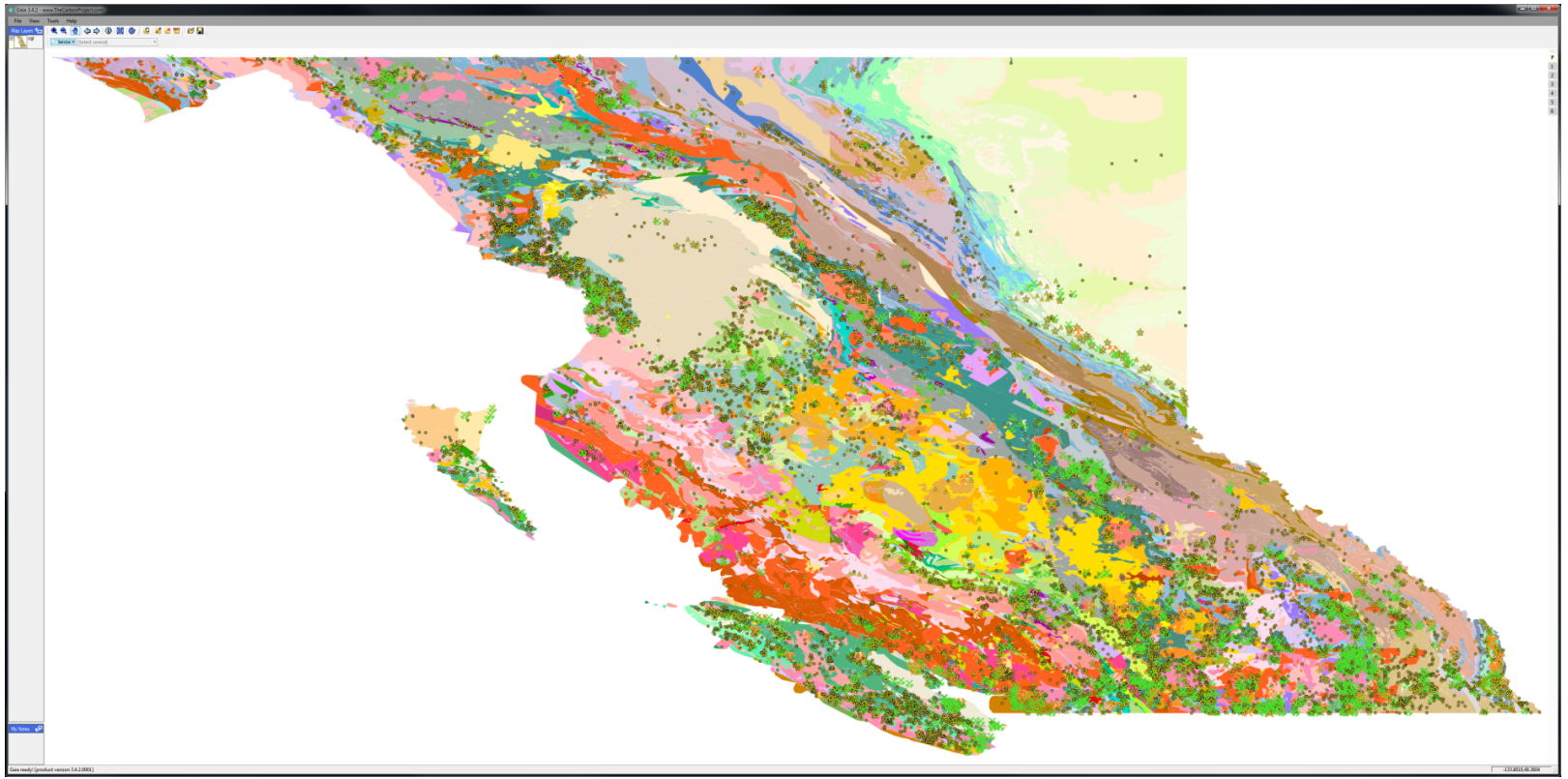
IUGS / OGC standards

- GeoSciML
- EarthResourceML

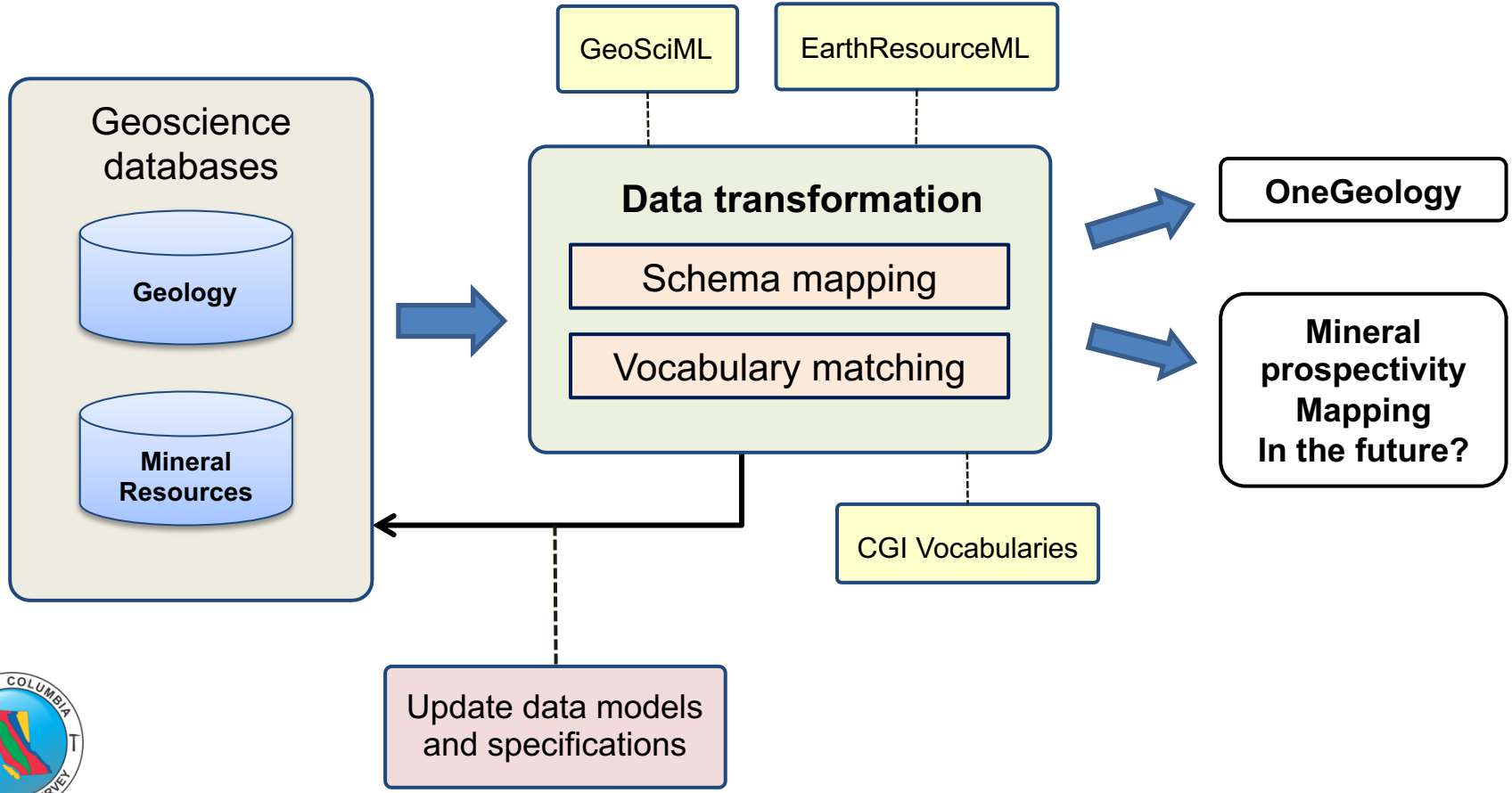


BCGS bedrock geology and mineral resources

at scale of 1:250,000, as WMS and WFS, posted to OneGeology



Towards GeoSciML and EarthResourceML



Solutions originated from Victoria

PostGIS, spatial extension to PostgreSQL

- Originated from Victoria
- Spatial library GEOS, ported from JTS Topology Suite
- JTS was developed by Martin Davis (2011 Sol Katz Award Winner), teamed up with and specified by staff from the Province of British Columbia, and partially funded by Natural Resource Canada.

JEQL Query Language

- Developed by Dr. JTS, Martin Davis from Victoria, BC
- a scripting language engine for spatial ETL and manipulation of spatial and non-spatial data, implemented on the Java platform
- table-oriented programming
- access to JTS spatial library

Summary

Streamlined from field to web services

- Driven by mineral prospectivity mapping, land use management and interoperable web services
- System architecture centres on geospatial frame data (digital geology), not maps
- Operation follows lifecycle of geospatial data:
  - observation, compilation, integration, production

Thank you!

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