Integration and Delivery of British Columbia Digital Geology

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Compilation and Integration Problems

British Columbia Digital Geology is the data source to create the Geological Map of BC (Figure 1), a provincial compilation provided to clients in mineral exploration, mining, land planning, and other areas.

Digital mapping in the Earth sciences has long-used polygons to define map units. However, polygons are prone to errors in editing and edge matching if they are used as the base to update and integrate digital geology, causing discontinuities, slivers, gaps and overlaps that are hard to fix. Using polygons as the base also makes it excessively time consuming to reconcile shared boundaries between adjacent map units and coincident planar geological features such as faults. Some of these problems are depicted in Case 1 (Figures 2 to 5) and Case 2 (Figure 6).

British Columbia Geological Survey (BCGS) maintains and integrates the province-wide digital geology by implementing a Geologic Framework Data (GFD) model, and an anchoring mechanism with a set of anchor lines, hooks, rode lines, and anchor points. This approach eliminates the problems of shared boundaries and map edge matching.

We have dispensed with polygons for integrating updated maps into our database. Bedrock polygons are not part of the GFD but are generated from GFD in the finished map.

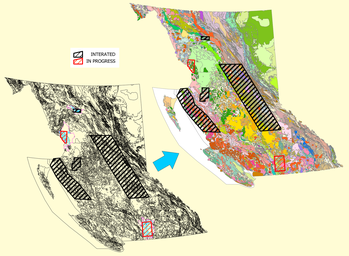

Figure 1. Geological Map of British Columbia: from digital Geologic Framework Data maintained in spatial database to publically distributed geological map.

Case 1. Updating shared boundaries

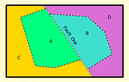

Figure 2. Original mapping; the contact between map units A and B is a fault with a linear trace.

Figure 3. Three features share the same boundary along the faulted contact.

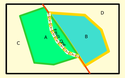

Figure 4. New mapping reveals that the faulted contact is curved. To update the map, parts of the lines that form polygons for units A and B also need to be adjusted.

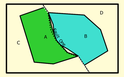

Figure 5. With polygons it is hard to make the shared boundaries perfectly coincident, which results in topological errors such as gaps, overlaps, and slivers between polygons.

Case 2. Edge matching

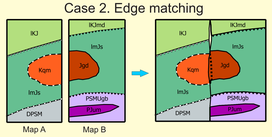

Figure 6. Merging recent mapping (Map B) with an older map (Map A) can result in: gaps and overlaps between polygons; crossing, overlaps and discontinuities between lines; and inconsistent map units along the map edges.

Figure 7. Maps generated from making field observations at point locations, to defining map units, to delineating unit boundaries, and to eventual map production.

Geologic Framework Data Model

Typical field surveys start from observations and measurements at point locations. These data are used to establish geological units and define unit boundaries (Figure 7). Using a similar logic, BCGS maintains the province-wide digital geology using what we refer to as a Geologic Framework Data (GFD) model, defined as the following.

1) Centroids (points) representing geological units (Figure 8).
2) Lines delineating geological boundaries (Figure 8).
3) Data quality specifications on data consistency, integrity, behaviour, and usability pertaining to the linework, points, and attribution.

The Geologic Framework Data are stored and managed in our Geology Operational Database Environment (GODE). When updates are available or data quality issues detected, changes are applied only to the lines and centroids that were affected by the update.

Bedrock polygons are not maintained. They are regenerated automatically when updates are integrated or data quality issues are resolved (Figure 9).

The BC Digital Geology is delivered to the public as downloadable shapefiles. It is also available on our MapPlace (Figure 10).

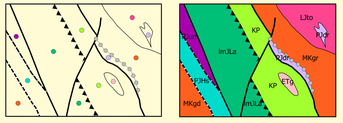

Figure 8. Geologic Framework Data consists of lines delineating geological boundaries and centroids representing geological units.

Figure 9. Bedrock geological map is created from the Geologic Framework Data.

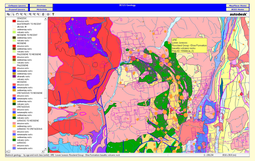

Figure 10. Public distribution of BC Digital Geology on MapPlace.

Integration of Geologic Framework Data

To integrate digital geological maps, a common task is to fix overlaps, gaps, discontinuities, and other problems along mapsheet boundaries (as described in Figure 6). The use of Geologic Framework Data model allows us to develop a 'checking-out' process and an anchoring mechanism to fully automate the data integration, thus saving time by eliminating the task of edge matching.

Checking-out Geologic Framework Data before updating

When a new mapping project commences, a copy of the Geologic Framework Data is 'checked out' for the area with an extended regional context (Figures 11 and 12). The checking-out process sets up the Geologic Framework Data with tags in a series of steps (Figure 11 to 14).

1) The outer boundaries of the Geologic Framework Data in the regional context are defined and tagged as 'anchor lines' and the end points of anchor lines are defined as 'hooks' (Figure 13).
2) Lines connected to hooks are defined and tagged as 'rode lines' and the end points of rode lines on hooks are defined as 'anchor points' (Figure 13).
3) All other lines in the regional context are tagged as 'checked out for revision'.

A complete 'checked-out' package would include the framework data and bedrock polygons (Figure 15).

Updating Geologic Framework Data in project area

With sufficient regional context of Geologic Framework Data beyond the project area, the anchor lines (highlighted in red) and anchor points of rode lines (in green) will not be modified (Figure 15). The anchor lines and anchor points in both the project and provincial Geologic Framework Data can be symbolized or even locked up to prevent unintentional modification during map revision.

Figure 15. Updated project Geologic Framework Data.

Integrating updated project Geologic Framework Data

When a mapping project is completed, and the updated project Geologic Framework Data is admitted into GODE, the following steps are used to integrate the updates into the provincial Geologic Framework Data base.

1) After passing data quality rules, the accepted project Geologic Framework Data is admitted into the provincial framework database except the 'anchor line' (Figure 16).
2) Records tagged as 'rode line' and 'checked out for revision' in the provincial Geologic Framework Data are unlocked and retired.
3) The hooks on anchor lines in the provincial Geologic Framework Data are used to snap the anchor points of rode lines from the project Geologic Framework Data (Figure 17 and 18).
4) Lines in the regional context area are used to generate new bedrock polygons (Figure 19).
5) New bedrock polygons for the regional context area are attributed by the updated centroids in the project Geologic Framework Data.

If anchor lines have to be modified, the data "checking-out" process can be repeated to extend the regional context and the anchor lines and rode lines re-tagged.

An updated bedrock geological map for the entire province can be produced by applying the proper styles and colour legend to the bedrock polygons, contacts, faults and other geological features (Figure 20), and adding other cartographic enhancements.

Figure 11. New project area, outlined by dotted black line.

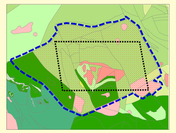

Figure 12. Selection of Geologic Framework Data in an extended regional context (dashed blue line).

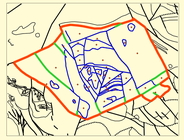

Figure 13. The selected GFD are tagged as anchor lines (in red), rode lines (in green), revision (in blue); also defined as hooks at the ends of anchor lines, and anchor points at the ends of rode lines that connect to hooks.

Figure 14. Extracted Geologic Framework Data for the project area with extended regional context, and the bedrock polygons.

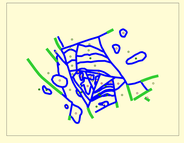

Figure 16. Updated project Geologic Framework Data (without anchor lines) ready for integration.

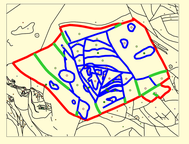

Figure 17. Updated project Geologic Framework Data integrated into provincial database, with anchor points of rode lines (green lines) snapped to hooks on anchor lines (red lines) in the provincial framework database.

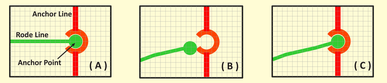

Figure 18. (A) before update; (B) after update showing that the rode line is modified and the anchor point has drifted away from the hook; and (C) after integration showing the anchor point snapped back to the hook on the anchor line.

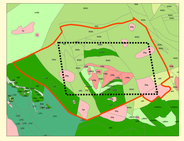

Figure 19. Updated project framework data integrated into provincial Geologic Framework Data.

Figure 20. Updated provincial bedrock map.

What's in it for you?

- The BC Geological Survey continues to maintain the province-wide digital geology for public distribution.
- The BCGS has developed and implemented an effective process to integrate updated geological maps into the BC Digital Geology database.
- The data integration process described here can be easily adopted by organizations that have a need to integrate their own geological maps.

Integration Environment

Geologic Framework Data integration is carried out in our Geology Operational Database Environment using spatial databases in PostgreSQL/PostGIS, data quality rules and quality assurance applications, and desktop GIS Manifold System® (Figure 21).

The Geology Operational Database Environment fulfills the following tasks:

① Loading source data into the Observation Database where the original maps are stored using common schema so they are readily retrievable with data contents intact
② Carrying out data quality assurance, updating and data integration in the Staging Database
③ Archiving completed maps as the authoritative data sources in the Archive Database

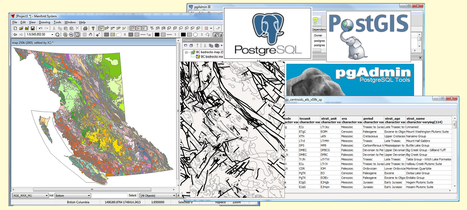

Figure 21. Geologic Framework Data integration environment.

Summary

British Columbia Geological Survey updates and integrates digital geological maps by using a Geologic Framework Data model, a data 'checking-out' process, and an anchoring mechanism, implemented in a spatial database environment. This approach has helped us to streamline the data integration and delivery process. It:

- eliminates issues in shared boundaries and edge matching
- allows fully automatic data checking-out, anchoring and integration
- enables rule-driven data quality assurance and content standardization
- tracks and audits data revisions automatically
- permits multiple users to perform concurrent operations
- automates updating of colour schemes and legends to produce customized maps
- shortens the time to deliver updated digital geology to clients through MapPlace

The approach and practices can be easily adopted by others using spatial database technology.

Acknowledgements

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