Development of the Geological Map of the Arctic: Scientific Challenges and Opportunities for Evaluation of Resource Potential

Christopher Harrison*
Geological Survey of Canada (GSC), Calgary,
charriso@nrcan.gc.ca

Marc St-Onge
Geological Survey of Canada (GSC), Ottawa,

Sergey Strelnikov
Russian Geological Research Institute (VSEGEI) , St. Petersburg,

Boris Lopatin
All-Russia Research Institute for Geology and Mineral Resources of the World Ocean (VNIIOkeangeologia), St. Petersburg,

Frederic Wilson
United States Geological Survey (USGS), Anchorage, Alaska,

Stefan Bergman
Geological Survey of Sweden (SGU), Uppsala,

Arne Solli
Geological Survey of Norway (NGU),

and

Hans F. Jepsen
Geological Survey of Denmark and Greenland (GEUS), Copenhagen

Abstract

This project began with a Russian proposal, submitted in July 2003, for international consideration of an Atlas of geoscience maps of the circumpolar Arctic at a scale of 1:5,000,000. International ministers of natural resources debated the proposal at the 2004 International Geological Congress (IGC) held in Florence and, later that year, the Russian proposal was endorsed by the general assembly of the Commission for the Geological Map of the World (CGMW). In June 2005, the Assistant Deputy Minister for Natural Resources (NRCan) agreed that Canada would lead the bedrock map component of the Atlas, and that the finished map would be presented at the 2008 IGC in Oslo.

Development of the map and related database was led by a Canadian team (based in Calgary and Ottawa) with the active participation of scientific and technical staff from the geological surveys of Russia, the United States, Norway, Sweden and Denmark. Project work began in February 2006, and a completed draft in hard copy was presented as intended at the Oslo IGC in August 2008. The map was completed in preliminary form by October 2008 and published as Geological Survey of Canada (GSC) Open File 5816 on November 18, 2008.

Technical challenges included converting numerous hard copy compilation maps to digital, and converting existing diverse digital products to a common database standard. The base map had to be built to carry the geological features. Issues to resolve included proper registration of features to shorelines and ice caps, and production of seamless registered layers for drainage and bathymetric contours. Hundreds of source maps had to be simplified from a wide variety of source scales. Methods had to be found for referencing published and unpublished sources, and for giving credit to both minor and major project participants. (The ultimate total includes 47 named contributors).

Geological challenges were as diverse as finding agreement as to what constitutes a geology map. Specific contributors needed convincing that composition can be displayed at 1:5,000,000 scale; others insisted on including surficial materials. Agreement on several other attributes had to be found including: use of standard time scale terms; definition of map units in the deep ocean basins where Quaternary is widespread at the sea floor; state of metamorphism, and; the importance of tectonic features (domains). Interpretive inconsistencies along map boundaries had to be resolved.

The “Geological Map of the Arctic” is supported by the first complete, seamless, spatial database of onshore and offshore bedrock geology for approximately half of Russia and Canada (including most of Canada’s three territories), most of Alaska and Scandinavia, and the entire Arctic offshore north of 60. Included in the database and portrayed in simplified form on the hard copy map product are tens of thousands of spatial objects including: 1) geology polygons attributed for composition, age, metamorphism, and Precambrian domain; 2) geological vectors (contacts, faults and spreading ridges), and; 3) selected point data (kimberlites, diapirs, volcanoes, impact structures). It is the largest and perhaps the most intricate map of its kind ever produced in the 168 year history of the Geological Survey of Canada.

The heart of the underlying database is an eight digit code that, parsed into separate text and numeric attribute fields, allows queries of geology polygons for the occurrence of 27 compositional end members, 137 divisions of geological age, varying degrees of metamorphism, and distribution with respect to major physiographic features of the Arctic and Precambrian domains. Relevant to sedimentary and petroleum geology is the circumarctic occurrence and evolution from the Neoproterozoic of unmetamorphosed continental clastics, deltaic and nearshore clastics, shallow marine clastics, evaporites, carbonates, and slope and deep water sediments of various ages. Studied together with known resource occurrence datasets, the new map and database can be used for project planning and for evaluating mineral and energy resource potential in a wide range of geological settings.