BEDROCK EXPLANATORY NOTES

ERLIS Data Set 6
Bedrock Geology of Ontario, Seamless Coverage ArcView 3.1 format

The Bedrock Geology Data Set is a Geological map of the Province and shows the distribution of bedrock units underlying Ontario. It illustrates geological rock types, major faults, granulite areas, Kimberlite Intrusions and dike swarms. The geology of the Province consists of Precambrian rocks of the Canadian Shield and Phanerozoic sedimentary rocks in basins that overlie the Canadian Shield. Based on differences in age , metamorphism and tectonic setting, the Precambrian rocks are subdivided into the Superior, Southern and Grenville provinces. The Phanerozoic rocks occur in four basins. The dataset is an overview of this geology on a Provincial Compilation scale of 1:1 000 000. Two major classes of faults and shear zones are also viewable on the map: faults traceable in surface exposure and subsurface faults.

Bedrock Features Found Within This Data

Kimberlite:
An intrusive rock with high contents of magnesium, iron and alkali elements. Commonly porphyritic with pehenocrysts of olivine, phlogopite and garnet. Generally has a brecciated or fragmental texture. Can contain diamonds in rare cases. Forms dikes and small intrusions generally of Mesozoic age in Ontario.

Lamproite:
A dark intrusive rock rich in magnesium and potassium, commonly porphyritic. Can contain diamonds

Iron formation:
A sedimentary rock of Precambrian age consisting of beds of quartz or carbonate alternating with iron rich beds consisting of iron-rich minerals such as magnetite, pyrite, iron carbonate or iron silicates.

Granulite facies:
Granulite facies is the highest facies of regional metamorphism in which rocks have been subject to heat and pressure just below the melting point of sedimentary rocks i.e. 650 degrees C. these rocks contain garnet and both ortho and clinopyroxene.

Fault:
A surface along which movement of a body of rock has occurred. Faults are marked by ground up rock and alteration brought about by fluids circulating along the fault. Faults may be exposed on surface and are therefore traceable in rock exposures on the Earth’s surface today.

Subsurface faults:
Subsurface faults are those which are present only in rock units at depth and are not exposed on the present day Earth’s surface. They can be traced by seeing discontinuities in subsurface rock units through indirect mapping for example through the use of drill holes, seismic images or magnetic data.

Dike Swarms:
Dikes are tabular bodies of igneous rock which have intruded pre-existing geological units near the Earth’s surface. Dikes are therefore long linear bodies of igneous rock that can extend laterally for hundreds of kilometers with a width of perhaps a few hundred meters. Dikes normally occur, not as single dikes, but rather as several parallel dikes forming a dike swarm all of the same material which intruded at roughly the same time. The most common dike swarms in the Precambrian of Ontario are diabase dike swarms extending up to 3000 km in length which can form up to 30% of the Earth’s crust at the center of the swarm.

The explanatory notes provide an overview of the geology of Ontario and describe the map units of each of the geologic regions in order of decreasing age.

The legend is subdivided geochronologically in the Phanerozoic, but geochronometrically in the Proterozoic and Archean. The Archean rocks of the Superior Province are subdivided into lithologic units. Supracrustal units of the Southern Province and the Phanerozoic Eon are subdivided lithostratigraphically. The Grenville Province is subdivided into major tectonic blocks and within each block the legend is mainly lithologic, with only part of the supracrustal rock record subdivided into lithostratigraphic units.

Terminology and Classification

Time subdivisions are based on the International Union of Geological Sciences time scale for the Phanerozoic (Cowie and Bassett 1989) and the proposed Precambrian time scale of the Subcommission on Precambrian Stratigraphy (Plumb and James 1986), with some of the modifications of Okulitch (1988; see Table 1).

Table 1. Subdivision of geologic time.

Eon	Era	Geochronometry (Ma)
	Cenozoic	<65
Phanerozoic	Mesozoic	65-250
	Paleozoic	250-570
	Neoproterozoic	570-900
Proterozoic	Mesoproterozoic	900-1600
	Paleoproterozoic	1600-2500
	Neoarchean	2500-2900
Archean	Mesoarchean	2900-3400
	Paleoarchean	>3400

Terminology used in the Legend and Explanatory Notes is based on the following standards: plutonic rock nomenclature of Streckeisen (1976), nomenclature and geochemical classification of volcanic rocks of Jensen (1976), and metamorphic grade terminology of Winkler (1976).

Archean metavolcanic rocks are grouped into mafic to ultramafic, mafic to intermediate, and felsic to intermediate compositions, based on field mapping supplemented by petrographic and geochemical data. The field classification is based on estimates of colour index and on the nature of primary volcanic textures. Ultramafic sequences have a high colour index and consist largely of flows characterized by the presence of spinifex texture and polysuturing. Flow sequences lacking the above features are classified as mafic to intermediate in composition. Sequences with a low colour index that are predominantly fragmental are classified as felsic to intermediate in composition.

ARCHEAN

Superior Province

The Archean Superior Province of Ontario includes units of Neoarchean and Mesoarchean age. The Superior Province is subdivided into subprovinces, commonly fault-bounded, that can be distinguished on the bases of contrasting rock type, structural geology, age and metamorphic grade. The subprovinces of Card and Ciesielski (1986) served as subdivisions for purposes of compilation of this map. Changes to the subprovince scheme of Card and Ciesielski (1986) resulting from this compilation are described in The Geology of Ontario (Ontario Geological Survey 1991).

In Ontario, granite-greenstone subprovinces include the Sachigo, Uchi, Wabigoon, Abitibi and Wawa subprovinces. The greenstone belts are elongate areas of metavolcanic rocks and minor volumes of metasedimentary rocks that form linear to anastomosing patterns separated by elliptical granitic complexes. The greenstone belts are characterized by shear zone-bounded homoclinal and complexly folded panels of supracrustal rocks. Greenstone belts are typically of low metamorphic grade in their centres and of medium metamorphic grade near the margins of younger granitoid domains. Pretectonic to syntectonic granitic units display well-developed foliation and gneissosity, while late granite intrusions have little or no tectonic fabric.

The English River and Quetico metasedimentary subprovinces are characterized by wacke-mudstone couplets, with migmatized equivalents in the high grade parts of the subprovinces. Minor volumes of coarse clastic metasedimentary rocks occur at the subprovince margins. Metamorphic grade is generally low at the margins of the metasedimentary subprovinces, but varies locally to medium grade; amphibolite to granulite grade assemblages are found mainly in the interior. These assemblages are cut by muscovite-bearing granitic rocks (unit 13) and granitic rocks of unit 15.

The Kapuskasing Structural Zone consists of metavolcanic and metasedimentary rocks of high metamorphic grade, foliated tonalites and tonalitic gneisses, all cut by undeformed granitic units. The Berens River and Winnipeg River plutonic subprovinces of Card and Ciesielski (1986) include minor volumes of high grade, metavolcanic and metasedimentary remnants, older gneissic to foliated granitic rocks, and a high proportion of post-tectonic granitic batholiths.

Uranium-lead zircon age determinations define a limited spatial distribution of Mesoarchean supracrustral rocks (units 1 to 3) in the Sachigo subprovince and the central part of the Wabigoon subprovince. Mesoarchean supracrustal sequences include mafic to ultramafic metavolcanic rocks (unit 1) and intermediate to felsic metavolcanic rocks (unit 2) similar to units within Neoarchean greenstone belts. Unit 3, commonly occurring within Mesoarchean greenstone belts, is characterized by distinctive, quartz-rich, mature metasedimentary rocks and may also include carbonate metasedimentary rocks, iron formation, and mafic to ultramafic metavolcanic rocks.

Most supracrustral rocks in the supracrustal rocks in the Superior Province of Ontario are of Neoarchean age. Such rocks in the greenstone belts, along with rocks of uncertain age, are assigned to units 4 to 8. Archean metasedimentary rocks within greenstone belts are assigned to unit 7 with some exceptions: Mesoarchean quartz-rich metasedimentary rocks of unit 1; and metasedimentary-metavolcanic sequences of unit 9, which unconformably overlie older metavolcanic rocks. Unit 7a is paragneiss within metasedimentary subprovinces and unit 7b is conglomerate which occurs at the margins of metasedimentary subprovinces. Some units on earlier maps that are likely of sedimentary origin, but previously identified as grey gneiss, granite, and biotite gneiss, are included in unit 7. Supracrustal septa of medium metamorphic grade, found between granitoid and gneissic units or along strike from greenstone belts, are assigned to unit 8. Unit 9 comprises coarse conglomerates with subordinate finer grained clastic metasedimentary rocks and alkalic to subalkalic metavolcanic rocks. Unit 9 commonly occurs in fault-bounded sequences unconformably overlying older supracrustal rocks of greenstone belts.

Mesoarchean to Neoarchean intrusive rocks of units 10 to 15 include most Archean granitoid units and synvolcanic to post-tectonic, mafic to ultramafic units. Granitoid units have been mapped in some detail in the Winnipeg River, English River, and in the western parts of the Quetico and Wabigoon subprovinces; less detail is available elsewhere. Archean granitic rocks were classified primarily using modal mineralogy and texture; aeromagnetic interpretation aided the classification in poorly understood areas. Crosscutting relationships have established a general sequence of rock units in order of relative age from early to late: gneissic tonalite suite (unit 11), foliated tonalite suite (unit 12), diorite-monzonite-granodiorite suite (unit 14), muscovite-bearing granitic rock (unit 13), and massive granodiorite to granite (unit 15).

The gneissic tonalite suite (unit 11) and the foliated tonalite suite (unit 12) display the widest range in age, from 3.17 to 2.71 Ga. These suites have been intruded by plutons of massive tonalite. Muscovite-bearing granitic rocks (unit 13), which formed between 2.67 and 2.69 Ga, predominate in the metasedimentary subprovinces and postdate tonalites in those subprovinces. Two-mica granites also occur as small plutons in the Winnipeg River, Uchi, Berens River, Wabigoon and Sachigo subprovinces, particularly along major shear zones.

Units 14 and 15 are widespread in granitoid complexes of all subprovinces. Unit 15 is a voluminous, widely distributed unit ranging between 2.76 and 2.56 Ga in age. The youngest members of this suite crosscut the two-mica granites (unit 13), as for example in the English River subprovince. The older parts of unit 15 include the 2.69 to 2.76 Ga, potassium feldspar magacrystic granite-granodiorite that forms large batholiths in the Winnipeg River, Berens River and Sachigo subprovinces. These rocks are characterized by a distinctive pattern of high magnetic susceptibility caused by the anomalous concentration of magnetite. The Neoarchean diorite to nepheline syenite suite (unit 16) rocks are generally the youngest Archean plutonic phases in the Superior Province.

PROTEROZOIC

Southern and Superior Provinces

Paleoproterozoic and Mesoproterozoic rocks of the Southern Province in Ontario consist mostly of sedimentary and volcanic assemblages that overlie Archean rocks and are generally little deformed to moderately deformed. In addition, a wide variety of Proterozoic dikes and plutons have intruded the rocks of the Superior Province and the supracrustral sequences of the Southern Province.

Diabase dikes of the 2454 Ma Matachewan and Hearst swarms (unit 17a) have intruded the rocks of the Superior Province and are widely distributed across northeastern Ontario. These dikes are spatially associated with the 2480 to 2491 Ma gabbro to anorthosite intrusive rocks in the vicinity of Elliot Lake (unit 17b), and the 2450 Ma basalt, rhyolite and clastic/chemical sedimentary sequence of the Elliot Lake Group (unit 18b). The Elliot Lake Group and the overlying clastic and carbonate sedimentary rocks of the Hough Lake, Quirke Lake and Cobalt Groups (units 18b and 19) constitute the Huronian Supergroup. These rocks form a sedimentary prism with a maximum thickness of approximately 12 km near Lake Huron. The southward - increasing thickness is associated with south-side-down normal faults. The Cobalt Group (unit 19) overlaps the lower groups and has the most widespread distribution, being preserved in the Cobalt Embayment, extending north into the Abitibi region. The lower part of the Huronian Supergroup, in the vicinity of Sudbury, is cut by the 2388 to 2333 Ma Murray Granite and Creighton Granite plutons (unit 20); the entire Supergroup has been intruded by sills and dikes of 2219 Ma Nipissing diabase and related rocks (unit 21d). Even though some folding of the Huronian Supergroup occurred during an unnamed event prior to 2219 Ma, the major thrusting and folding of the Huronian occurred at ca. 1.86 Ga during the Penokean Orogeny. Other dike swarms which are probably of similar age to the Nipissing sills, include the Preissac swarm in northeastern Ontario (unit 21a), the Marathon swarm east of Lake Nipigon (unit 21b), and the Kenora-Fort Frances swarm in the northwestern Ontario (unit 21c).

The Animikie Group (unit 22a), within the Animikie Basin near Thunder Bay, includes iron formation of the Gunflint Formation and wackes and argillite of the Rove Formation; it forms a homoclinal sequence unconformably overlying the Superior Province. The Animikie Group is correlated with the upper part of the Marquette Range Supergroup, south of Lake Superior, and is interpreted to have been deposited during the Penokean Orogeny. Sedimentary rocks of the Sutton Inlier (unit 22b), exposed within the Paleozoic Hudson Bay Basin, overlie Archean basement and form part of the 1.9 to 1.8 Ga Trans-Hudson Orogen. Based on geophysical data, these sedimentary units are interpreted to be continuous with the Belcher Islands fold belt in Hudson Bay and with the Fox River belt in Manitoba. In Manitoba, diabase of the 1884 Ma Molson swarm (unit 23a) intruded the Fox River belt; thus, sills that intruded the Sutton Inlier are probably of similar age. The Wabigoon diabase dikes (units 23b), in northwestern Ontario, and the North Channel swarm (unit 23c), on the north shore of Lake Huron, are also probably of similar age. Coincident with the Penokean and Trans-Hudson orogenic activity, ca. 1.9 Ga alkalic and carbonatite stocks (unit 24) intruded the vicinity of the Kapuskasing Structural Zone and several other localities in Ontario.

The 1850 Ma, noritic to granophyric, Sudbury Igneous Complex (unit 26) intruded brecciated Archean and Proterozoic country rocks. The Whitewater Group (unit 25), which consists of fragmental rocks, wackes and mudstones, is entirely contained within and intruded by the Sudbury Igneous Complex. The origin of this complex has been variously attributed to events related to either a meteorite impact or an explosive volcanic event, or a combination of both.

Mesoproterozoic felsic intrusive rocks and minor volumes of related volumes of related volcanic rocks form two zones: a 1.4 to 1.5 Ga magmatic zone along the north shore of Lake Huron and the west shore of Lake Nipigon (unit 27a), and the 1.4 to 1.75 Ga Killarney magmatic zone south of Sudbury (units 27b and 27c). Unit 27a is part of an anorogenic magmatic suite extending across North America. Deformed equivalents of rocks of the Killarney magmatic zone occur within the adjacent Grenville Front tectonic zone. The anorogenic granites cut rocks of the Sibley Group (unit 28). The Sibley Group is a thin (less than 1 km thick) sequence of predominantly clastic sedimentary rock, preserved within a fault-bounded basin between Lake Nipigon and Lake Superior.

In the Lake Superior area, the Mesoproterozoic Keweenawan Supergroup (unit 29) and associated intrusive rocks occupy the Midcontinent Rift, and form sequences in excess of 25 km thick overlying an attenuated Superior Province basement. The lower part of the Keweenawan Supergroup consists of 1107 to 1086 Ma basaltic and rhyolitic volcanic rocks and minor volumes of sedimentary rocks. Volcanic and sedimentary accumulations are thickest beneath Lake Superior, within a graben that developed at about the same time as the latest phase of deformation in the Grenville Province. Diabase dikes of the 1238 Ma Sudbury swarm (unit 30b) are related to major Mesoproterozoic extensional events which are not otherwise represented in the Southern and Superior provinces of Ontario and are coincident with the main period of magmatism in the Elzevir Terrane and Central Metasedimentary Belt of the Grenville Province. In the Thunder Bay and Lake Nipigon areas, Keweenawan diabase sills (unit 31a), dikes of the Pigeon River and Pukaskwa swarms (unit 31b), ultramafic, gabbroic and granophyric plutons (unit 31c), and felsic to intermediate plutons (unit 31d), intruded Archean basement, Sibley Group and Animikie Group sedimentary rocks, and Keweenawan volcanic rocks. Diabase dikes of the 1141 Ma Abitibi swarm (unit 31e), and possibly correlative dikes in the Atikokan area, may be related to an early stage of Keweenawan rifting. At approximately the same time as the rifting, carbonatitic and alkalic plutons such as the Coldwell Complex (unit 32) were emplaced along fault zones in the Superior Province north of Lake Superior. Clastic sedimentary rocks (unit 33) form the upper part of the Keweenawan Supergroup and were deposited during regional subsidence, following cessation of magmatism. These rocks include sandstone, shale and conglomerate of the Oronto Group and unconformably overlying sandstone of the Jacobsville Group. The alkalic intrusive suite of unit 35 includes the Hecla-Kilmer intrusion, at the north end of the Kapuskasing Structural Zone, and the stocks in Lake Nipissing.

Grenville Province

The Grenville Province is a Mesoproterozoic orogenic belt extending from the Gulf of Mexico to Scandinavia. The province is characterized in Ontario by a period of widespread deformation and metamorphism during the period 1.06 to 1.1 Ga. Within Ontario, the Grenville Province consists of two major lithotectonic subdivisions, the Central Gneiss Belt (units 36-40) and the Central Metasedimentary Belt (units 41-47). The boundary between these two belts is a Zone of ductile deformation (unit 48), interpreted as a major deep crustal thrust zone.

The Central Gneiss Belt can be subdivided into a number of smaller tectonic domains, using structural trends, rock types, geochronologic data and aeromagnetic patterns. These domains are separated by ductile deformation zones (unit 48). The Central Gneiss Belt consists of a variety of migmatitic rocks and gneisses of unknown protolith (unit 38), of Archean, Paleoproterozoic and Mesoproterozoic ages, which are cut by Mesoproterozoic to Neoproterozoic intrusive rocks of several ages (units 37, 39 and 40). Rocks of the Central Gneiss Belt have all been metamorphosed to medium to high grade; areas of granulite grade are indicated on the map. In many areas, several periods of metamorphism have occurred and these periods are not coincident across the entire Central Metasedimentary Belt. Archean and Paleoproterozoic rocks have only been reported in a zone between the Grenville Front and the French River. Similar scale tectonic domains are also present in the extension of the Central Gneiss Belt beneath the Phanerozoic cover of southwestern Ontario.

The Central Metasedimentary Belt is a supracrustal terrane, generally younger than 1.3 Ga, that can be subdivided into a number of smaller, fault-bounded terranes on the basis of structural trends, rock types, geochronologic data, magmatic history, geophysics and relative timing of metamorphism. These terranes are, from west to east, the Bancroft, Elzevir, Sharbot Lake and Frontenac terranes. The Bancroft and Frontenac terranes consist mainly of shallow-water metasedimentary rocks (unit 42 and 43), with carbonate metasedimentary rocks (unit 43) predominant. Rocks of the Bancroft and Frontenac terranes are metamorphosed to medium grade and high grade. Most volcanic rocks (unit 41) in the Central Metasedimentary Belt are in the Elzevir and Sharbot Lake terranes, with both calc-alkalic and tholeiitic metavolcanic rocks present. The lowest metamorphic grade rocks in the Grenville Province occur in the Elzevir and Sharbot Lake terranes. Both carbonate and siliceous clastic metasedimentary rocks were deposited contemporaneously during volcanism. A variety of plutonic rocks of different ages intrude the supracrustal rocks. Plutonic activity in the Elzevir terrane was concentrated between 1.25 to 1.22 Ga and 1.1 to 1.08 Ga, whereas plutonism in the Frontenac terrane occurred mainly between 1.18 and 1.16 Ga.

Following the latest period of deformation at ca. 1.07 Ga, the Grenville Province experienced minor intrusive activity in the form of pegmatite dike swarms, and the injection of the Frontenac (ca. 0.9 Ga) and Grenville (ca. 0.5 Ga) diabase dike swarms (unit 34).

Based on interpretation of subsurface geology in southwestern Ontario, it appears that rocks of the Midcontinent Rift are deformed in the Grenville Front Tectonic Zone.

PHANEROZOIC

Most of the units for the Phanerozoic are lithostratigraphic and are assigned to geological periods. Three Paleozoic units, the Port Lambton Group, the Detroit River Group and the Kenogami River Formation, however, contain geologic period boundaries. For simplicity, the legend shows the latter two units within the period representing the dominant part of the unit. The legend lists units in stratigraphic order with the oldest unit at the base of each period, such that unit 52e is older than unit 52d. This practice is followed so as to conform with the organization of the Precambrian part of the legend. Each chronostratigraphic subdivision lists northern Ontario units followed by southern Ontario units. Detailed mapping has been conducted in southern and eastern Ontario, and in the area of the Niagara Escarpment, whereas northern Ontario has been mapped at a reconnaissance scale, supplemented by compilation of drilling records.

The Paleozoic rocks of southern and northern Ontario (units 49 to 58) were deposited unconformably on the eroded Superior and Grenville provinces. The Paleozoic rocks of southern Ontario occur within the Michigan and Appalachian basins and parts of the St. Lawrence Platform. In northern Ontario, Paleozoic strata are restricted to the Hudson Bay Basin, the Moose River Basin, and isolated outliers. Lithostratigraphic and faunal similarities in these widely separated regions suggest intermittent interconnection of these areas and a formerly more extensive Paleozoic cover, an interpretation supported by the presence of numerous outliers (not shown) distributed across the Canadian Shield. Sedimentation was predominantly in a shallow marine environment with minor episodes of continental deposition. The distribution and character of the sediments was largely a function of spatial variation in water depth, determined by tectonic uplift, the balance between chemical and clastic sedimentation and the amount of terrigenous input.

Mesozoic deposits (unit 60) occur in the Moose River Basin of northern Ontario (Mattagami Formation and Mistuskwia Beds), and the Hudson Bay Basin where the Evans Strait Formation has been recently discovered underlying a small area. The strata are mainly unconsolidated, continentally derived sediments.

Ultramafic lamprophyre and kimberlite dikes and small plutons (unit 59), shown by the diamond symbol, are commonly of Jurassic age. These rocks intrude the Paleozoic rocks of southern Ontario, the Abitibi subprovince and the James Bay Lowland. Occurrences are known throughout the rest of the province, but have not been systematically mapped.

FAULTS

Two major classes of faults and shear zones are shown on the map:

1. Those faults traceable in surface exposures are shown as long dashes.
2. Those faults cutting Precambrian basement rocks, and not known to affect overlying Phanerozoic platform units, and faults cutting lower Paleozoic strata, but not extending to the surface, are shown as short dashes.

Geological and geophysical evidence has been used to identify faults and shear zones. Many fault and shear zone systems are several hundred metres in width and subsidiary faults produce an anastomosing pattern. Space considerations dictate depiction of only the trace of the central part of regional-scale fault systems. Faults and shear zones are not classified as active or inactive. No assessment of seismic risk is implied in selection of faults for display on the map. In areas with abundant major faults, the faults displayed are regionally the most important features and commonly related to major crustal structures.

Shear zones within the Superior Province occur within subprovinces, form subprovince boundaries and represent both brittle and ductile regimes. The Murray Fault, in the Southern Province, separates deformed, metamorphosed Huronian strata in the south from less deformed Huronian strata in the Elliot Lake area. Major faults in the northern part of Lake Superior control the formation of the Lake Superior graben and the thickness of Keweenawan strata. The boundary between the Grenville and southern provinces is the crustal-scale, southeastward-dipping Grenville Front Tectonic Zone. The boundary between the Central Gneiss Belt and the Central Metasedimentary Belt as well as the boundaries between subsidiary tectonic units are commonly defined by shear zones. In southern Ontario, the faults shown cutting Phanerozoic strata on the map have greater than 3 m of stratigraphic offset. A number of faults controlling the location of petroleum occurrences offset Lower Paleozoic strata, and are not exposed at surface.

Compilation And Production

This geological map of Ontario was compiled mainly from maps and reports of the Ontario Geological Survey, the Geological Survey of Canada, and the geological surveys of Manitoba, Quebec, New York, Minnesota and Michigan. In addition, the compilation incorporated unpublished maps and reports on file with the Ontario Geological Survey, university theses, papers in professional journals, aeromagnetic maps, gamma ray spectrometric and gravity maps, aerial photographs and satellite images. A complete reference list for the map and explanatory notes is provided in The Geology of Ontario (Ontario Geological Survey 1991).

The map was compiled by teams for each subprovince of the Superior Province, the Southern Province and the Grenville Province, and for the Phanerozoic rocks (Figure 1). The compilers for each unit or area are as follows:

Province, subprovince, unit or area	Compiler(s)
Sachigo subprovince	I.A. Osmani
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Phanerozoic rocks	M.D. Johnson, R.K. Bezys, D. Williams, A. Henry
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Manitoba	W. Weber, M.T. Corkery, R.K. Bezys
Quebec	M. Rive

Minnesota	D. Southwick, T.J. Boerboom
New York	Y. Isachsen
Michigan	R. Reed

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Parts of the map have benefitted from reviews by B.V. Sandford, formerly of the Geological Survey of Canada, and K.D. Card of the Geological Survey of Canada.

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