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MAP P.3597–Revised

PRECAMBRIAN GEOLOGY

HUDSON BAY AND JAMES BAY LOWLANDS REGION INTERPRETED FROM AEROMAGNETIC DATA

WEST SHEET

Scale 1:500 000

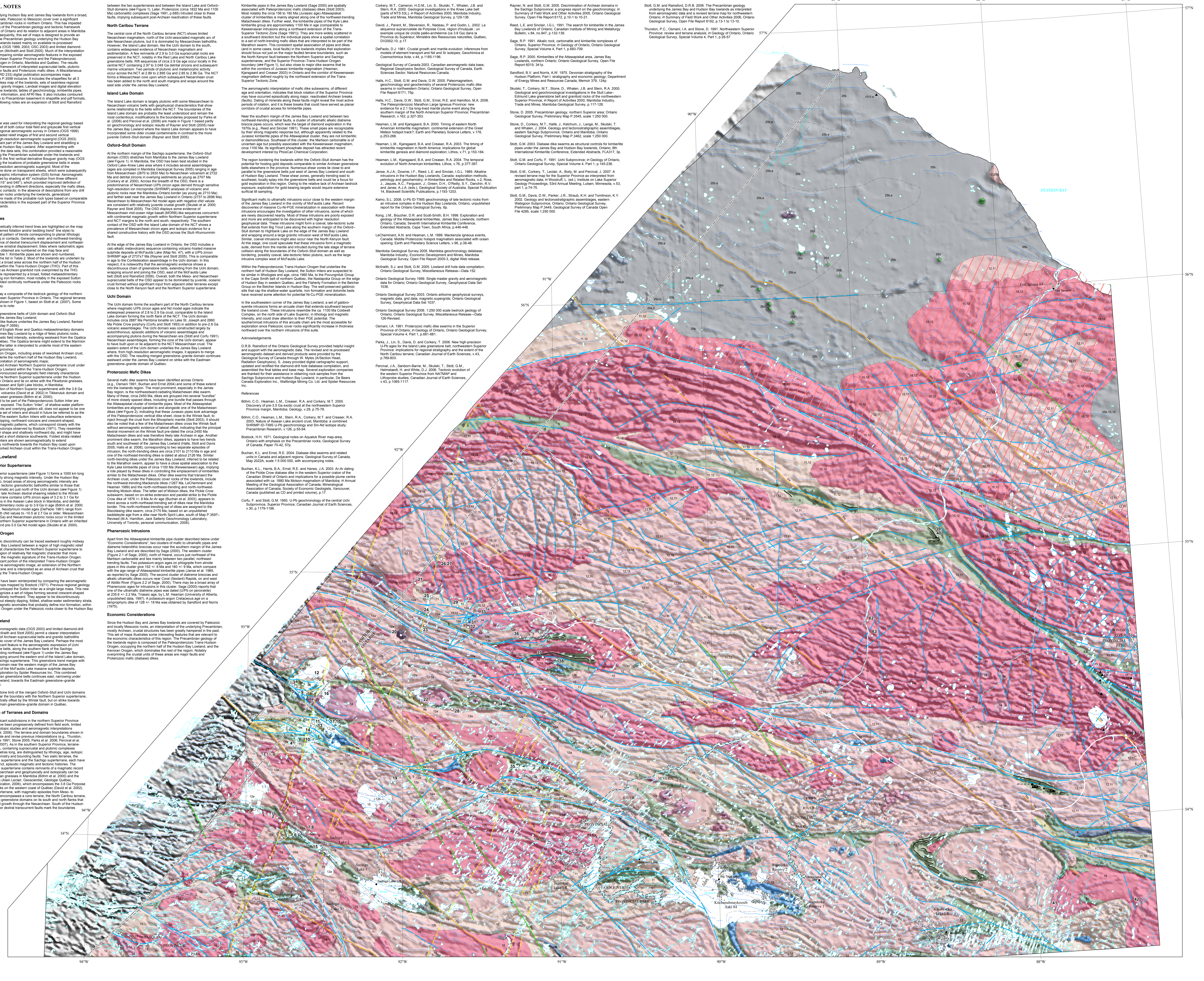


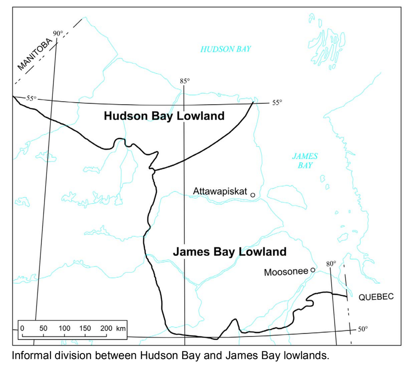
Table 1. Geochronology of Precambrian rocks, Phanerozoic ultrabasic intrusions and kimberlite pipes.

Map No.	Rock Type	Reference	UTM zone	UTM east	UTM north	Crystallization Age (Ma)	Maximum Deposition Age (Ma)	Inherited Age (Ma)	Metamorphic Age (Ma)	ЄNd	DePaolo Nd Model Age (Ga)
1	quartz-rich wacke	1	15	503609	5995692		2863.2±0.7				
2	biotite granite	1	15	513188	5992377	2723±6					
3	quartz+feldspar porphyry	1	15	518939	6047828	2717±3					
4	hornblende+biotite tonalite gneiss	1	15	519988	6022428	2848±7					
5	aphyric dacite tuff	1	15	519989	6047178	2726±2		2742, 2752			
6	biotite tonalite	1	15	522267	5986363	2863.3±0.7					
7	conglomerate	1	15	522717	5985941		2863.8±0.7				
8	quartz-rich conglomerate	1	15	522788	5985927		2865±1				
9	arkose	1	15	523989	6044128		2713±5				
10	sandstone	1	15	526778	6026659		2722.6±2.7				
11	fragmental felsic volcanic	1	15	527687	6031850	2718.2±1.0					
12	hornblende granodiorite	1	15	527589	6050927	2715±8		2747			
13	quartz+feldspar porphyritic rhyolite	1	15	528034	6030203	2722.5+6.1/-4.4					
14	sandstone	1	15	528218	6028675		2709.4±1.7				
15	quartz porphyry in mafic volcanic	1	15	530988	5978727	2857±2					
16	hornblende granodiorite	1	15	531389	6042727	2710±6					
17	sandstone	1	15	534147	6030004		2718.7±2				
18	felsic tuff	1	15	534147	6030004	2720.9±0.9					
19	biotite tonalite	1	15	560489	6007926	2855±5			2758		
20[a]	carbonatite	1	15	563590	6069227	1822±96					
21	biotite granodiorite	1	15	569291	6091076	2846±5		2872	2717		
22	fragmental felsic volcanic	1	15	572780	6040336	2732.4±1.0					
23	biotite tonalite	1	15	573664	6073414	2822.0±0.8					
24	biotite granodiorite	1	15	574901	6078016	2722.5±2					
25	hornblende+biotite tonalite gneiss	1	15	576191	6085526	2814±4		3209, 3572	2741		
26	biotite tonalite gneiss	1	15	580041	6101226			3292, 2854			
27	granite dike	1	15	580041	6101226	2690-2711					
28	biotite tonalite	1	15	585390	6038676	2733.7±1.7		2849±12			
29	foliated tonalite	1	15	587062	6081622	2701.1+4.0/-1.8		2745, 2840			
30	hornblende granodiorite	1	15	591879	6044115	2718.7±1.5					
31	gabbro	1	15	591290	6075281	2716±1.3					
32	intermediate tuff	1	15	591575	6072948	2718.1+2/-1.8					
33	hornblende granodiorite-monzonite	1	15	595691	6077926	2714±8		2813, 2720			
34	quartz+feldspar porphyry	1	15	603214	6041472	2730.4±1.3		2735.6±2.2			
35	plagioclase porphyry	1	15	613019	6014137	2724.6±1.0			2715.1±1.5		
36	hornblende granodiorite	1	15	613376	6069023	2716.2±1.2					
37	felsic tuff	1	15	622884	6060853	2718.1±0.9					
38	rhyodacite tuff	1	15	628783	6059926	2838±1.1		2846.6±1.3			
39[b]	feldspar porphyritic granodiorite	2	16	403925	6104905	2726±6 (max) 2710±7(min)		ca. 2780		-1.69	3.10
40[b]	quartz-rich grit at Precam.-Paleoz. contact	2	16	403925	6104905		2668 to 2745^				
41[b]	tonalite-quartz diorite	2	16	440617	5946704	2727±4				0.83	2.84
42[b]	granodiorite	2	16	475190	5945618	2696±3		2886±12		0.03	2.91
43[b]	tonalite gneiss	2	16	484785	5961820	2683±5		2729±5		0.89	2.78
44[b]	tonalite to granodiorite gneiss	2	16	485636	5964254	2813±4			ca. 2740	1.70	2.86
45[b]	biotite tonalite gneiss	2	16	492417	5945180	2700±4				0.91	2.83
46[b]	biotite tonalite to granodiorite	2	16	498283	5963777	2715±5					
47[b]	intermediate volcanic (McFaulds Lake)	2	16	563126	5850462	2737±7				1.13	2.84
48[b]	hornblende-biotite quartz diorite to diorite	2	16	593549	5824221	2724.3±0.8					
49[b]	quartz diorite	2	16	605500	5832171	2728±5				1.44	2.80
50[b]	quartz diorite	2	16	621021	5864670	2710±4				2.44	2.71
51[b]	quartz-rich grit at Precam.-Paleoz. contact	2	17	306189	5854792		2664 to 2770^				
52[c]	MacFayden 1 kimberlite	3	17	301516	5862943	177.2±1.3					
53[c]	Charlie (C1) kimberlite	3	17	302167	5861400	179.9±1.6					
54[d]	Uniform (U1) kimberlite	4	17	303979	5863163	180					
55[f]	Golf (G1) kimberlite	5	17	309956	5866796	156±2					
56[f]	Alpha-1North kimberlite	5	17	312386	5842382	156±2					
57[c]	Bravo "A" kimberlite	3	17	305529	5857130	179.4±2.2					
58[c]	Bravo "B" kimberlite	3	17	305529	5857130	175.7±1.8					
59[c]	Kyle 1 kimberlite	4	16	608467	5813846	1123±20					
60[c]	Kyle 5 alnoite	4	16	616617	5882214	1076.2±3.8					
61[b]	granodiorite gneiss	2	16	609277	5787608	2690±3		2787±6, ca.2900		-0.34	2.95
62	K-feldspar megacrystic granodiorite	6	16	372388	6072085	>2705±2				-1.11	2.95
63	quartz diorite	6	16	373801	6065609	2709.1±0.8				-1.06	3.02
64[e]	alkalic ultrabasic diatreme breccias	7	17	306976	5573404	152±8					
65[e]	alkalic ultrabasic diatreme breccias	7	17	336646	5574811	180±9					
66[c]	alkalic ultrabasic diatreme breccias	8	17	439311	5574837	235.6±2.2					
67	Goldray carbonatite	9	17	493247	5586109	1884±2					
68[g]	Argor carbonatite	9	17	525869	5629661	1950					

Notes and Abbreviations

Methods
All U-Pb zircon thermal ionization mass spectrometry (TIMS) except:
[a] K-Ar biotite
[b] U-Pb zircon sensitive high-resolution ion microprobe (SHRIMP)
[c] U-Pb perovskite
[d] U-Pb perovskite (SHRIMP)
[e] K-Ar phlogopite
[f] Rb-Sr phlogopite
[g] Pb-Pb
^ Range of detrital zircon ages

References
1. Stone 2005 (and references therein). Note that originally published UTM coordinates, which were in NAD 27, have been converted here to NAD 83 values.
2. Rayner and Stott 2005.
3. Heaman and Kjarsgaard 2000.
4. Heaman, Kjarsgaard and Creaser 2004.
5. Kong, Boucher and Scott-Smith 1999.
6. Kamo 2008.
7. Janse et al. 1989.
8. Heaman, unpublished 1997 (in Sage 2000).
9. Kwon, unpublished 1986 (in Sage 1991).
(See "References" section of Marginal Notes.)



Informal division between Hudson Bay and James Bay lowlands.

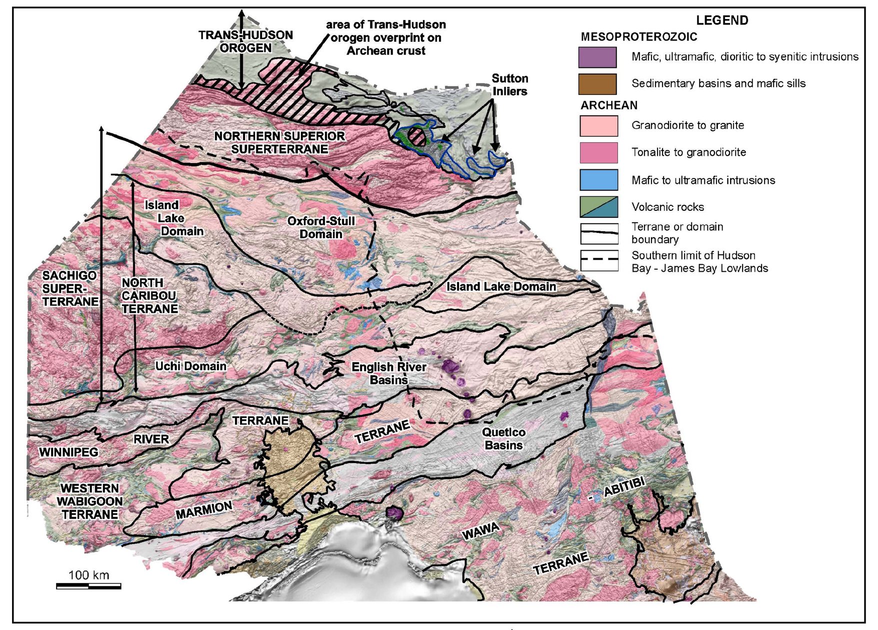


Figure 1. Regional tectonic subdivisions of northern Ontario (after Stott et al. 2007).

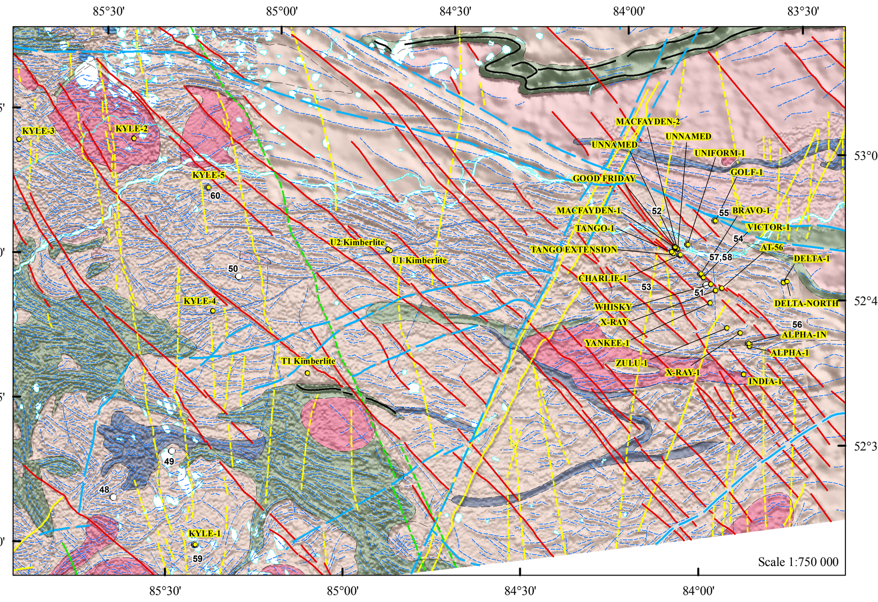


Figure 2. Close-up of the Attawapiskat cluster of kimberlite pipes on an aeromagnetic image that also highlights Proterozoic mafic (diabase) dikes.

MARGINAL NOTES

between the two superterranes and between the Island Lake and Oxford–Stull domains (see Figure 1). Later, Proterozoic (circa 1822 Ma and 1100 Ma) carbonatitic complexes (Sage 1991, p.685) intruded close to these faults, implying subsequent post-Archean reactivation of these faults.

North Caribou Terrane

The central core of the North Caribou terrane (NCT) shows limited Neoarchean magmatism, north of the Uchi-associated magmatic arc of late Neoarchean plutons, but it is dominated by Mesoarchean batholiths. However, the Island Lake domain, like the Uchi domain to the south, contains widespread evidence of Neoarchean magmatism and sedimentation. A few remnants of 2.9 to 3.0 Ga supracrustal rocks are preserved in the NCT, notably in the Red Lake and North Caribou Lake greenstone belts. Rift sequences of circa 2.9 Ga age occur locally in the central NCT containing 2.97 to 3.048 Ga detrital zircons and subsequent marine volcanism. Two periods of plutonic and metamorphic activity occur across the NCT at 2.89 to 2.895 Ga and 2.85 to 2.86 Ga. The NCT forms a Mesoarchean core upon which subsequent Neoarchean crust has been added to the north and south margins and wraps around the east side under the James Bay Lowland.

Island Lake Domain

The Island Lake domain is largely plutonic with some Mesoarchean to Neoarchean volcanic belts with geophysical characteristics that show some relationship to the belts within the NCT. The boundaries of the Island Lake domain are probably the least understood and remain the most contentious; modifications to the boundaries proposed by Parks et al. (2006) and Percival et al. (2006) are made in Figure 1 based partly on geochronology and isotopic results of Rayner and Stott (2005) near the James Bay Lowland where the Island Lake domain appears to have incorporated some older crustal contaminants in contrast to the more juvenile Oxford–Stull domain (Rayner and Stott 2005).

Oxford–Stull Domain

At the northern margin of the Sachigo superterrane, the Oxford–Stull domain (OSD) stretches from Manitoba to the James Bay Lowland (see Figure 1). In Manitoba, the OSD has been best studied in the Oxford Lake–Knee Lake area where it includes several assemblages (ages are compiled in Manitoba Geological Survey 2005) ranging in age from Mesoarchean (2870 to 2830 Ma) to Neoarchean volcanism at 2722 Ma and detrital zircons in overlying sediments as young as 2707 Ma (Corkery et al. 2000). Across the breadth of the OSD, there is a predominance of Neoarchean U/Pb zircon ages derived through sensitive high-resolution ion microprobe (SHRIMP) analyses of volcanic and plutonic rocks near the Manitoba–Ontario border (as young as 2710 Ma) and farther east near the James Bay Lowland in Ontario (2737 to 2696 Ma). Neoarchean to Mesoarchean Nd model ages with positive εNd values are consistent with relatively juvenile crustal growth (Skulski et al. 2000; Rayner and Stott 2005). The OSD displays some evidence of Mesoarchean mid-ocean ridge basalt (MORB)-like sequences concurrent with continental magmatic growth within Northern Superior superterrane and NCT margins to the north and south, respectively. The southern contact of the OSD with the Island Lake domain of the NCT shows a prevalence of Mesoarchean zircon ages and isotopic evidence for a shared constructive history with the OSD across the Stull–Wunnummin fault.

At the edge of the James Bay Lowland in Ontario, the OSD includes a calc-alkalic metavolcanic sequence containing volcanic-hosted massive sulphide deposits at McFaulds Lake (Map No. 47), with a U/Pb zircon SHRIMP age of 2737±7 Ma (Rayner and Stott 2005). This is comparable in age to the Confederation assemblage in the Uchi domain. In this respect, it is noteworthy that the aeromagnetic evidence shows a discontinuous chain of greenstone belts, extending from the Uchi domain, wrapping around and joining the OSD, east of the McFaulds Lake belt (Stott and Rainsford 2006). Overall, both the Meso- and Neoarchean supracrustal belts of the OSD appear to be dominated by juvenile, oceanic crust formed without significant input from adjacent older terranes except close to the North Kenyon fault and the Northern Superior superterrane.

Uchi Domain

The Uchi domain forms the southern part of the North Caribou terrane where magmatic U/Pb zircon ages and Nd model ages indicate the widespread presence of 2.8 to 2.9 Ga crust, comparable to the Island Lake domain forming the north flank of the NCT. The Uchi domain includes circa 2887 Ma Pembina tonalite on Lake St. Joseph and 2860 Ma Pickle Crow porphyry (Corfu and Stott 1993) in addition to pre-2.8 Ga volcanic assemblages. The Uchi domain was constructed largely by autochthonous, episodic additions of volcanic assemblages and accompanying plutons during the Neoarchean era (Stott and Corfu 1991). Neoarchean assemblages, forming the core of the Uchi domain, appear to have built upon or lie adjacent to the NCT Mesoarchean crust. The eastern extent of the Uchi domain underlies the James Bay Lowland where, from high-resolution aeromagnetic images, it appears to merge with the OSD. The resulting merged greenstone–granite domain continues eastward under the James Bay Lowland on strike with the Eastmain greenstone–granite domain of Québec.

Proterozoic Mafic Dikes

Several mafic dike swarms have been identified across Ontario (e.g., Osmani 1991; Buchan and Ernst 2004) and some of these extend into the lowlands region. The most prominent, especially in the James Bay region, is the northwestward-radiating Matachewan dike swarm. Many of these, circa 2450 Ma, dikes are grouped into several "bundles" of more closely spaced dikes, including one bundle that passes through the Attawapiskat cluster of kimberlite pipes. Most of the Attawapiskat kimberlites are aligned parallel to and alongside one of the Matachewan dikes (see Figure 2), indicating that these Jurassic pipes took advantage of this Paleoproterozoic vertical dike sheet, close to the Winisk fault, to inject through the crust from the lithospheric mantle (Stott 2003). It should also be noted that a few of the Matachewan dikes cross the Winisk fault without aeromagnetic evidence of lateral offset, indicating that the principal dextral movement on the Winisk fault pre-dated the circa 2450 Ma Matachewan dikes and was therefore likely late Archean in age. Another prominent dike swarm, the Marathon dikes, appears to have two trends south and southwest of the James Bay Lowland (Halls, Stott and Davis 2005; Halls et al. 2008), corresponding to two separate episodes of intrusion; the north-trending dikes are circa 2101 to 2110 Ma in age and one of the northeast-trending dikes is dated at about 2126 Ma. Similar north-trending dikes under the James Bay Lowland, inferred to be related to the Marathon swarm, appear to have a close spatial association to the Kyle Lake kimberlite pipes of circa 1100 Ma (Keweenawan) age, implying a role played by these dikes in controlling the emplacement of kimberlites similar to the Matachewan dikes. Other dike swarms that transect the Archean crust, under the Paleozoic cover rocks of the lowlands, include the northwest-trending Mackenzie dikes (1267 Ma, LeCheminant and Heaman 1989) and the north-northeast-trending and north-northwest-trending Molson dikes. The latter set of Molson dikes, the Pickle Crow subswarm, based on on-strike extension and parallel-strike to the Pickle Crow dike of 1876 +/- 8 Ma Ar-Ar age (Buchan et al. 2003), appears to trend across a north-northeast-trending set of dikes near the Manitoba border. This north-northeast-trending set of dikes are assigned to the Biscotasing dike swarm, circa 2175 Ma, based on an unpublished baddeleyite age from a dike near North Spirit Lake, south of Map P.3597–Revised (M.A. Hamilton, Jack Satterly Geochronology Laboratory, University of Toronto, personal communication, 2008).

Phanerozoic Intrusions

Apart from the Attawapiskat kimberlite pipe cluster described below under "Economic Considerations", two clusters of mafic to ultramafic pipes and diatreme heterolithic breccias occur near the southern margin of the James Bay Lowland and are described by Sage (2000). The western cluster (Figure 2.1 of Sage, 2000), north of Hearst, occurs just northeast of the Martison carbonatite and lies mainly between two parallel, northeast-trending faults. Two potassium-argon ages on phlogopite from alnoite pipes in this cluster give 152 +/- 8 Ma and 180 +/- 9 Ma, which compare with the age range of Attawapiskat kimberlite pipes (Janse et al. 1989, as reported by Sage 2000). The second cluster of diatreme breccias and alkalic ultramafic dikes occurs near Coral (Sextant) Rapids, on and west of Abitibi River (Figure 2.2 of Sage, 2000). There may be a broad array of Phanerozoic ages for intrusions in this cluster. Sage (2000) reports that one of the ultramafic diatreme pipes was dated (U/Pb on perovskite) at 235.6 +/- 2.2 Ma, Triassic age, by L.M. Heaman (University of Alberta, unpublished data, 1997). A potassium-argon Cretaceous age on a lamprophyric dike of 128 +/- 18 Ma was obtained by Sandford and Norris (1975).

Economic Considerations

Since the Hudson Bay and James Bay lowlands are covered by Paleozoic and locally Mesozoic rocks, an interpretation of the underlying Precambrian, mostly Archean, crustal structures has been greatly hampered in the past. This set of maps illustrates some interesting features that are relevant to the economic characteristics of this region. The Precambrian geology of the lowlands region is composed of the Paleoproterozoic Trans-Hudson Orogen, occupying the northern half of the Hudson Bay Lowland, and the Kenoran Orogen, which dominates the rest of the region. Notably overprinting the crustal units of these areas are major faults and Proterozoic mafic (diabase) dikes.

Kimberlite pipes in the James Bay Lowland (Sage 2000) are spatially associated with Paleoproterozoic mafic (diabase) dikes (Stott 2003). Most notably the circa 156 to 180 Ma (Jurassic age) Attawapiskat cluster of kimberlites is mainly aligned along one of the northwest-trending Matachewan dikes. Further west, the kimberlite pipes of the Kyle Lake kimberlite group are approximately 1100 Ma in age (comparable to Keweenawan intrusions along a northward extension of the Trans-Superior Tectonic Zone (Sage 1991)). They are more widely scattered in a southward direction but the individual pipes show a spatial correlation to a set of north-trending mafic dikes that are interpreted to be part of the Marathon swarm. This consistent spatial association of pipes and dikes (and in some cases, local faults) in the lowlands implies that exploration should focus not just on the major faulted terrane boundaries, such as the North Kenyon fault between the Northern Superior and Sachigo superterranes, and the Superior Province–Trans-Hudson Orogen boundary (see Figure 1), but also close to major dike swarms that lie within the corridors of Jurassic kimberlite magmatism (Heaman, Kjarsgaard and Creaser 2003) in Ontario and the corridor of Keweenawan magmatism defined roughly by the northward extension of the Trans-Superior Tectonic Zone.

The aeromagnetic interpretation of mafic dike subswarms, of different age and orientation, indicates that block rotation of the Superior Province may have occurred episodically along major, reactivated Archean breaks (faults). Dating of minerals along these faults might reveal the most active periods of rotation, and it is these breaks that could have served as planar corridors of crustal access for kimberlite pipes.

Near the southern margin of the James Bay Lowland and between two northeast-trending sinistral faults, a cluster of ultramafic alkalic diatreme breccia pipes occurs, which was the target of diamond exploration in the 1970s (e.g., Reed and Sinclair 1991). These small pipes are recognizable by their strong magnetic response but, although apparently related to the Jurassic kimberlite pipes of the Attawapiskat cluster, they are not kimberlitic or diamondiferous. Southeast of this cluster, the Martison carbonatite is of uncertain age but possibly associated with the Keweenawan magmatism, circa 1100 Ma. Its significant phosphate deposit has attracted recent development interest by PhosCan Chemical Corporation.

The region bordering the lowlands within the Oxford–Stull domain has the potential for hosting gold deposits comparable to similar Archean greenstone belts elsewhere in the province. Numerous shear zones lie close to and parallel to the greenstone belts just west of James Bay Lowland and south of Hudson Bay Lowland. These shear zones, generally trending east to southeast, locally splay into the greenstone belts and could be a focus for gold exploration in this region. Owing to the relative lack of Archean bedrock exposure, exploration for gold-bearing targets would require extensive surficial till sampling.

Significant mafic to ultramafic intrusions occur close to the western margin of the James Bay Lowland in the vicinity of McFaulds Lake. Recent discoveries of massive Cu-Ni-PGE mineralization in association with these intrusions encourages the investigation of other intrusions, some of which are newly discovered nearby. Most of these intrusions are poorly exposed and more are anticipated to be discovered with higher resolution geophysical data. These intrusions might form a coeval, late-tectonic suite that extends from Big Trout Lake along the southern margin of the Oxford–Stull domain to Highbank Lake on the edge of the James Bay Lowland and wrapping around a large granitic intrusion west of McFaulds Lake. Similar, coeval intrusions might also occur near the North Kenyon fault. At this stage, one could speculate that these intrusions form a magmatic suite, derived from the mantle and intruded during the late stage of terrane collision along the boundaries of the Oxford–Stull domain as well as bordering, possibly coeval, late-tectonic felsic plutons, such as the large intrusive complex west of McFaulds Lake.

Within the Paleoproterozoic Trans-Hudson Orogen that underlies the northern half of Hudson Bay Lowland, the Sutton Inliers are suspected to be similar in lithologies and age, circa 1960 Ma, to the Povungnituk Group in the Cape Smith belt of northern Québec, the Nastapoka Group on the edge of Hudson Bay in western Québec, and the Flaherty Formation in the Belcher Group on the Belcher Islands in Hudson Bay. The well-preserved gabbroic sills that cap the shallow-water quartzite, iron formation and dolomite beds have received some attention for potential Ni-Cu-PGE mineralization.

In the southwestern corner of the James Bay Lowland, a set of gabbro-syenite intrusions forms an arcuate chain that extends southward beyond the lowland cover. These intrusions resemble the ca. 1100 Ma Coldwell Complex, on the north side of Lake Superior, in lithology and magnetic intensity, and could draw attention to their PGE potential. The southernmost intrusions of this arcuate chain are the most accessible for exploration since Paleozoic cover rocks significantly increase in thickness northward over the northern intrusions of this suite.

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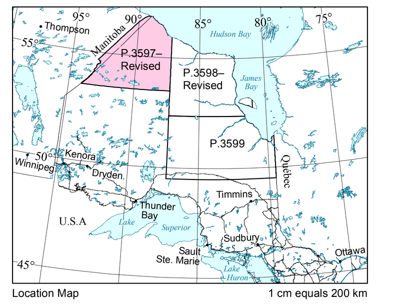
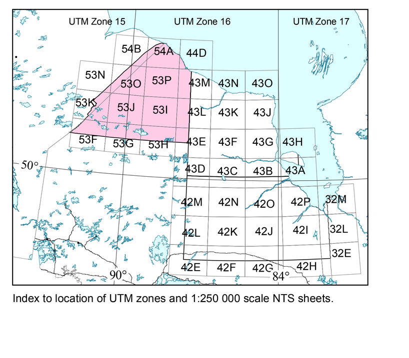
LEGEND



Location Map



Index to location of UTM zones and 1:250 000 scale NTS sheets.