Tectonic Domains of the Central Wabigoon Area

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Introduction

The Marmion terrane is an old crustal block in the central Wabigoon area of northwest Ontario. The 3.0 Ga Marmion terrane is thought to represent an early continental fragment that was assembled, along with a variety of other crustal fragments, volcanic arcs and sedimentary prisms, into the Superior Province at 2.7 Ga (see Figure 1). New mapping and geochronology have defined several new domains within the Marmion terrane, each of which appears to represent a unique magmatic event. The domains are described below and provide insight on evolution of the Marmion terrane from 3.0 to 2.7 Ga.

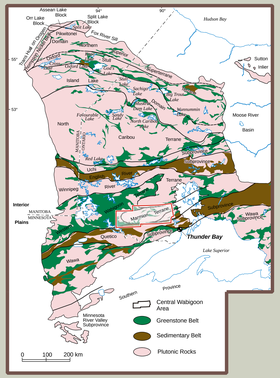

Figure 1. Regional subdivisions of the western Superior Province

Geology of the Central Wabigoon area

The central Wabigoon area extends 30 to 270 km west of Thunder Bay in northwest Ontario and includes the towns of Upsala, Ignace, Atikokan and Mine Centre. Typical of granite-greenstone areas in the Wabigoon Subprovince, it is underlain by thin, bifurcated and anastomosed greenstone belts separated by large, commonly oval masses of felsic plutonic rocks. The greenstone belts, named in Figure 2, are composed primarily of mafic volcanic rocks with lesser components of intermediate to felsic volcanic rocks, gabbro and sedimentary rocks.

Well bedded wacke siltstone sequences (Quetico sedimentary sequences) of the Quetico Subprovince extend along the south margin of the central Wabigoon area. Plutonic rocks are divided into seven major suites (Figure 2). Two major sets of transcurrent faults of late-Archean age transect the area. Archean rocks of the central Wabigoon area are cut by Proterozoic diabase dikes and sills. The larger masses of Proterozoic diabase in the eastern part of the area are associated with the Nipigon Sill Complex.

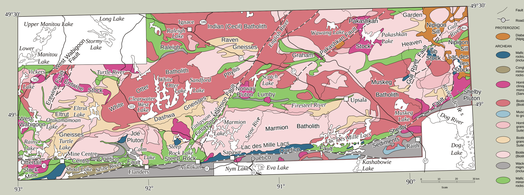

Figure 2. Geology of the central Wabigoon area. (Note, the following names are abbreviated: "Heaven" is Heaven Lake greenstone belt, "Garden" is Garden Lake greenstone belt, "Lumby" is Lumby Lake greenstone belt, and "Raleigh" is Raleigh Lake greenstone belt.)

Table 1: U-Pb Age data for volcanic, plutonic and sedimentary units of the Central Wabigoon Area.

Map No.	Sample No.	Area	UTM east	UTM north	Rock Type	Greenstone belt or Domain	Assemblage or plutonic suite	Crystallization Age	Detrital grain age Maximum Depositional Age (Bold)	Inherited Age	Metamorphic Age	Reference
Marmion domain												
1	OD84-10	S of Lumby Lake	624430	5427561	tonalite gneiss	Marmion Batholith	Tonalite Gneiss	3009+/-8				1
2	OD85-10	N of Sleep Rock Lake	598425	5408925	mafic (hornblende) tonalite	Marmion Batholith	Hornblende Tonalite	3001.6+3.4/-2.3				1
3		Little Falls Lake	596880	5409971	sandstone	western Marmion Domain	Finlayson East		**2997.1+/-0.9**			3
4	Z1	Finlayson Lake	601040	5414724	conglomerate, sandstone	western Marmion Domain	Finlayson East		3002, 3001, 3001, 2999, 2999, **2997**			2
5	05D0126	Elizabeth Property	593580	5405780	qtz diorite or subvolcanic intrusion	western Marmion Domain	Finlayson East	2999.4+/-0.7				4
6	Sample 1	W of Lumby Lake	621029	5437763	felsic tuff	Lumby	Lumby South	2999.4+/-2.9				5
7	DD97-4	Lumby Lake	623930	5423549	rhyolite	Lumby	Lumby South	3001.1+/-1.1				1
8	Sample 2	Jefferson Lake	632109	5433335	quartz porphyry	Lumby	Lumby South	2999.1+/2.0				5
9	DD97-5	S of Pyramid Lake	640328	5441694	rhyolite	Lumby	Lumby North	3013.6+/-1.3				1
10	00KYT-25	W of Raven Lake	622735	5461789	tonalite gneiss	western Marmion Domain	Raven Gneisses	2989+/5-3				6
Whitton domain												
15	96KYT-249	N of Whitton Lake	758394	5478046	felsic dike	Heaven	Whitton	2953.1+/-1.6				1
16	96KYT-252	N of Whitton Lake	757844	5475542	felsic tuff	Heaven	Whitton	2953.7+/-1.3				1
17	96KYT-50	Tony Lake	643036	5440869	felsic tuff	Lumby	Lumby North	2963.3+/-4.5		3016+/-5		1
18	00KYT-24	N of Phyllis Lake	620809	5454850	felsic tuff	Phyllis	Phyllis	2955.8+/-0.8				1
Central Wabigoon domain												
22	00D592	S of Garden Lake	742745	5486637	biotite tonalite	eastern Central Wabigoon	biotite tonalite	2924.1+/-9			2690 titanite lower intercept	8
23	03D593	E of Armstrong Lake	733130	5474740	tonalite gneiss with wacke and gabbro	eastern Central Wabigoon	tonalite gneiss	2937.1+/-1.2*			2722 (monazite)	7
24	05D556	NW of Graham	659562	5465150	biotite tonalite	Central Wabigoon	biotite tonalite	2929+/-4				4
25	DD88-15	Finlayson Lake	604450	5420873	felsic tuff	Finlayson	Finlayson West	2931.4+/-2				1
26		NW of Finlayson Lake	602020	5424440	biotite tonalite	Dashwa Gneiss Complex	biotite tonalite	2936				9
27		NW of Finlayson Lake	597930	5424500	tonalite gneiss	Dashwa Gneiss Complex	tonalite gneiss	2928				9
28	00KYT14	N of Perch Lake	577155	5405380	felsic volcanic fragmental	Perch	Perch	2925.6+/-1.2				1
29	00KYT16	N of Mine Centre	519820	5409812	tonalite gneiss	West Wabigoon Boundary Zone	tonalite gneiss	2924+/-2				6
Bar assemblage												
35	PT1	Bar Lake	629412	5434560	felsic tuff	Lumby	Bar	2897.6+/-2.1		2903 to 2999		1
Hillyer domain												
40	00KYT15	N of Perch Lake	577300	5405566	hornblende tonalite	Hillyer Domain margin	Hornblende Tonalite	2883+/-2				10
41	00KYT11	N of Mine Centre	541452	5415004	hornblende tonalite	Hillyer Domain margin	Hornblende Tonalite	2869+/-4				6
Marmion South Margin domain												
45	DD98-4	Lac des Mille Lacs	693300	5412160	felsic volcanic fragmental	Lac des Mille Lacs	Marmion South Margin	2830.2+/-3.1				1
46	04D557	S of Bedivere Lake	653680	5410603	conglomerate	Lac des Mille Lacs	Wagita Formation		3007, 3006, 3004, 3002 2981, **2927**			7
47		Steep Rock Mine	599316	5409238	tonalite cobble in conglomerate	Steep Rock	Wagita Formation		**2994**			9
Pinecone-Savoy domain												
50	00KYT02	S Gargoyle Lake	637385	5437320	felsic tuff in komatiite	Lumby	Pinecone	2828.3+/-1.8				1
51	05D557	E. of Savoy Lake	650020	5462475	biotite tonalite	Savoy	Biotite Tonalite	2814.0+/-1.2				4
52	05D560	SE of Raven Lake	630017	5457740	biotite tonalite	Savoy	Biotite Tonalite	2817+/-2			2694 (titanite)	4
Dog domain												
55	DD98-6	Lac des Mille Lacs	685620	5418565	hornblende tonalite	Dog	Hornblende Tonalite	2780.7+/-1.8				1
56	05D585	W of Shelby Lake	736906	5440575	tonalite gneiss	Dog	Biotite Tonalite	2773.6+/-1.2				4
57	05D573	S of Buck Lake	723380	5445360	biotite tonalite to granodiorite	Dog	Tonalite Gneiss	2777+/-3				4
58	DD85-3	S of Lac des Iles			tonalite gneiss	Dog	Tonalite Gneiss	2775+/-8		2722+/-3		11
Whistle domain												
60	97KYT-75	E of Whistle Lake	763285	5489530	felsic tuff	Heaven	Whistle	2729+/-2		2813		1
61	DD96-4	E of Whistle Lake	762323	5467740	quartz+feldspar porphyry intrusion	Heaven	Whistle	2727.8+/-1.6		2758 to 2779		1
62	THD-149	E of Legris Lake	760980	5454050	dacite tuff	Lac des Iles	Lac des Iles	2727.8+/-3.3				1
63	DD96-25A	Lac des Iles	745093	5452405	hornblende tonalite	Heaven Domain	Hornblende Tonalite	2727.8+/-1.5				11
73	03D594	S of Upsala	687712	5432346	biotite tonalite	Whisler?	Biotite Tonalite	2716.8+/-3.0			2707+/-37 (titanite)	7
Mine Centre domain *(includes Witch Bay and Puffy Pillow assemblages)*												
64	05D587	Lac des Mille Lacs	692750	5409820	dacite breccia	Lac des Mille Lacs	Puffy Pillow	2725.0+/-1.1				4
65	05D5154	Atikokan airport	600330	5403550	leucogabbro	Steep Rock	Witch Bay	2735.2+/-.8				4
66	05D5133	W of Steep Rock Lake	594658	5402278	quartz porphyritic tonalite	Steep Rock	dike cutting Witch Bay	2729.7+/-1.9		2865		4
67		Steep Rock Mine	599490	5406790	sandstone	Steep Rock	unknown sedimentary sequence		**3002.6+/-1.4**			12
68	11	Cairn Lake	565210	5399360	felsic volcanic	Mine Centre	Mine Centre	2722.3+1.3/-1.1				13
70	10	E of Mine Centre	533350	5399380	quartz-phyric volcanic rock	Mine Centre	Mine Centre	2727.0+/-1.2				13
71	9	NW of Bad Vermillion L	535420	5398310	tonalite	Mine Centre	Biotite Tonalite	2728.1+1.8/-1.3				13
72	8	NW of Bad Vermillion L	519320	5399550	quartz porphyritic rhyolite	Mine Centre	Mine Centre	2727.8+&/-2.6				13
Dismal assemblage												
68	97KYT-60	Steep Rock Mine	599320	5407880	ultramafic lapilli tuff	Steep Rock	Dismal			2997, 2995, 2780		1
Winnipeg River subprovince												
75	00KYT06	S Garden Lake	714296	5484815	rhyolite	Garden	Garden	2725.5+/-1.3				1
76	00KYT34	NE Wawang Lake	667280	5482630	tonalite gneiss		Tonalite Gneiss	2712+/-2				10
Western Wabigoon terrane												
80	00KYT19	NW of Ethrut Lake	537761	5436468	tonalite gneiss	West Wabigoon boundary	Tonalite Gneiss	2732				10
81	00KYT23	N of Irene Lake	605622	5454407	hornblende tonalite	Grit gneisses	Hornblende Tonalite	2721.3+/-1				6
Quetico subprovince												
90		E of Legris Lake	765886	5452545	conglomerate		Seine Group		**2696**			14
91	DD86-11	S of Atikokan	604211	5397904	wacke	Quetico sequence	Quetico		3009, 3009,3004, 3004, 2701, **2680**			15
92	3A2	S of Atikokan	602950	5398943	wacke	Quetico sequence	Quetico		**2707**			15
93	8B2	S of Atikokan	602610	5397940	wacke	Quetico sequence	Quetico		**2704**			15
94	11A2	S of Atikokan	602064	5398020	wacke	Quetico sequence	Quetico		**2739**			15
95	DD86-10	S of Atikokan	600612	5398020	wacke	Quetico sequence	Quetico		2901, **2701**			15
96	15C2	S of Atikokan	599510	5398130	wacke	Quetico sequence	Quetico		**2796**			15
97	27B2	SW of Atikokan	594866	5399500	wacke	Quetico sequence	Quetico		2798, **2706**			15
98	33A2	SW of Atikokan	592060	5398600	wacke	Quetico sequence	Quetico		2719, **2709**			15
99	35B2	SW of Atikokan	588187	5398584	wacke	Quetico sequence	Quetico		**2792**			15
100	45C2	S of Calm Lake	573300	5397880	wacke	Quetico sequence	Quetico		2709, **2704**			15
101	101DZ	S of Calm Lake	567275	5397826	wacke	Quetico sequence	Quetico		2913, 2787, **2704**			15
102	101EZ	S of Calm Lake	566962	5397558	wacke	Quetico sequence	Quetico		2724, 2705, **2700**			15
103	103BZ	S of Calm Lake	565867	5398206	wacke	Quetico sequence	Quetico		**2788**			15
104	12	E of Mine Centre	538409	5399392	tonalite clast in conglomerate	Shoal Basin	Seine Group	2696.1+5/-3	**2696**			13
105	6 and 7	S of Rainy Lake	504500	5395650	wacke	Couchiching sequence	Quetico		3059, 3057, 3056, 2940, 2830, 2726, 2721, 2714, 2712, 2704, **2704**			13
106	00KYT22	N of Irene Lake	605242	5455570	conglomerate		Seine Group?		2718, 2710, 2707, **2700**			6
107	Sample 5	Bear Pass	501770	5395540	felsic sill in Couchiching sediments	Couchiching sedimentary sequence				2717, 2825		13
Late plutonic rocks												
Biotite Granite suite												
110	05D546	Savanne	707560	5423735	K-feldspar megacrystic granite	Muskeg Batholith	Biotite Granite	2686+/-2		2690		4
111	WO686	White Otter Lake	587900	5433989	coarse grained biotite granite	White Otter Batholith	Biotite Granite	2685+/-2			2667 (titanite)	16
112	00KYT28	N of Ignace	611745	5488309	biotite granite	Indian (Cook) Lake Batholith	Biotite Granite	2671				10
Sanukitoid suite												
115	00KYT08	Roaring River			monzonite	Roaring River Complex	Sanukitoid	2697				10
116	03D591	S of Lac des Iles	747519	5447943	hornblende diorite	Shelby Lake Batholith	Sanukitoid	2690+/-0.9			2674, 2667 (titanite)	8
117	ON-050	Sapawe	622794	5453985	quartz monzonite	Blalock Pluton	Sanukitoid	2688+/-4				15
118		N of Atikokan	595442	5417355	biotite-hornblende granite	Eye-Dashwa Pluton	Sanukitoid	2684+/-25**			2665 (titanite)	17
119	13	Rainy Lake	509600	5397240	quartz monzodiorite	Otterbat Pluton	Sanukitoid	2686.1+1.5/-1.4				13
Tonalite Gneiss suite												
125	04D580	Raith	729017	5411947	tonalite to granodiorite gneiss	Raith gneisses	Tonalite Gneiss	2673.0+/-1.1			2657 (titanite)	7
Lac des Iles suite												
130	DD88-22	Tib Lake	733478	5458252	Gabbro Pegmatite	Tib Stock	Lac des Iles	2685.9+/-1.6				11
131	Murphy 1	Lac des Iles	747853	5453420	Gabbro Pegmatite	Mine Block Intrusion	Lac des Iles	2693.3+/-1.3				18
132	DD85-2	Lac des Iles	746868	5451861	Gabbro Pegmatite	Mine Block Intrusion	Lac des Iles	2689.0+/-1.0				11
133	JP01-04		346300***	5504619	Gabbro	Johnpine Gabbro	Lac des Iles?	2699.0+/-0.9				18
134	GK01-08		335900***	5495503	Gabbro	Gelke Gabbro	Lac des Iles	2687.6+/-1.2				18
135	99TRH-47e/82	Garden Lake	315100***	5485328	Gabbro	Garden Lake Gabbro	Lac des Iles	2686.1+/-2.2				18
136	00TRH-092		331113***	5453513	Gabbro	Lac des Iles East Gabbro	Lac des Iles	2671+/-11				18

References

1 Tomlinson et al. (2003)
2 Fralick and King (1996)
3 P. Fralick unpublished data (2001)
4 Davis (2006)
5 Davis and Jackson (1988)
6 Tomlinson et al. (2001)
7 Davis (2005)
8 Kamo (2004)
9 D. Davis unpublished work reported in Stone, Kamineni and Jackson (1992)
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12 D. Davis unpublished work (1986) reported in Stone et al. (2002)
13 Davis, Poulsen and Kamo (1989)
14 D Davis unpublished work (1984)
15 Davis, Pezzutto and Ojakangas (1990)
16 Davis (1993)
17 Zartman and Kwak (1990)
18 Heaman and Easton (2006)

[1]he dated zircon grains are rounded and probably are derived from the sedimentary component of the rock
*U-Pb whole rock age
UTM coordinates are in meters for Zone 15, NAD 83.
***Coordinates are in Zone 16, NAD83 and are mainly east of the present area

Domains of the Central Wabigoon area

Figure 3. Distribution of U/Pb ages in the central Wabigoon and adjacent areas.

Table 2: Crustal domains of the Central Wabigoon Subprovince

Domain	Shape and contact relations	Rock types	Magmatic Ages (Ma)	Crystallization Pressure of hornblende bearing plutonic rocks (kbars)	Possible tectonic affinity
Marmion	Fragmented block 30 x 100 km; rifted on N and S; intruded by younger plutons	Biotite tonalite; tonalite gneiss; mafic greenstone belts	2889 to 3013	4.8 to 6.1	An early continental block possibly developed in a magmatic arc
Whitton	Fragmented 10 x 100+km belt; locally rifted on S and intruded by younger plutons on N and S	Dominantly mafic greenstone sequences	2953 to 2963	-	Continental margin aror obducted oceanic material
Central Wabigoon	Elongate 50 x 300+km; fragmented; intrudes Whitton	Biotite tonalite; tonalite gneiss mafic greenstone sequences	2924 to 2936	4.5 to 9.2 increasing easterly	Dominantly felsic continental magmatic arc
Hillyer	Oval 20 x 70 km with sheared margins	Biotite tonalite; tonalite gneiss; hornblende tonalite	2869 to 2883	4.2 to 8.3 increasing easterly	Uplifted continental margin or accreted indenter
Marmion South Margin	Elongate 10 x 100 km; Unconformably overlies Marmion to N and in fault contact with Quetico to S	Conglomerate, felsic volcanics, diorite and gabbro dikes	2830	-	Rift margin
Pinecone Savoy	Irregular, bifurcated and tapered block 60+ km long; cuts Whitton and Marmion	Biotite tonalite; hornblende tonalite; mafic to ultramafic volcanics; clastic sediments	2814 to 2828	3.7 to 8.0	Rift and rift-related plutonism
Dog	Elongate 30 x 100 kmntrudes Marmion	Biotite tonalite; tonalite gneiss; hornblende tonalite	2773 to 2780	4.8 to 8.3	Continental magmatic arc
Whistle	Elongate 50 x 100+ km; intrudes Dog	Biotite tonalite, hornblende tonalite, mafic to felsic volcanic sequences	2716 to 2729	5.6to 8.0 increasing westerly	Continental magmatic arc
Mine Centre	Discontinuous, elongate 20 x 200+ km; locally in fault contact with older domains to N	Mainly mafic to felsic volcanic sequences	2722 to 2735	-	Accreted continental margin arc

More than 85 samples that are representative of a broad range of Archean rocks in the central Wabigoon area have been dated by the U-Pb method. The age determinations (Table 1) show as many as a dozen magmatic events ranging between 3000 and 2670 Ma as illustrated in Figure 3. In some instances, the age determinations or clusters of age determinations correspond with greenstone-belt assemblages although the majority of age clusters span a variety of intrusive and extrusive magmatic rocks and are considered to represent distinct sub-blocks or domains of the central Wabigoon area. Each domain appears to have a unique geographic extent as well as a unique magmatic history although in many instances, the boundaries of domains are poorly constrained and tectonic relations with neighbouring domains, whether they be allochthonous or autochthonous, are unknown. Nine major domains and several assemblages are recognized within the central Wabigoon area (Table 2 and Figure 4) with other clusters of age determinations representing neighbouring terranes such as the Winnipeg River and Western Wabigoon terranes and Quetico Subprovince. The youngest age determinations in Table 1 correspond with suites of post-tectonic plutonic rocks that appear to have been emplaced after development of the domain architecture. In some areas such as at White Otter Lake and Ignace, post-tectonic biotite granite batholiths have possibly intruded as large sills and preclude definition of the domains.

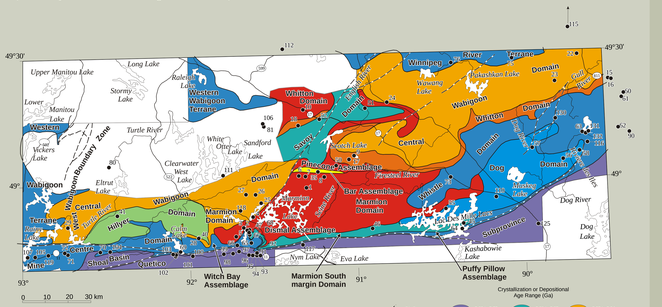
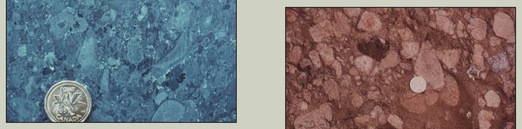


Figure 4. Domains and assemblages of the central Wabigoon area. Numbers refer to age determinations in table 1. Posttectonic batholiths and a lack of age determinations or mapping preclude definition of domains within the blank areas.

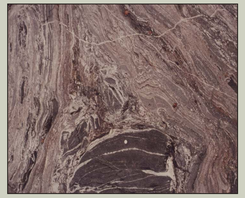
Amphibolite mylonite at base of West Wabigoon Terrane (2700 Ma).



Ashrock of the Dismal Assemblage (2730 Ma).

Conglomerate of the Marmion South Margin Domain (perhaps 2830 Ma).

Gneissic tonalite of the Central Wabigoon Domain (2925 Ma).



Gneisses of the Savoy Domain (2817 Ma).

Pillowed lavas of the Witch Bay Assemblage (2730 Ma).

Tonalite and gabbro dike of Marmion Batholith (3000 Ma).

Conclusions

Up to nine domains are recognized in the central Wabigoon area and each appears to represent a distinct magmatic event, which generated new crustal material. These events are spaced throughout a 300 million year period from 3.0 to 2.7 Ga. Although some magmatic events, such as the circa 2.7 Ga Kenoran Orogeny are recognized throughout the western Superior Province, others are much less widely observed. Hence, the central Wabigoon area appears to contain an exceptional record of late Mesoarchean to Neoarchean magmatism.

The series of magmatic events combined with the litho-structural characteristics of the domains produced by each event are a basis for speculation on the tectonic evolution of the central Wabigoon area. The evolution appears to have involved progressive growth of the 3.0 Ga Marmion micro-continent through multiple additions of magmatic and crustal material in continental arcs and through accretion of exotic material. At least one rifting event affected the Marmion micro-continent before it was assembled with other terranes into the Superior craton at 2.7 Ga.

The domain architecture and domain boundary relations provide some useful guidance for mineral exploration. The majority, but by no means all, known mineral showings occur in younger domains and posttectonic plutons. Although gold is associated mainly with late transcurrent faults, somewhat earlier faults that have thrust volcanic sequences of the Witch Bay assemblage onto older strata west of Atikokan, are also mineralized with gold. These deformed thrust faults provide new exploration targets for gold. Also, the mafic to ultramafic and iron-rich Dismal assemblage that extends from Atikokan to Sapawe has potential for copper-nickel and PGE mineralization.

Parts of this poster may be quoted if credit is given. It is recommended that reference be made in the following format:

Stone,D. and Davis, D.W. Tectonic Domains of the Central Wabigoon Area.Ontario Geological Survey, poster, Ontario Exploration and Geoscience Symposium, Sudbury, Ontario. December 12-13, 2006.

Precambrian Geoscience Section

Ontario Geological Survey