

LEGEND

This lithotectonic map builds upon previous geological maps of the Red Lake area (see Fig. 2) to which the reader is also referred. Some lithological and structural information compiled from these sources are indicated by c either preceding the legend code or associated with the structural symbol.

NEOARCHEAN (2800–2600 Ma)

LATE-TO POST-TECTONIC PLUTONIC ROCKS

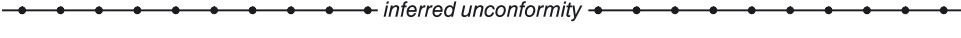
16e	Syenodiorite dykes, Bateman township.
16d	Diabasic gabbro, pyroxenite±lamprophyre dykes that cut the dioritic phase of the McKenzie Island and Dome stocks, and locally transect Balmer strata in Balmertown and in northwestern East Bay.
16c	Muscovite-bearing monzogranite to granodiorite, exposed on Medicine Stone Lake.

16b	Granodiorite, and minor monzogranite syenogranite and diorite; massive to weakly foliated, relatively unaltered and unrecrystallized biotite-hornblende and hornblende-biotite granodiorite±monzogranite±quartz monzonite, commonly with megacrysts of K-feldspar and cut by pink granite pegmatite dykes. Includes main phase of the 2704 ± 1.5 Ma Killala-Baird batholith (U-Pb #10) and associated granodiorite dykes (U-Pb #14); the 2701 ± 1.5 Ma Wilmar west granodiorite intrusion (U-Pb #30), and the ca. 2699 Ma Cat Island pluton (U-Pb #46, #47); characterized by calc-alkaline affinity, and moderate to strong LREE-enrichment, with PRIM-normalized Th/Nb >>1.
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16a	Tonalite, quartz diorite: biotite- and/or hornblende-bearing tonalite and quartz diorite (diorite); weakly foliated to massive; includes diorite dykes that cut gold mineralization at the Madsen Mine (U-Pb #18).
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ENGLISH RIVER ASSEMBLAGE (< ca. 2700 Ma)

15	Pebble conglomerate; poorly bedded, poorly sorted, mafic volcanic-derived pebble conglomerate containing detritus dated at ca. 2.99 Ga, ca. 2.94 Ga, ca. 2.92 Ga, ca. 2.85 Ga, ca. 2.74 Ga, ca. 2.72 Ga, and ca. 2.7 Ga; foliated to schistose, garnet-bearing, amphibolite-facies. Found at Madsen Mine locality U-Pb #19 (see Inset A).
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PRE- TO SYN-TECTONIC (post-volcanic) INTERMEDIATE TO FELSIC PLUTONIC ROCKS

14d	Monzodiorite, quartz monzonite, and granodiorite of sanukitoid affinity; includes granodiorite and hornblende±biotite phyric monzodiorite (minor) of the Faulkenham Lake stock; monzodiorite has high Mg#, Ni, K ₂ O, Ba and Sr, and is enriched in LREE; granodiorite is foliated and locally charged with felsic and mafic xenoliths.
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14c	Granodiorite: variably foliated and recrystallized biotite, locally quartz-porphyritic granodiorite±monzogranite±quartz monzonite, commonly with megacrysts of K-feldspar and cut by pink granite pegmatite dykes. Locally cut by metagabbroic dykes (unit 16d). Includes 2720 ± 2 Ma phase of the McKenzie Island stock (U-Pb #28) and 2720 +7/-5 Ma Abino granodiorite (U-Pb #35), both cut by auriferous quartz-tourmaline veins; the central 2718 ± 1 Ma phase of the Dome stock (U-Pb #21); and a 2714 ± 4 Ma porphyry (U-Pb #43) that cuts gold mineralization on the 16th level of the Red Lake mine. Calc-alkaline affinity with moderate LREE-enrichment, and Th/Nb >>1.
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14b	Tonalite: variably foliated and recrystallized biotite-hornblende and hornblende-biotite tonalite±quartz diorite±quartz monzodiorite±ronchjemite; porphyritic on Hammell Lake.
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14a	Diorite: variably foliated and recrystallized diorite; includes locally augite- and hornblende-bearing, includes mafic border phases to the ca. 2.72 Ga Dome and McKenzie Island stocks.
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PRE- TO SYN-TECTONIC (post-volcanic) MAFIC PLUTONIC ROCKS

13c	Gabbroic anorthositic±diorite±gabbro: weakly foliated to massive with lath-shaped plagioclase phenocrysts at Para Lake.
13b	Gabbro±leucogabbro±diorite and associated hornblende amphibolite; locally with plagioclase phenocrysts up to 1 cm (Balmer Lake).
13a	Ultramafic intrusive rocks of unknown age or affinity, typically magnetite-bearing, locally coarse-grained, massive; serpentinite, serpentized peridotite±gabbro; includes the Golden Arm pyroxenite.

GRAVES PLUTONIC SUITE

12c	Granodiorite-tonalite±quartz monzonite: variably foliated medium-grained to K-feldspar porphyritic, magnetite-bearing biotite- and less commonly hornblende-bearing granodiorite-tonalite±quartz monzonite, typically cut by pink weathering granitic veins; includes the 2731 +3/-2 Ma Little Vermilion Lake batholith (U-Pb #26) and a 2736 +3/-2 Ma felsic dyke that cuts the upper Trout Bay basalt sequence (U-Pb #3); calc-alkaline, moderate LREE-enrichment, with PRIM-normalized Th/Nb >>1.
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12b	Diorite±quartz diorite±syenodiorite: may be plagioclase or augite porphyritic and includes the 2720 ± 1.5 Ma Red Crest quartz diorite stock (U-Pb #11) and marginal phases to the Douglas Lake pluton.
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12a	Tonalite: equigranular, fine- to medium-grained, foliated to gneissic biotite±hornblende-bearing tonalite±ronchjemite, including the main phase of the 2734 ± 2 Ma Douglas Lake pluton (U-Pb #1). Calc-alkaline, moderate LREE-enrichment, with PRIM-normalized Th/Nb >>1.
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GRAVES ASSEMBLAGE (ca. 2733 Ma)

11	Intermediate to felsic calc-alkaline pyroclastic rocks including, buff to grey weathering, 2732.8 +1.4/-1.2 Ma tuff (U-Pb #24), and biotite- and plagioclase-phyric lapilli tuff; with low TiO ₂ , LREE-enriched (type F1 felsic), PRIM-normalized Th/Nb >>1; may include fine-grained, likely synvolcanic hornblende-biotite tonalite±diorite.
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HUSTON ASSEMBLAGE (<2742 Ma >2733 Ma)

10c	Wacke; well-bedded, well-graded feldspathic wacke interbedded with lithic wacke (turbiditic facies), argillite with associated volcanoclastic and/or epiclastic rocks; well-preserved primary sedimentary structures include grading, flame structures, scour, and mud rip-up clasts; rare crossbedding.
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10b	Marble±chert±sulphides and associated skarn, e.g. adjacent to the Dome stock.
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10a	Conglomerate, immature to well-rounded volcanic, plutonic and sedimentary clasts that locally show evidence of intense hydrothermal alteration; dominated by iron-formation clasts south of Balmer Lake.
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CONFEDERATION ASSEMBLAGE (ca. 2748 to 2739 Ma)

9	Undifferentiated intermediate volcanic rocks.
9k	Diorite±quartz diorite, syenodiorite: commonly plagioclase porphyritic with tholeiitic affinity and FIII-type REE profiles, including the Howey diorite; likely subvolcanic to the tholeiitic Heyson mafic volcanic sequence.
9j	Light-weathering, feldspar- and quartz- (±blue quartz) porphyritic, intrusive and/or hypabyssal rocks with 20–30% phenocrysts; includes the 2742 +3/-2 Ma Brewis (Balmer Lake) porphyry (U-Pb #44).

Heyson Sequence (ca. 2739 Ma; dominantly tholeiitic affinity)

9i	Intermediate volcanic rocks of calc-alkaline affinity; andesitic to dacitic flows, commonly plagioclase phyric; with low TiO ₂ (<1%), LREE-enriched, and PRIM-normalized Th/Nb >>1.
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9h	Mafic volcanic rocks of tholeiitic affinity including massive to pillowed, high-TiO ₂ basalt (>1.5%), pillow breccia, locally plagioclase-phyric; with flat to LREE-enriched profiles and PRIM-normalized Th/Nb >1; associated gabbro.
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9g	Felsic volcanic rocks consisting of rhyolitic flows that may be quartz-phyric, spherulitic, and locally exhibit primary lobate structure, including 2746 +36/-17 Ma spherulitic rhyolite near Madsen (U-Pb #17); lesser pyroclastic tuff including 2739 ± 3 Ma rhyolite crystal tuff west of Keg Lake (U-Pb #36); characterized by tholeiitic (type FII) affinity with flat to LREE-enriched REE profiles, high total REE contents and pronounced negative Eu anomalies; commonly cut by northeast-trending gabbro sills.
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9f	Intermediate pyroclastic rocks of tholeiitic affinity (see also unit 9e), generally dacite±andesite tuff, lapilli tuff and pyroclastic tuff; commonly cut by quartz porphyry dykes (unit 9j) near Madsen.
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9e	Intermediate volcanic (flow) rocks of tholeiitic affinity; massive and pillowed andesite±dacite flows typically containing lath-shaped plagioclase phenocrysts, including pillowed andesitic flows south of the Killala-Baird batholith; characterized by flat to modest LREE-enrichment, locally with high TiO ₂ (>1%), and PRIM-normalized Th/Nb >1.
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McNeely Sequence (ca. 2744–2742 Ma; dominantly calc-alkaline affinity)

9d	Andesitic calc-alkaline flows; pillowed, aphyric.
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9c	Mafic volcanic rocks of calc-alkaline affinity including pillowed and massive basalt, local hyaloclastite, with low TiO ₂ (<0.8), LREE-enriched, and PRIM-normalized Th/Nb >3; associated gabbro.
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9b	Intermediate volcanic rocks of calc-alkaline affinity; dacitic to andesitic±rhodacitic pyroclastic±epiclastic rocks and lesser massive flows; commonly plagioclase phyric and interbedded with minor argillite; includes 2742 ± 1 Ma dacite tuff interbedded with epiclastic rocks at Wolf Bay (U-Pb #9), 2742 +3/-2 Ma lapilli tuff interlayered with pumaceous tuff at Martin Bay (U-Pb #13), 2744 ± 1 Ma lapilli tuff forming the hanging wall to the Madsen Mine (U-Pb #15), dacitic tuff exposed along western McKenzie Island (U-Pb #22 and #27) and 2748 +10/-5 Ma heterolithic tuff near Balmertown (U-Pb #38); characterized by LREE-enriched (type FI), with PRIM-normalized Th/Nb >>1; commonly cut by quartz porphyry dykes (unit 9j) near Madsen.
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9a	Oligomictic conglomerate derived mainly from underlying Balmer assemblage; variably dominated by chemical sedimentary clasts (Wolf Bay) or basaltic clasts (north shore of Red Lake); minor lithic wacke and/or argillaceous beds.
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MESOARCHEAN (2999–2800 Ma)

TROUT BAY MAFIC PLUTONIC SUITE

8b	Anorthositic gabbro, gabbroic anorthosite intrusive into chemical sedimentary rocks of the Trout Bay assemblage; pervasive quartz-tourmaline alteration in southeastern Trout Bay.
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8a	Gabbro±ultramafic rocks intrusive into the Trout Bay assemblage; locally plagioclase megacrystic; with variable flat to LREE-depleted REE profiles and PRIM-normalized Th/Nb <1 to >1. May include gabbro that is geochemically similar to upper tholeiitic basalt; may include 2870 ± 15 Ma quartz gabbro (U-Pb #42) at the Red Lake mine.
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TROUT BAY ASSEMBLAGE (>ca. 2853 Ma (lower basalt); <ca. 2853 Ma (upper basalt))

7g	Upper chert-magnetite iron-formation±interbedded siltstone, wacke, argillite.
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7f	Upper tholeiitic basalt: pillowed, strong carbonate alteration reflected by pale buff weathering; characterized by low TiO ₂ (<1%), LREE-depletion and PRIM-normalized Th/Nb <1.
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7e	Fragmental unit containing intermediate to mafic volcanic fragments and banded iron-formation clasts, possibly representing an explosive pyroclastic tuff deposit containing accidental clasts of chemical sedimentary rocks (unit 7d).
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7d	Lower chert-magnetite iron-formation.
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7c	Intermediate to felsic calc-alkaline volcanic rocks including rhyodacite flows and well-bedded and graded 2855 ± 3 Ma dacitic lithic tuff, tuff and ash at mouth of Slate Bay (U-Pb #23) and 2852 ± 1 Ma dacitic lapilli tuff in Hoyles Bay (U-Pb #32); notable amphibole alteration on southeast shore of Slate Bay.
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7b	Clastic and epiclastic rocks (U-Pb #2) with minor interbedded intermediate tuff dated at ca. 2853 ± 1 Ma (U-Pb #4), siltstone, and pelite.
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7a	Lower tholeiitic basalt: strongly foliated to gneissic pillowed flows and fine- to coarse-grained garnet-amphibolite, rarely plagioclase-phyric equigranular flows; tholeiitic basalt, low TiO ₂ (<1%), LREE-depleted with PRIM-normalized Th/Nb <1; associated gabbro.
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BRUCE CHANNEL ASSEMBLAGE (ca. 2894 Ma)

6d	Magnetite-chert iron-formation.
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6c	Biotite schist, paragneiss; amphibolite facies metasedimentary rocks, mainly occurring within the contact thermal aureole of the Cat Island pluton.
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6b	Wacke, siltstone, argillite iron-formation: wacke siltstone-argillite displays local low-angle, centimetre-scale cross-stratification (east shore of McKenzie Channel, inset B) and is typically interbedded with, and transitional to, overlying magnetite-chert ironstone; some intraformational conglomerate.
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6a	Intermediate to felsic calc-alkaline pyroclastic rocks dominated by well-bedded, poorly graded tuff and lapilli tuff of rhyolitic to dacitic composition with minor pumaceous interbeds includes 2893.5 +1.4/-1.2 Ma rhyolite on Bruce Channel (U-Pb #29) and 2894 ± 2 Ma tuff east of Balmer Lake (U-Pb #45); LREE-enriched (type FI).
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SLATE BAY ASSEMBLAGE (<ca. 2903 Ma >ca. 2850 Ma, dominated by Ball assemblage detritus)

5d	Siltstone-, mudstone-dominated clastic sequence.
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5c	Quartz arenite±siltstone±feldspathic wacke±conglomerate: quartz arenite is locally graded with crossbedding, luchs-site-bearing; conglomerate contains grit-size angular lasts of fine-grained felsic volcanics, free quartz and luchsite.
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5b	Chert±marble±argillite±magnetite locally basal to Slate Bay quartz arenite sequence, rarely internal (i.e. north of Martin Bay).
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5a	Basal conglomerate, locally developed and/or preserved (i.e. through Tomato Lake); conglomerate is polymictic and/or is dominated by volcanic clasts.
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BALL PLUTONIC SUITE

4b	Gabbro±diorite intrusive into Ball assemblage and geochemically similar to lower and middle Ball mafic volcanic sequences.
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4a	Serpentinite, serpentized peridotite, and rare pyroxenite, variably carbonatized, intrusive into, and geochemically similar to the Ball assemblage; trace elements indicate affinity with Ball komatiite and komatiitic basalt (unit 3m).
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BALL ASSEMBLAGE (>ca. 2940 Ma and <ca. 2925 Ma)

3m	Pillowed komatiite flows West Narrows, Trout Bay, flat to LREE-depleted, with PRIM-normalized Th/Nb >1.
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3k	Upper tholeiitic basaltic to andesitic flows with flat to LREE-depleted profiles and PRIM-normalized Th/Nb >1; interlayered with and overlying upper rhyolite unit.
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3j	Upper calc-alkaline felsic flows: rhyolitic flows (type FI) intercalated with dacitic flows (unit 3i); white weathering, typically 3–15% quartz phenocrysts, locally spherulitic ² texture.
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3i	Upper intermediate calc-alkaline flows: white-weathering dacite dated at 2925.4 +3.4/-2.9 Ma (U-Pb #6); typically massive and aphyric, locally with minor quartz phenocrysts and plagioclase microphenocrysts.
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3h	Chert-magnetite; chert-magnetite±sulphides, typically overlying and transitional with stromatolitic chert-marble unit.
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3g	Chert-marble: locally stromatolitic including coarse-grained wollastonite- and/or diopside-bearing metamorphosed equivalents along northern margin of belt, north of Pipestone Bay; displays pseudofossil mound 'Atikokania' on west shore Golden Arm.
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3f	Chert-magnetite ironstone.
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3e	Middle calc-alkaline basaltic sequence: massive basalt flows with low TiO ₂ (<0.6), modest LREE-enrichment, and high PRIM-normalized Th/Nb; interbedded magnetite-chert ironstone.
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3d	Felsic calc-alkaline volcanic rocks; thin rhyodacitic and rhyolitic flows and tuff including 2940.1 +2.4/-1.7 Ma massive rhyolite flows (U-Pb #5), typically quartz phyric and sericite-bearing, locally plagioclase phyric; with pronounced LREE-enrichment (type FI) and high PRIM-normalized Th/Nb.
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3c	Intermediate calc-alkaline volcanic rocks: dacitic to lesser andesitic rocks dominated by pyroclastic tuff and lapilli tuff, locally spherulitic in Pipestone and Sadler bays ±siltstone; characterized by pronounced LREE-enrichment and high PRIM-normalized Th/Nb; may include altered pillowed basalt north of Rowan Lake.
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3b	Spinifex-textured komatiite and massive komatiitic basalt exposed near Middle Bay and Miles Creek; with flat to LREE-enriched profiles with PRIM normalized Th/Nb >2; associated serpentinite and gabbro.
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3a	Lower basalt: massive to locally pillowed, calc-alkaline basalt with low TiO ₂ (<0.7%), modest LREE-enrichment and primitive mantle (PRIM) normalized Th/Nb >2.
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BALMER PLUTONIC SUITE

2b	Gabbro±diorite±leucogabbro intrusive into Balmer assemblage ² , locally plagioclase phyric (i.e. south shore of central Red Lake); includes Campbell diorite.
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2a	Serpentinite, serpentized peridotite, pyroxenite: typically actinolite-bearing, locally tremolite and talcose schist; variably carbonatized; intrusive into, and geochemically related to, the ca. 2.99 Ga Balmer assemblage, possibly the intrusive equivalent of the middle Balmer komatiite and komatiitic basalt (units 1) and 1k); may include some ultramafic volcanic rocks and gabbro.
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BALMER ASSEMBLAGE

1q	Pervasively ferroan dolomite altered rocks spatially associated with the Balmer assemblage (i.e. Cochenour area), but of uncertain protolith.
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1p	Upper felsic volcanic rocks: massive, aphyric, fine-grained rhyodacite dated at 2964 +5/-1 Ma (U-Pb #39); with moderate LREE-enrichment (type FII).
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1o	Upper intermediate volcanic rocks; andesitic to dacitic tuffs and flows.
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1n	Upper chert-magnetite ironstone: thinly bedded to thickly laminated.
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1m	Upper tholeiitic basalt flows and associated gabbroic rocks: pillowed and massive flows, aphyric, characterized by TiO ₂ <1.3% and LREE depletion; extensively altered; carbonate-cemented breccia along north shore of central Red Lake may reflect close proximity to unconformity between Meso- and Neoproterozoic volcanic assemblages.
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1k	Middle komatiitic basaltic flows; typically overlying middle komatiite; preserving cumulate and quench textures including "string-beef" clinopyroxene spinifex at Post Narrows; characterized by flat to LREE-depleted profiles.
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1j	Middle komatiite flows; generally preserving cumulate and quench textures, including olivine spinifex-textured komatiite at Campbell Mine (see Inset B) and along the southeastern shore of Golden Arm; pillowed at entrance to Martin Bay; flat to LREE-depleted profiles; may have associated interbedded chert-magnetite iron-formation (Fisher Islands).
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1i	Siltstone, feldspathic wacke±tuff; may have minor associated lithic wacke±mudstone ±argillite; locally pyritiferous.
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1h	Felsic volcanic rocks: quartz-phyric and sericitic flows and tuffs including 2889 ± 3 Ma massive rhyolite (U-Pb #40; see inset B) and rhyodacitic flows (e.g. at Campbell Mine) and 2888 ± 3 Ma pyroclastic breccia and tuff at Coin Lake (U-Pb #20); with modest LREE-enriched profiles (type FI) and low total REE contents.
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1g	Dacitic volcanic rocks: generally pyroclastic including tuff and 2992 +20/-9 Ma lapilli tuff (U-Pb #34) and tuff breccia with clasts more felsic than matrix, locally garnet-bearing reflecting amphibolite facies metamorphism of hydrothermal alteration; includes quartz-feldspar porphyritic horizon associated with McMarmac ore zone; may include altered basalt north and east of Wolf Bay.
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1f	Chert, chert-magnetite ironstone; chert-sulphide (sul); thinly bedded to thickly laminated, locally associated intraformational breccia.
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1e	Middle tholeiitic basaltic flows and associated gabbroic rocks: pillowed and massive (e.g. Slate Bay) tholeiitic flows, commonly variolitic ¹ , interpillow spaces may be filled with hyaloclastic fragments; characterized by TiO ₂ <1.5%; with typically flat, to LREE-depleted profiles; associated magnetite-chert and sulphidic ironstone (unit 1i). Hornblende amphibolite near Ranger Lake.
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1d	Intermediate flows: andesite±basaltic andesite flows, generally occurring at, or close to, the interface between the lower and middle Balmer basalt sequences.
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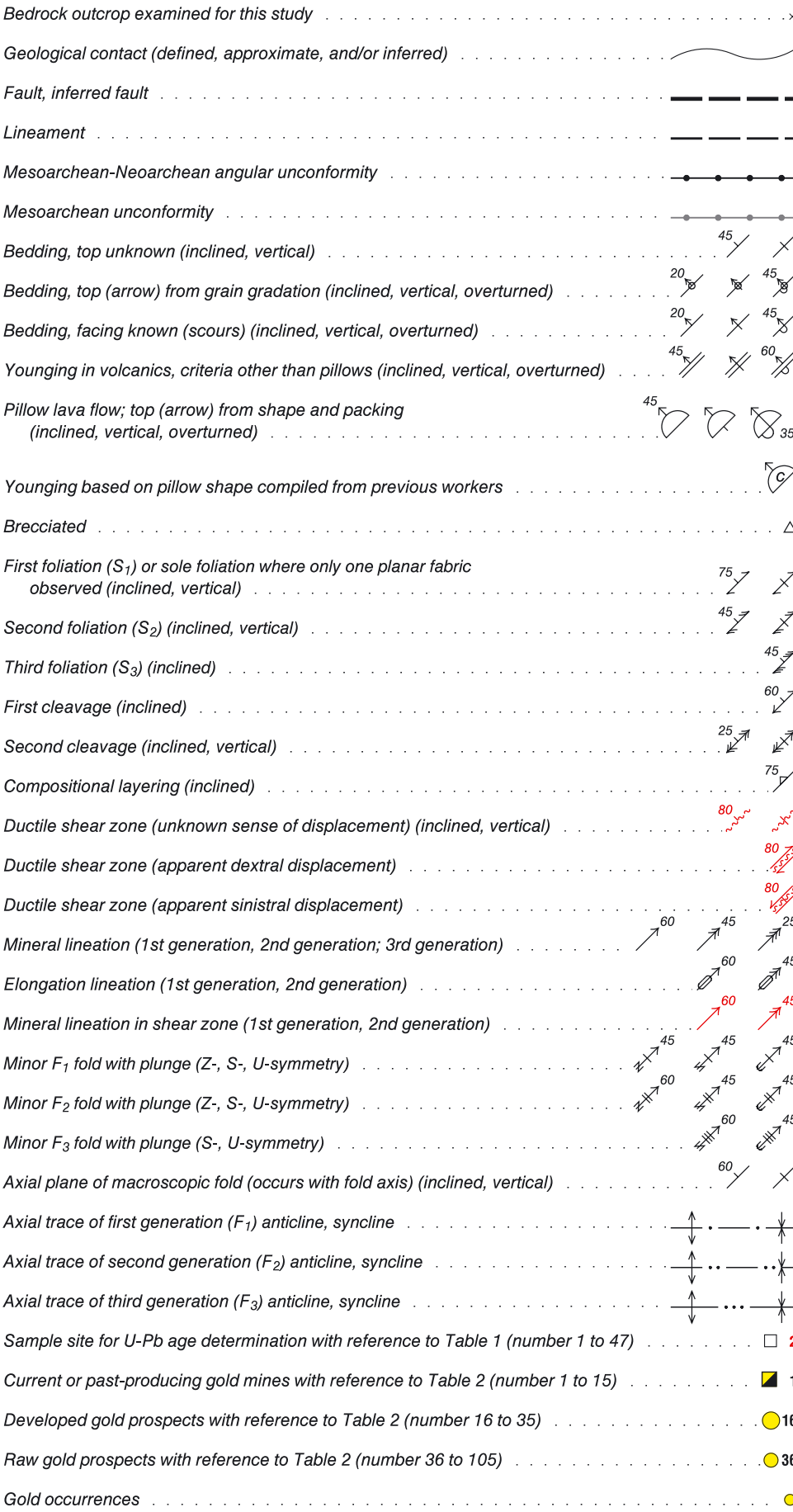
1c	Lower komatiitic basalt flows (Starratt-Olsen, Nungesser Road), locally pillowed and variolitic; with flat to LREE-enriched REE profiles.
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1b	Lower komatiite flows (Russet Lake, Nungesser Road), locally pillowed (Flat Lake road) with variable, LREE-depleted to -enriched REE profiles; ±gabbro.
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1a	Lower pillowed and massive tholeiitic basalt and associated gabbro: flows are typically aphyric, sparsely vesicular, and include basalts characterized by TiO ₂ >1.5% that may show moderate enrichment of light rare earth elements (LREE); commonly cut by quartz-feldspar porphyry dykes east of Beatrice Peninsula, East Bay.
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¹ variolitic basalt indicated on map face by a white dot

² gabbroic rocks intrusive into Balmer assemblage in part may belong to the geochemically similar Trout Bay gabbroic suite



Base metal, PGE occurrences (number 1 to 10)	1
1 Microwave Tower porphyry	6 Zinc Pit No.1, Trout Bay
2 Bug River zinc occurrence	7 Zinc Pit No.2, Trout Bay
3 Hydro Line zinc occurrence	8 L126, 97+75N - Trout Bay PGE
4 Herbo sulphide zone	9 Kilaran Creek Sulphide Zone
5 Hermiston zinc occurrence - Keg Lake	10 Trout Bay PGE