

# Geological Reconnaissance of the Northern Tazin Lake Map Area (NTS 74N), Including Parts of the Ena, Nolan, Zemlak, and Taltson Domains, Rae Province

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## Abstract

*The northern part of the Tazin Lake map area is dominated by plutonic rocks and derived gneisses comprising the Nolan, Ena, and Zemlak lithotectonic domains. The Nolan Domain is mainly made up of weakly deformed and homogeneous ca. 2.6 Ga granitic and granodioritic rocks that are progressively more strained towards the Zemlak Domain boundary to the south, which is marked by mylonitization, widespread partial melting, and the injection of abundant leucogranite derived by crustal melting. This 'tectonic front' is probably composite, with an inferred 1.93 Ga southeasterly trending component in the southwest that has been overprinted in the southeast by 1.91 to 1.90 Ga northeasterly trending structures related to the Black Bay straight belt.*

*The central Zemlak Domain is more heterogeneous, mylonitized, and recrystallized. It probably includes 3.0 and 2.3 Ga plutonic rocks in addition to the 2.6 Ga rocks extending from the Nolan Domain and the 1.93 Ga crustal melt rocks. Supracrustal sequences include the 2.3 Ga Murmac Bay Group, and the more weakly metamorphosed 1.93 to 1.82 Ga Thluicho Lake Group, as well as pelitic gneisses and derived diatexites of unknown age. The Ena Domain, located to the northeast, appears lithologically similar to the Zemlak Domain. Since the Tazin Lake Fault separating the two domains appears to be a late structure without significant displacement, there seems little to justify their distinction.*

*The Taltson Domain, located along the Saskatchewan-Alberta border, comprises many of the same-aged rock types as the Zemlak Domain, but in Saskatchewan is dominated by the 2.02 to 1.97 Ga greenschist facies Waugh Lake Group and the ca. 1.97 Ga Taltson arc-type granodiorite-quartz diorite suite. The Taltson-Zemlak Domain boundary is a ductile mylonite zone with a steep, eastward-increasing metamorphic gradient, such that Waugh Lake Group rocks traced into this zone exhibit upper amphibolite facies metamorphic assemblages. The eastward extension of Taltson Domain rock types suggests that many of the orthogneisses and paragneisses making up the western Zemlak Domain may be derived from Taltson plutons and the Waugh Lake Group, respectively.*

*The southeast-trending structural fabric in the west-central part of the Tazin Lake area may have resulted from ca. 1.93 Ga northeast-directed accretion of the Buffalo Head or some other exotic terrane to the Rae Province margin. Subsequent plate interactions farther west are thought to be responsible for the regional bending of this fabric farther west into the northerly to northeasterly trend characterizing the Taltson Magmatic Zone. The northeasterly trending structural overprint in the eastern part of the area may be a far-field effect of tectonism focused along the 1.91 to 1.90 Ga Snowbird Tectonic Zone.*

**Keywords:** Zemlak Domain, Nolan Domain, Ena Domain, Rae Province, Churchill Province, Uranium City, Taltson Magmatic Zone.

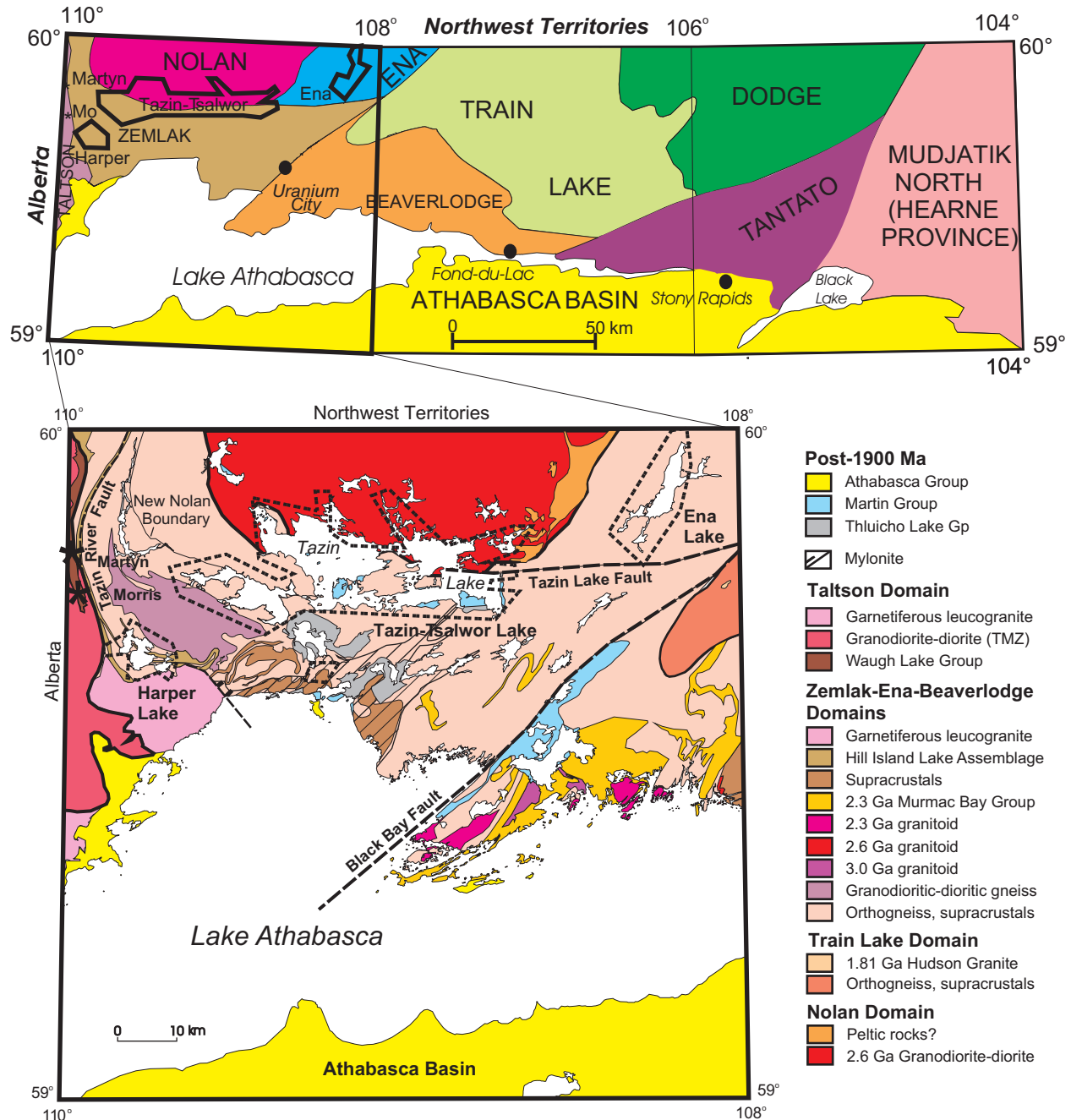
## 1. Introduction

The bedrock geology of the 1:250 000-scale Tazin Lake map area (NTS 74N) is currently being compiled to complete the province's quarter million scale map series and to contribute to the 1:500 000-scale compilation of the Western Churchill Province being undertaken as part of the Western Churchill Metallogeny Project. Although the southern half of the Tazin Lake map area has seen a significant amount of recent re-mapping (Hartlaub and Ashton, 1998; Hartlaub, 1999, Ashton *et al.*, 2000, 2001; Ashton and Hunter, 2003, 2004); the northern half has not been updated since originally mapped between 1950 and 1970. In order to better understand and potentially update these

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ca. 50-year-old maps, brief visits were made to several representative localities with the intention of seeing as many of the previously defined map units as possible. Two weeks were spent investigating each of four areas centred on Ena, Tazin, Tsalwor, and Harper lakes (Figure 1). Since the intent was not to undertake systematic mapping, the scale of work varied with the size of the lake and accessibility. All four areas are accessible by float plane from Stony Rapids.



**Figure 1 - Location map showing lithotectonic domains in the Rae Province of northwestern Saskatchewan; areas mapped in 2005 outlined by heavy black line; Martyn and Morris (Mo) lakes areas visited as part of regional reconnaissance denoted by asterisks. Inset shows geological compilation of Tazin Lake area prior to recent mapping and outlines of areas studied in 2005.**

## 2. Regional Geology

The northern Tazin Lake map area (74N) spans several lithotectonic domains including the Ena, Nolan, Zemplak, and Taltson (Figure 1). The Nolan Domain comprises a relatively well preserved core of upper amphibolite to granulite facies, granitic to granodioritic rocks that have yielded 2640 to 2580 Ma crystallization ages (Van Schmus *et al.*, 1986) and K-Ar metamorphic ages of  $2370 \pm 40$  Ma (Koster and Baadsgaard, 1970). This metamorphosed plutonic suite is bounded to the east by biotite gneisses of inferred sedimentary origin (Koster, 1970; de Zoysa, 1974), which mark a transition into the adjacent Ena Domain. This boundary also marks an important transition in the regional structural fabric from northwest trending in the Nolan Domain to northeast trending in the Ena Domain.

The Zemplak Domain lies south and west of the Nolan Domain and south of the Ena Domain (Figure 1). Recent mapping in the southern part of the domain has shown that it is dominated by variably mylonitized orthogneisses of unknown age. These probably include a variety of plutonic suites based on the presence of *ca.* 3.0, 2.63, 2.3, and 1.9 Ga intrusions in the Beaverlodge area to the east (Persons, 1983; O'Hanley *et al.*, 1994; Hartlaub, 2004; Hartlaub *et al.*, 2004). A number of supracrustal successions overlie the orthogneiss basement in the Zemplak Domain, including the *ca.* 2.3 Ga (Ashton and Hunter, 2003) Murmac Bay (quartzite-dolostone-basalt-pelite), 1.93 to 1.82 Ga (Ashton and Hunter, 2004; R. Berman, pers. comm., 2005) Thluicho Lake (conglomerate-arkose-argillite), *ca.* 1.82 Ga (R. Hartlaub, pers. comm., 2003) Martin (redbed-basalt), and *ca.* 1.75 to 1.5 Ga (Saskatchewan Geological Survey, 2003) Athabasca (conglomerate-quartz sandstone) groups. In addition, there are pelitic migmatites and diatexites in the southwestern Zemplak Domain (Ashton and Hunter, 2004), for which the age and origin is unknown. The Hill Island Lake Assemblage of the Northwest Territories (Bostock and van Breemen, 1994) appears to extend southward into Saskatchewan where it was termed the 'pegmatite-migmatite complex' (Koster, 1968). Farther south, the same unit was previously referred to as the 'White Lake metasedimentary rocks' (Koster, 1963). Approaching Lake Athabasca, these rocks swing to the east where they were re-interpreted as mylonitized granitoid rocks (Ashton and Hunter, 2004), leaving questions about the nature of the entire unit. An attempt to date the pervasive upper amphibolite facies metamorphism recorded by the orthogneisses and Murmac Bay Group resulted in a 1900 Ma age (L. Heaman, pers. comm., 2003), similar to that found in the Beaverlodge Domain to the southeast (Hartlaub, 2004). Greenschist facies metamorphism of the Thluicho Lake Group records a pre-1820 Ma event (Ashton and Hunter, 2003).

The southern boundary between the Nolan and Zemplak domains extends through southern Tazin Lake, but is poorly defined. The western boundary is marked by a transition from granitoid rocks into gneisses and migmatites of unknown relative or absolute age (Koster, 1962, 1968). Thus, the relationship between the apparently Archean plutonic rocks of the Nolan Domain and the orthogneisses making up the Zemplak Domain is not known.

The Zemplak Domain is bounded to the east by the Black Bay Fault, which separates it from the Beaverlodge Domain; to the northeast, it is separated from the Ena Domain by the Tazin Lake Fault (formerly Tazin River Fault). The Ena Domain is reportedly dominated by an upper amphibolite to granulite facies mix of felsic biotite and hornblende gneisses, granitoids, and subordinate mafic rocks and paragneisses of unknown age and origin (Koster, 1965a, 1965b; de Zoysa, 1974). Many of these rocks were interpreted as having intermediate to mafic plutonic protoliths by previous compilers (Macdonald and Slimmon, 1999), but the green colour used to designate them on the provincial geological map has led to some confusion as that colour is usually reserved for volcanic rocks. Recent mapping around the Hoidas Lake REE property has shown that most of these previously designated intermediate to mafic rocks were derived from granodioritic to tonalitic precursors with only minor amphibolites (Harvey *et al.*, 2002; Gunning and Card, 2005). The Ena Domain is bounded to the east by the dominantly Archean (Ashton *et al.*, 1999; Card, 2001) Train Lake Domain.

The Zemplak Domain is bounded to the west by the Taltson Domain, which is dominated by a 1.98 to 1.92 Ga granite-diorite suite that has been interpreted as a continental arc (Hoffman, 1988) or an intra-continental batholith derived by compressional thickening and crustal melting (Chacko *et al.*, 2000; De *et al.*, 2000). The Waugh Lake Group, comprising conglomerates, quartzites, turbidites, and bi-modal volcanic and volcanoclastic rocks, is temporally constrained by the youngest detrital zircon of 2.02 Ga and an intrusive relationship with the 1.97 Ga Colin Lake quartz diorite; it has been interpreted as an intra-arc basin (McDonough and McNicoll, 1997).

In Saskatchewan, the Taltson-Zemplak domain boundary is generally marked by extensive mylonites and coincides with the eastward change from greenschist to upper amphibolite facies metamorphic conditions. In the south, this involves a transition from Taltson porphyritic granodiorite in the west into biotite gneiss exhibiting local feldspar megacrysts in the east (Koster, 1967). The main foliation, however, transects the boundary at a high angle suggesting that it may represent the easternmost limit at which the plutonic rocks could be easily identified rather than a lithological contact.

A number of late mafic dyke sets have been described from various parts of the northern Tazin Lake map area. The best known is the 1.83 to 1.82 Ga (Bostock and van Breemen, 1992; Ashton *et al.*, 2004) east-trending Sparrow

diabase swarm (McGlynn *et al.*, 1974), which extends from the Great Slave Lake Shear Zone in the Northwest Territories to a few kilometres east of the Black Bay Fault.

Late brittle faulting is widespread. Northeast-trending dextral (*e.g.*, Black Bay Fault) and east-trending normal faults, including those defining much of the northern and southern shorelines of Tazin Lake, are the most common.

Ice-flow indicators in the southern Tazin Lake map area suggest a number of ice-advance directions. From oldest to youngest, they are: 229°, 209°, 256°, and 224°.

### 3. Tazin-Tsalwor Lakes Area (Southern Nolan Domain, Central Zemplak Domain, and the Nolan-Zemplak Domain Boundary)

The two weeks spent at each of Tazin and Tsalwor lakes facilitated a reconnaissance of the southern Nolan and central Zemplak domains, as well as their mutual boundary (Figures 1 and 2). The critical lesson learned from this work is that the domain boundary represents a tectonic front rather than a lithological break. Porphyritic granite of the Nolan Domain clearly continues southward into the Zemplak Domain, but is variably recrystallized, mylonitized, injected by widespread crustal melts in the form of leucogranite, and locally has undergone anatexis. This highly tectonized zone extends more or less continuously southward to Lake Athabasca and westward to the Taltson Domain, and probably includes the majority of the Zemplak Domain. The location of the 'front' (*i.e.*, the domain boundary) has been modified, but remains somewhat poorly defined because it is dependent upon the criterion chosen for delineation (*i.e.*, first appearance of extensive mylonites or first appearance of abundant crustal melt).

#### a) Unit Descriptions

##### Probable Archean Rocks

Due to the dearth of age dates in the Tazin-Tsalwor lakes area, there are no clear indications as to which are the oldest rocks. The two outcrops yielding *ca.* 2.6 Ga ages (Van Schmus *et al.*, 1986); however, have been taken to indicate that the Nolan Domain is dominantly composed of Neoproterozoic plutonic rocks (Figure 2). The oldest of these are massive to layered, fine to medium-grained **diorites and gabbros**, which constitute mappable bodies in the Zin Bay area, but more generally occur as net-veined inclusions up to tens of metres across in younger plutonic rocks (Figures 3 and 4). They locally exhibit comagmatic inclusions themselves as well as feldspar phenocrysts up to 1 cm long (Figure 5), and contain 30 to 40% combined hornblende, biotite, and/or pyroxene. They are also recognized as **dioritic gneiss** (Figure 6) in the Taz Bay area south of the tectonic front. The diorites and gabbros are viewed as the earliest representatives of a batholithic intrusive suite encompassing all of the Nolan Domain.

**Coarse-grained granodiorite with minor quartz diorite** makes up much of the Nolan Domain and has yielded a 2.58 Ga crystallization age (Van Schmus *et al.*, 1986). It is multi-phase with complicated crosscutting relationships. Most are pink-grey to white, but a local waxy green colour on fresh surfaces may indicate that metamorphic conditions were transitional into the granulite facies. The best-preserved rocks are medium to coarse grained with local euhedral megacrysts up to 5 cm in length and 10 to 25% combined hornblende, biotite ± pyroxene (Figure 7), and rare blue quartz. Most outcrops also contain lenticular inclusions of diorite/gabbro and are intruded by amphibolitized mafic dykes and various medium-grained to pegmatitic granites. The granodiorites are generally non-magnetic, but the transition into derived **granodioritic gneisses** south of the tectonic front is typically accompanied by partial melting and the development of metamorphic magnetite, along with hornblende melts, hybrid phases, and schlieren derived from the inclusions (Figure 8).

**Garnetiferous granite-granodiorite** in the Soulier Lake area (Figure 2) shares the coarse grain size, homogeneous nature, lenticular inclusions, and crosscutting granitoid intrusions of the granodioritic rocks, but has marginally lower colour indices, containing 10 to 25% combined biotite ± hornblende ± pyroxene, and local garnet (Figure 9). The garnet can occur preferentially in either the diorite/gabbro inclusions or the granite-granodiorite, where it is most common adjacent to pegmatitic dykes, suggesting a compositional control. The main rocks are white-grey to pink or waxy green and are medium to coarse grained with local centimetre-scale feldspar augen.

A **coarse-grained to porphyritic granite** clearly spans the Nolan-Zemplak domain boundary. It is also a multi-phase intrusion including both coarse-grained, equigranular rocks with a grain size of about 1 cm (Figure 10) and a variety containing about 30% K-feldspar phenocrysts reaching up to 4 cm long (Figure 11). Most rocks are pink to white-grey and contain 10 to 15% biotite, which is variably replaced by chlorite, and rare blue quartz. As with other rocks in the Nolan Domain, lenticular inclusions of diorite/gabbro are common and the granite is typically intruded by pink medium-grained to pegmatitic granite and pink leucogranite (unit G1). It is progressively more mylonitic

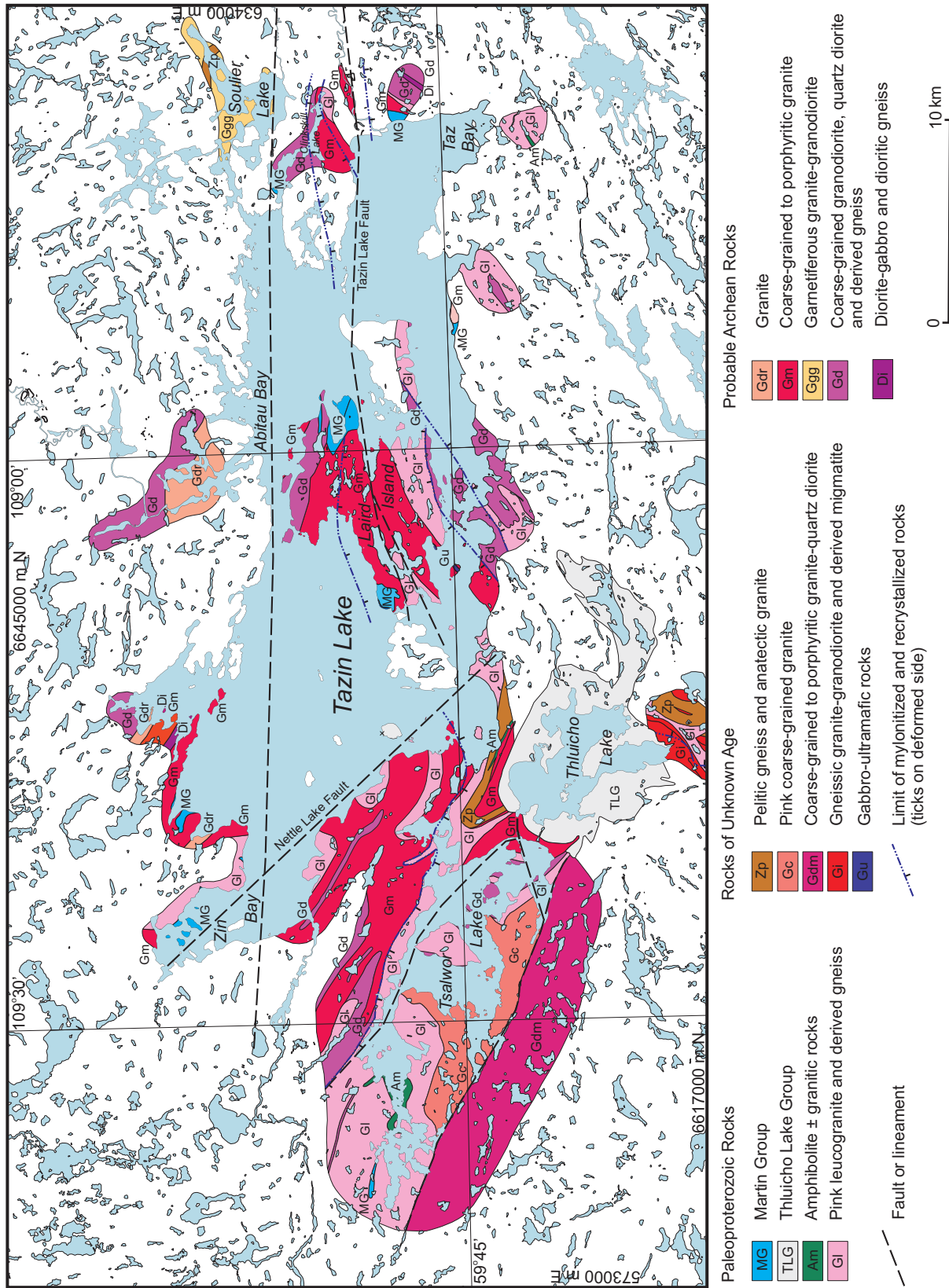


Figure 2 - Simplified geological map of the Tazin-Tsalwor lakes area.



**Figure 3 - Fine-grained diorite/gabbro inclusion net-veined by host granodiorite; from northern Zin Bay, Tazin Lake (UTM 599865 m E, 6641726 m N). Note that all UTM's are in NAD83, zone 12 unless otherwise stated.**

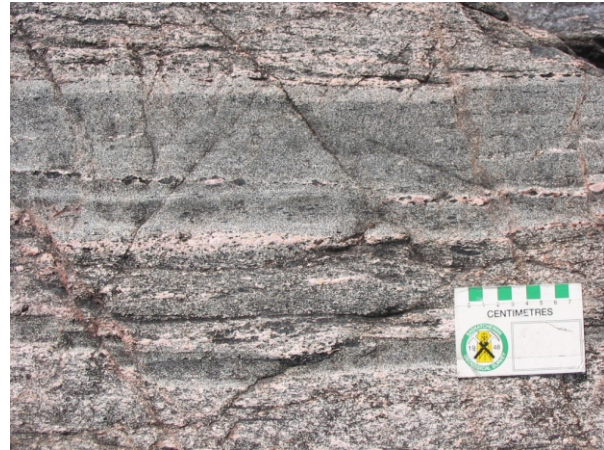


**Figure 4 - Transposition of net-veining in diorite/gabbro, transitional to development of a straight gneiss; from 1.5 km east of Tazin Lake (UTM 630228 m E, 6627724 m N).**

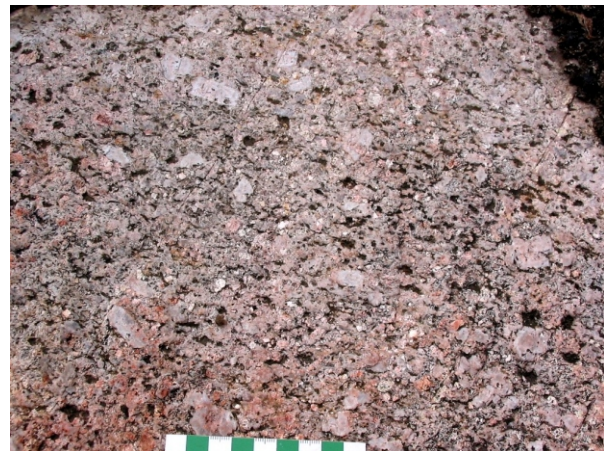
towards the south (Figure 12). Pink-white and grey-green **gneissic granite** in the southwestern Tazin Lake area also contains 10 to 15% biotite and lenticular diorite/gabbro inclusions, but is locally melted to produce schlieren and a gneissosity. It is commonly at margins of the coarse-grained to porphyritic granite and probably represents either a marginal or deformed phase. The term **granitic migmatite** was used for



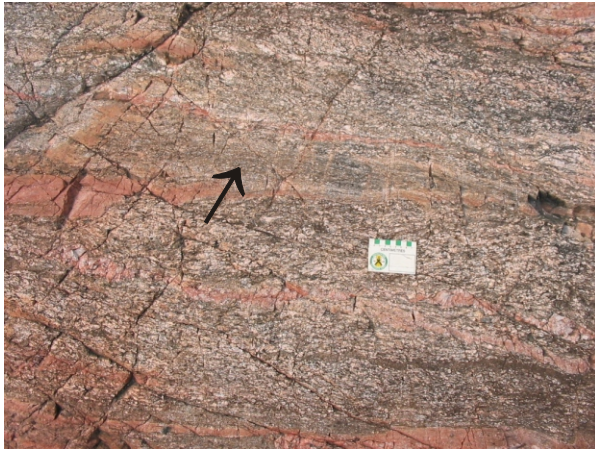
**Figure 5 - Diorite/gabbro containing lenticular inclusions and feldspar phenocrysts; from western shore of Zin Bay (599585 m E, 6639364 m N).**



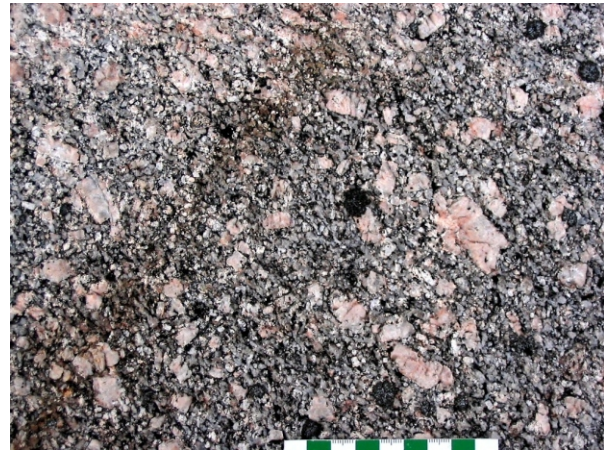
**Figure 6 - Dioritic gneiss comprising partially melted granodiorite (medium-grained pink leucosome with hornblende pods derived by partial melting) in transposed net veins and finer grained, dark, unmelted diorite/gabbro; from eastern shore of Laird Island, Tazin Lake (UTM 613890 m E, 6631844 m N).**



**Figure 7 - Coarse-grained granodiorite; from 3 km north of Abitau Bay (608671 m E, 6641115 m N).**



**Figure 8 - Strain gradient in coarse-grained granodiorite; from southern shore of Tazin Lake (UTM 612141 m E, 6623211 m N). Note grain size reduction in central layer (arrow) and injected pink leucogranite sheets.**



**Figure 11 - Porphyritic granite showing K-feldspar phenocrysts up to 4 cm long; from southwest shoreline of Tazin Lake (UTM 598070 m E, 6625042 m N).**



**Figure 9 - Garnetiferous granite; from island in southern Soulier Lake (UTM 629464 m E, 6634007 m N). Note red garnet (arrows) in rock with feldspar phenocrysts up to 5 mm.**



**Figure 12 - Variably mylonitized coarse-grained to porphyritic granite from eastern Laird Island, Tazin Lake (UTM 612529 m E, 6628803 m N); note least-deformed zone (arrow) just below injected pink leucogranite sheet and grain size reduction with rare centimetre-scale relict feldspars in layers further below.**



**Figure 10 - Equigranular coarse-grained granite; from northwestern Tazin Lake (UTM 595440 m E, 638774 m N).**

approximately equal mixtures of coarse-grained to porphyritic granite with minor hornblende melt and injected pink leucogranite. Minor amounts of hybrid phases were derived by interaction with the diorite/gabbro inclusions.

White-pink to grey, fine- to medium-grained **granite** sheets and dykes constitute 20 to 100% of the coarse-grained granodiorite outcrops in the southern Abitau Bay area (Figure 2). The rocks vary from massive to gneissic, where they include schlieren and hybrid compositions derived from the host rocks, and contain 2 to 15% biotite. Up to 2% garnet poikiloblasts reaching 1 cm in diameter are found in granite (Figure 13) adjacent to the contact with the coarse-grained granodiorite unit to the north.

## Rocks of Unknown Age

There is no information on the ages of a variety of rocks restricted to the area south of the tectonic front. **Gabbro and ultramafic rocks** intruded the gneissic granite at the southern end of Laird Island (Figure 2). The gabbroic rocks are green, fine to medium grained, and foliated, with 50% altered hornblende. They grade into dark green, medium- to coarse-grained, massive, clinopyroxenite(?).

**Gneissic granite-granodiorite** is structurally interleaved with pelitic rocks south of Thluicho Lake and represents the northward extension of a unit mapped previously (Ashton and Hunter, 2004). It is pink and grey, fine to locally coarse grained, and contains rare feldspar relicts up to more than 1 cm and 10 to 20% biotite ± hornblende. It is commonly injected by ~20% pink leucogranite sheets (unit G1) and ~10% amphibolitized mafic dykes, and is both variably magnetic and mylonitic. Injection of an equal proportion of pink leucogranite creates a **granitic gneiss-migmatite**, which is magnetic and characterized by hornblende-bearing melt leucosome, hybrid phases, and biotite-rich schlieren derived from mafic inclusions.

In the southwest, highly magnetic mylonitized gneisses, previously interpreted as ‘Tazin Group’ metasedimentary rocks by both Hale (1955) and Koster (1962), have been re-interpreted as a **coarse-grained to porphyritic granite-granodiorite-quartz diorite suite**. The discrepancy is due to the mylonitized nature of the rocks, which are characterized by shear-induced tectonic layering, extreme grain size reduction, and local hornblende blastesis, so that the precursors were mis-identified as fine-grained tuffs and other supracrustal rocks. Their re-interpretation as orthogneisses is based on locally preserved, coarse grain sizes (Figure 14) and relative compositional homogeneity. Due to the strong attenuation, rock types are generally too thin to show individually on 1:50 000 scale maps. Most are white to pink and grey and contain 15 to 30% biotite/chlorite ± hornblende, with local amphibolite inclusions. Their strongly magnetic character is at least partly due to the partial melting of granodioritic compositions and the resulting metamorphic magnetite.

Another variably mylonitized, **pink, coarse-grained granite** is exposed along the southern shore of Tsalwor Lake (Figure 2). In the best-preserved exposures, it weathers salmon pink and is medium grained, although vague centimetre-scale augen and coarse-grained interstitial quartz infer an originally coarse grain size (Figure 15). It contains 2 to 15% biotite/chlorite, is intruded by pink leucogranite and mafic dykes, and is variably magnetic. The unit may represent a phase of the coarse-grained to porphyritic granite, but its apparent homogeneity and salmon pink colour are features somewhat more akin to the 2.3 Ga North Shore granites in the Uranium City area (Ashton *et al.*, 2000; Hartlaub, 2004).

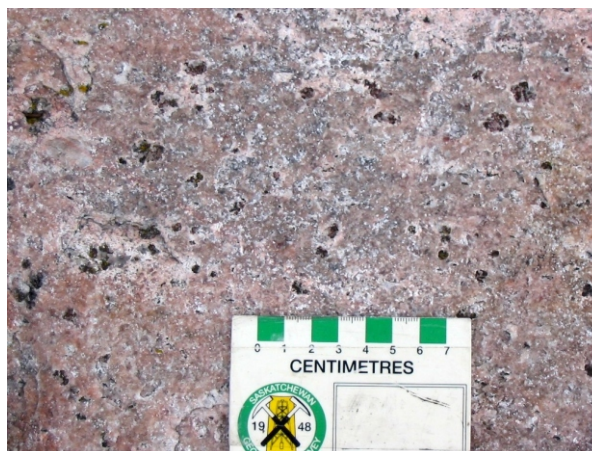


Figure 13 - Garnet poikiloblasts in fine- to medium-grained granite adjacent to contact with coarse-grained granodiorite (not visible in photo); eastern Abitau Bay (UTM 611773 m E, 6637681 m N).



Figure 14 - Relict coarse grain size preserved in quartz diorite; from southern shore of Tsalwor Lake (UTM 584201 m E, 6622301 m N).

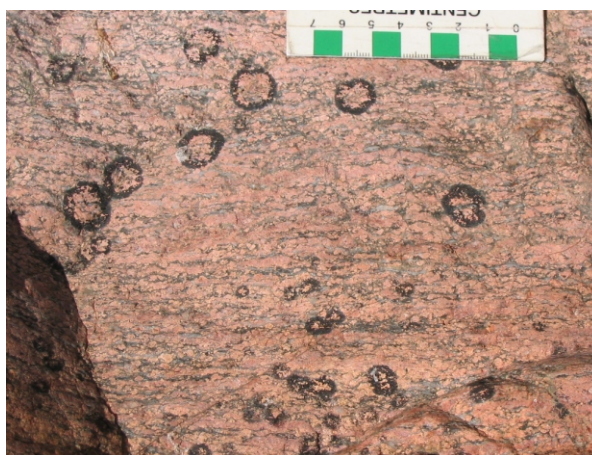


Figure 15 - Deformed granite showing feldspar augen ≥1 cm and coarse quartz indicating an originally coarse-grained granite; from island in southern Tsalwor Lake (UTM 586936 m E, 6623152 m N).

**Psammopelitic to pelitic gneiss** is structurally interleaved with gneissic granite/granodiorite south of Thluicho Lake and occurs with the coarse-grained to porphyritic granite and pink leucogranite between Tazin and Tsalwor lakes (Figure 2). The Thluicho Lake exposure represents the northward continuation of rocks previously mapped by Ashton and Hunter (2004). The best-preserved rocks are grey-brown, fine to medium grained, and non-magnetic, with 20 to 30% biotite, but many are mylonitized and altered to chlorite-sericite schists. Sheets of derived white to pink, medium-grained, anatectic granite are commonly injected.

**Anatectic granite with minor paragneiss** is also exposed in the Soulier Lake area of northwestern Tazin Lake (Figure 2). The white to grey, medium- to coarse-grained granite contains 3 to 8% biotite/chlorite, 2 to 3% garnet, and late muscovite along with centimetre-scale layers and schlieren of grey, fine-grained, non-magnetic psammopelitic to pelitic paragneiss containing 5 to 30% biotite, and minor sillimanite and garnet.

Several generations of dykes were recognized. The earliest appears to be amphibolitic and presumably derived from **diabase**. These are typically dark green to black and fine to medium grained with sharp contacts. They are magnetic, up to 1.5 m thick, and were locally emplaced *en echelon*. Hornblende, clinopyroxene, and/or biotite together account for 40 to 50% of the rock. The dykes postdate mylonitization, but have an internal foliation that is near-parallel to that in the host rocks. More **intermediate dykes** are grey, fine to medium grained, and up to 12 cm thick with 20 to 30% hornblende ± biotite. A 20 m thick, near-concordant, east-trending dyke in the Abitau Bay area may be a **lamprophyre**. It is grey and medium to coarse grained, with 30% combined mica and clinopyroxene megacrysts. Medium-grained to pegmatitic **granite dykes** are generally massive and up to 1 m thick. They contain little if any biotite, and intrude both the diabase and lamprophyre.

### Probable Paleoproterozoic Rocks

**Pink leucogranite and derived gneiss** constitutes one of the most widespread units in the region, extending discontinuously eastward to beyond Uranium City (Ashton *et al.*, 2000, 2003). Where weakly strained, it is pink-red, fine to medium grained, and massive. More commonly, however, it is strongly sheared, resulting in a tectonic gneissosity, beaded feldspars, ribboned quartz, and centimetre-scale patches and layers of altered feldspars and/or chloritization (Figure 16). The best-preserved samples contain ≤5% biotite/chlorite, but the chlorite concentration reaches as much as 20% in the sheared layers, making it difficult to distinguish these highly strained leucogranites from the more mafic granites. White, fine-grained, massive to platy, ultramylonitic varieties are exposed on northern Wylie Island in Tsalwor Lake (Figure 17). Local blue quartz and possible centimetre-scale, K-feldspar augen may indicate that minor amounts of other granites have been included in this unit, particularly in the western Tsalwor Lake area.

Black, fine-grained, salt-and-pepper-textured **amphibolite** occurs as metamorphosed dykes and inclusions in many rock types. The largest body of amphibolite is exposed in the western Tsalwor Lake area, where it apparently intrudes the Paleoproterozoic pink leucogranite, and is in turn intruded by younger, white coarse-grained to pegmatitic leucogranite. At a second occurrence, on the southern shores of Riach Bay, amphibolite is spatially associated with pelitic paragneisses and gneissic granite.

A number of late, medium-grained to pegmatitic granite sheets and dykes were encountered, but are not of mappable extent.

The rocks described above are unconformably overlain by the 1.93 and 1.82 Ga **Thluicho Lake Group**. The



**Figure 16 - Pink leucogranite showing development of shear-induced layering defined by altered feldspars and chlorite growth; from eastern shore of Laird Island, Tazin Lake (UTM 612632 m E, 6628085 m N).**



**Figure 17 - Ultramylonitic variety of pink leucogranite showing tighter and more pronounced layering defined by chlorite-rich zones and platy fracturing; from northern shore of large island in central Tsalwor Lake (UTM 588914 m E, 6625824 m N).**

Waterloo-Wellington structural basin of the Thluicho Lake Group has been recently described (Hunter *et al.*, 2003, 2004a and b). The Thluicho-Gulo lakes structural basin was studied this summer (Yeo, this volume).

The **Martin Group** is exposed at a number of localities around Tazin Lake (Figure 2), which have been described by previous workers in some detail (Koster, 1968, 1970; Mazimhaka and Hendry, 1985). It has been lithologically subdivided into polymictic conglomerate and sandstone. The conglomerate varies from clast to matrix supported, and is characterized by poorly sorted, angular to sub-rounded clasts up to 0.5 m in size in a red-brown matrix ranging from siltstone to gritty granite wash (Figure 18). The majority of clasts are fine- to medium-grained, variably foliated granites, although vein quartz, sedimentary and mafic clasts were also recognized.

East-trending diabase dykes up to 1 m thick are the youngest known rocks in the area. They weather brown with local yellow rinds along the contacts; fresh surfaces are grey (Figure 19). They have chilled margins and fine-grained cores containing local euhedral feldspar phenocrysts up to 2 mm long and rare mafic phenocrysts or amygdules up to 1 mm in size. Most exhibit contraction joints perpendicular to the dyke walls and are highly magnetic. These dykes are part of a regional swarm that has been dated at 1.82 Ga (R. Hartlaub, pers. comm., 2003) about 30 km to the south on Lake Athabasca, and are considered correlative with the Sparrow dykes of the Northwest Territories (McGlynn *et al.*, 1974; Bostock and van Breemen, 1992).

## b) Structure-Metamorphism

The structural history is complicated due to at least two overprinting events spatially restricted to opposite ends of the area. The best-preserved rocks are in the northern Nolan Domain, where the main regional fabric is southeast striking and dips steeply in both directions (Koster, 1968, 1970). Folding is uncommon due to the relatively homogeneous and weakly foliated nature of the dominant plutonic rocks, although rare ptygmatic folding of net veins (Figure 20) indicates that an early regional F1 phase accompanied development of the main regional S1 fabric. Although generally weak, this S1 fabric is locally defined by intense shearing, with indications of dextral, north-side-up displacement. It is locally refolded into tight to isoclinal, southeast-trending F2 folds that dip steeply to the northeast (Figure 21).

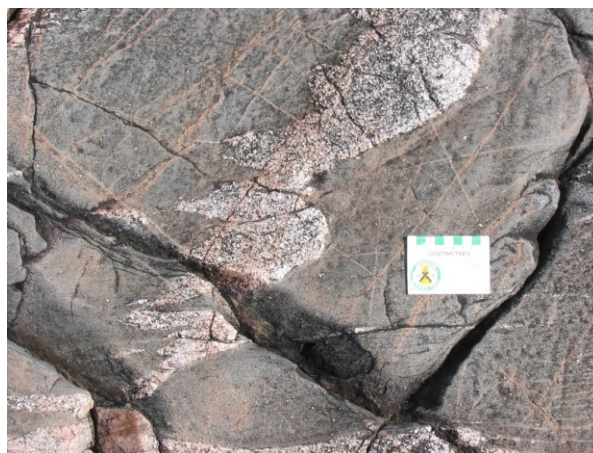
To the southwest, the main regional fabric is variably mylonitic, and pre-existing structures are, hence, likely transposed. Stretching lineations are rare and generally parallel to younger fold axes. The mylonitic S1 foliation is folded, defining rare F2 isoclines, which are probably synchronous with the main, regional shearing event. Overprinting these structures are southeast-trending, close to open, F3 structures with axial planes that dip moderately to steeply both ways, and have gently southeast- and northwest-plunging fold axes.



**Figure 18 - Martin polymictic conglomerate; from western shore of Laird Island, Tazin Lake (UTM 604491 m E, 6628138 m N).**



**Figure 19 - East-trending 'Sparrow' diabase dyke; from eastern shore of Laird Island, Tazin Lake (UTM 613640 m E, 6632414 m N); note chilled margin, yellow rind along contact (large arrow), and cooling cracks perpendicular to contacts (small arrow).**



**Figure 20 - Ptygmatic F1 folds in net veins crosscutting dioritic inclusion with axial planar fabric; from northern shore of Tazin Lake 2 km west of Zin Bay (UTM 597082 m E, 6638322 m N).**

The resulting southeast-trending, S1/S2/S3 transposition fabric was overprinted by northeast-trending structures to the southeast that represent a western extension of those forming the Black Bay straight belt (Macdonald and Slimmon, 1985; Ashton *et al.*, 2001; Ashton and Hunter, 2003). The western extent of this dominantly northeast-trending, variably mylonitic, overprint forms a relatively sharp line extending through Thluicho Lake, Laird Island, and southern Clinkskill Lake (Figure 2). Isoclinal F2 folds are rare, as are interference patterns resulting from superposition of the open to tight, northeast-trending F4 folds on the pre-existing, southeast-trending F3 structures (Figure 22). The F4 folds are characterized by steep axial planes and gentle to moderately southwest and northeast-plunging fold axes. Although F3 and F4 folds are similar in appearance and style, vertical derivative aeromagnetic maps (Carson *et al.*, 2001) show that the northeast-trending fabric produced in part by the F4 folds, truncates and overprints the southeast-trending fabric related to F3 folding. This relationship was observed on the ground in the western Soulier Lake area, where a discontinuous northeast-trending shear foliation overprints a weak southeast-striking foliation. Rare F5 folds are gentle and north-trending.

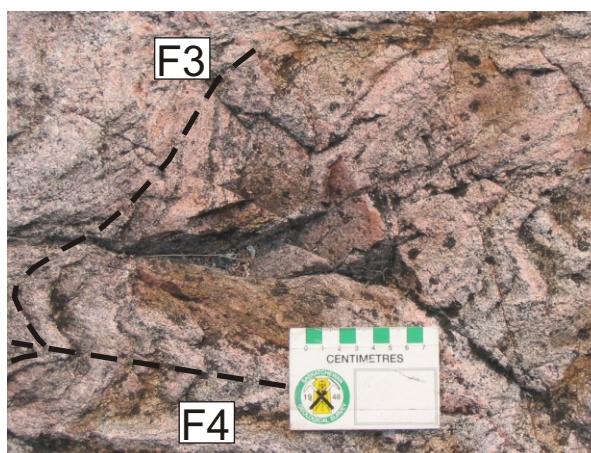
The greenschist-facies Thluicho Lake Group is exposed both in the southeast- and northeast-trending structural domains, and provides some insights into the relative age of these deformational events. It is not mylonitized, indicating that deposition took place after the regional shearing event (D1 and/or D2), but has been subjected to three or four periods of regional folding (Scott, 1978; Hunter *et al.*, 2003, 2004b; Yeo, this volume): 1) isoclinal in east; 2) steeply inclined, open to close, and southeast trending; 3) steeply inclined, open to close, and northeast trending; and 4) upright, open, and north trending. The latter three phases represent the F3, F4, and F5 regional phases described in this study, but it is presently unclear if the isoclinal phase is distinct or a tighter version of F3 fold recognized by Yeo (this volume) in the west.

The metamorphic grade of the basement rocks is upper amphibolite facies, but probably reached granulite facies locally as previous workers (Koster, 1968, 1970) have recognized orthopyroxene during petrographic analysis of some samples. An early attempt to date this metamorphic event using ID-TIMS yielded a 1.90 Ga result based on zircons from a meta-gabbro along the shore of Lake Athabasca about 3 km west of the Black Bay Fault (L. Heaman, pers. comm., 2003). This is consistent with 1.91 to 1.90 Ga metamorphic zircon and titanite ages from amphibolites characterized by northeast-trending regional structures in a zone extending for at least 50 km east of the Black Bay Fault (Hartlaub, 2004). In contrast, *in situ* SHRIMP analyses of monazite inclusions in garnet from two northeast-trending pelitic gneisses located 7 km due west of Uranium City and 9 km southwest of the Tazin-Tsalwor lakes area have yielded 1.93 Ga results (R. Berman, pers. comm., 2005), consistent with peak metamorphic conditions in the Taltson Magmatic Zone to the west. Since the monazite (and its enveloping garnet) presumably grew during formation of the gneissosity, the 1.93 Ga age is interpreted as dating the D2/D3 event responsible for this early southeast-trending fabric, whereas the 1.91 to 1.90 Ga data are thought to represent the D4 northeast-trending overprint.

The pink leucogranite is interpreted as a crustal melt derived during a major metamorphic event. It exhibits the S1/S2 foliation in the Tsalwor Lake area, indicating emplacement prior to or during their development, and extends throughout the area defined by both the F3 southeast- and F4 northeast-trending regional fabrics. A 1.93 Ga zircon age for the pink leucogranite supports the idea that the southeast-trending regional fabric was formed at this time.



**Figure 21 - Isoclinal F2 folds (dashed black lines denote axial traces) in variably sheared granodiorite, from eastern Abitau Bay (UTM 613830 m E, 6637766 m N).**



**Figure 22 - Superposition of F4 folds on inferred F3 folds; from island southwest of Laird Island in Tazin Lake (UTM 607714 m E, 6624528 m N).**

#### 4. Ena Lake Area (Central Ena Domain)

The Ena Lake area is situated in the core of the Ena Domain (Figure 1), about 45 km north-northeast of Uranium City and 30 km northeast of Soulier Lake (northeastern corner of Tazin Lake). The area was previously described as consisting of 'mafelsic' and undifferentiated biotite gneisses and migmatites, the 'Ena Lake Diorite' and the 'Ena Lake Granite' in the east (Koster, 1963); and 'mafelsic', granitic, and hornblende gneiss in the west (de Zoysa, 1974). The purpose of re-mapping the Ena Lake area was to determine protoliths for as many of the previously described rock units as possible in order to: 1) test whether the large unit of 'mafic to mafelsic gneiss' on the provincial geological compilation (Macdonald and Slimmon, 1999) is justified; 2) ascertain whether the rocks of the Ena Domain are sufficiently distinct from those around them to warrant a separate lithotectonic domain; and 3) provide some insights on the lithotectonic history and mineral potential of the Ena Domain.

Based on this study, the Ena Lake area is dominated by gneissic granodiorite and minor intermediate to mafic gneisses that have been injected with abundant sheets of pink leucogranite and have been variably mylonitized. Supracrustal rocks are limited to minor psammopelitic to pelitic paragneisses in the south and possibly volcanic-derived amphibolites at a number of localities.

##### a) Unit Descriptions

Small, grey-black, fine- to medium-grained **amphibolite** bodies vary from massive to lineated and contain 45 to 50% hornblende with coarser-grained, clinopyroxene-bearing segregations. A non-magnetic, homogeneous variety in the south is spatially related to paragneiss at one locality (Figure 23), possibly indicating derivation from volcanic rocks. In the southwest, a moderately magnetic variety is interlayered with the pink leucogranite and is gradational into more intermediate rocks. At an eastern locality, highly magnetic amphibolite contains layers of hornblende and others rich in clinopyroxene, suggesting an intrusive origin.

A small body of pink-white and green-black, fine- to medium-grained **gabbro** is exposed in southeastern Ena Lake (Figure 23). It is relatively homogeneous, though sheared, and contains 40 to 50% combined hornblende, clinopyroxene ± biotite and traces of sulphides. It is intruded by ultramafic dykes up to 15 cm thick as well as late granitoids.

Grey, fine- to medium-grained, variably magnetic rocks containing 25 to 40% combined hornblende, biotite, and clinopyroxene have been collectively termed **intermediate gneisses**. Most outcrops include gneissic granodiorite, which is gradational into the intermediate rocks or formed net veins in them prior to deformation. Locally abundant pink leucogranite sheets are also common. The unit probably includes a mix of variably granitized mafic rocks and tonalitic to gabbroic members of the granodioritic plutonic suite.

The most common rocks are highly strained **gneissic granodiorites** (Figure 23). Most are pink and grey, fine to coarse grained, and highly magnetic. They contain 15 to 25% combined hornblende and biotite, as well as local pink K-feldspar augen. Many exhibit a pink, locally hornblende, melt leucosome. Typical exposures contain layers and inclusions of more mafic material and are injected by up to 50% pink leucogranite to granite. The '**Ena Lake Diorite**' of Koster (1963) represents the best-preserved remnant of this gneissic granodiorite unit, and is characterized by pink K-feldspar phenocrysts that range from subhedral grains to vague augen up to 5 cm long and 0.5 cm wide (Figure 24) set in a fine- to medium-grained, intensely recrystallized matrix. It is notably similar to the 'megacrystic monzogranite' described by Gunning and Card (2005) from about 20 km to the east in the Nisikkatch Lake area.

Heterogeneous mixtures of gneissic granodiorites, leucocratic granitoid rocks, and minor granitized amphibolite layers and schlieren are termed **granitic gneiss**. Most outcrops exhibit a gneissic to migmatitic appearance, and comprise pink and grey, partially melted rocks containing 10 to 15% biotite and minor magnetite.

Minor **psammopelitic to pelitic paragneisses** are exposed south of Ena Lake (Figure 23). Grey, fine- to medium-grained psammopelitic gneisses containing about 20% biotite and minor garnet are the most common variety, but sillimanite-garnet-biotite pelitic gneisses are also present, as are minor hornblende-bearing layers. The paragneisses are commonly accompanied by metre-scale sheets of white medium- to coarse-grained **anatectic granitoid** containing 0 to 5% biotite and rare garnet. This white anatectic granitoid was also noted at the northwest corner of the lake where it contains fine-grained biotite gneiss layers and schlieren that probably also represent paragneisses. Local patches of garnetiferous leucosome at several other localities within the dominant granodioritic-quartz dioritic gneiss suite suggest that remnants of these paragneisses have been largely digested during widespread partial melting.

Both the granodiorite-quartz diorite and diorite/gabbro suites were intruded by a variety of **pink leucogranites and granites**, some of which were broadly termed the 'Ena Lake Granite' by Koster (1963). They include fine- to coarse-grained, near-massive to variably mylonitized rocks that exhibit a strong shear foliation and feldspar beading

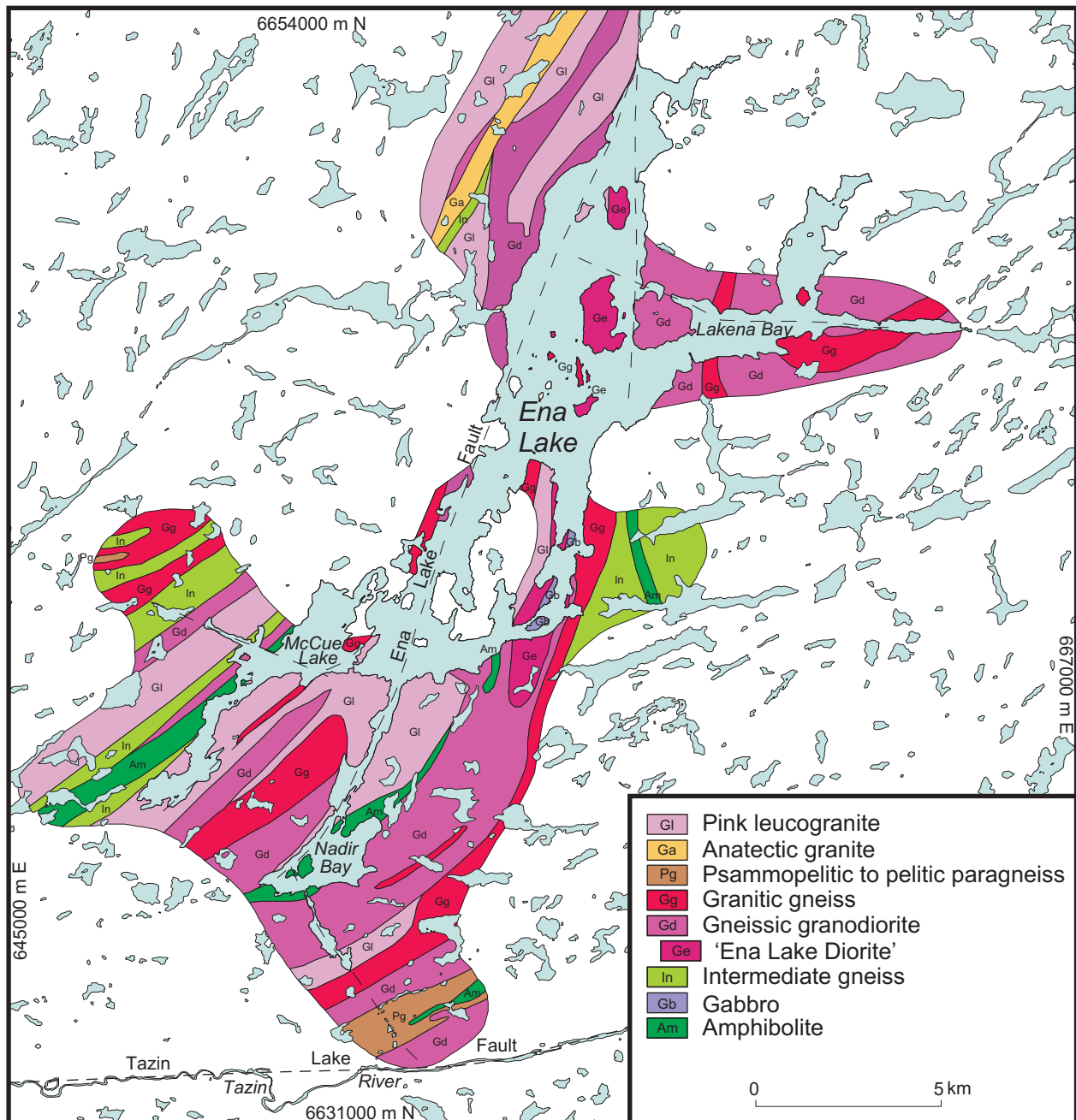


Figure 23 - Simplified geological map of the Ena Lake area.

due to cataclasis. Up to 10% primary biotite and rare hornblende have been variably altered to chlorite, which forms up to 15% of highly sheared rocks. Magnetite is ubiquitous, whereas allanite occurs as a local accessory, and some blue quartz was recognized in the west. Layers/schlieren of amphibolite are common.

Late crosscutting **diabase dykes** comprising equal proportions of hornblende and plagioclase intruded all previously described rock types, but have been subjected to late deformation and amphibolite facies metamorphism. Rare **pyroxenite dykes** up to 30 m thick weather brown, but are dark green-black on fresh surfaces, and are coarse grained and massive. The timing of their emplacement relative to deformation and metamorphism is unclear.

Brown, fine-grained, massive **diabase dykes** that postdate the medium- to high-grade metamorphic events were assigned to the Sparrow swarm.

## b) Deformation and Metamorphism

The Ena Lake area lies within a zone of uniformly northeast-striking and steeply dipping rocks referred to as the Black Bay straight belt (Macdonald, 1983). The earliest foliation (S1) defines folds ranging from tight-isoclinal (Figure 25) to open-tight that are interpreted as F2 and F3, respectively, although undisputed fold interference was rarely recognized. Many of the close folds exhibit sheared limbs with local injection of granitic material along the shear zones (Figure 26), suggesting that this deformation took place at relatively high temperatures. The partially melted nature of the granitic and granodioritic rocks, together with sillimanite-garnet-biotite mineral assemblages in the paragneisses, infers at least upper amphibolite facies metamorphic conditions. Although none was recognized this summer, Koster (1965a) alluded to the local preservation of orthopyroxene, which together with rare blue quartz may indicate that conditions attained the upper amphibolite-granulite facies transition or alternatively represent an upper amphibolite facies overprint of earlier granulite facies conditions. The amphibolite facies diabase dykes crosscut at least some of the northeast-trending folds, but are folded by north-northeast-trending (late F3?) and north-trending F4 structures and exhibit axial planar foliations. Rare north-trending F4 pygmatic folds and an S4 axial planar quartz flattening fabric were also noted in late granitic dykes.

The main northeast-trending regional fabric that characterizes the Black Bay straight belt probably resulted from the D3 event, and took place under amphibolite facies conditions. The **Black Bay Fault** is parallel to the straight belt, and may have been initiated as either a thrust fault or transpressional structure due to northwest-southeast shortening at that time. Later east-west shortening imposed during D4 time is thought to have produced dextral re-activation. The main regional fabric appears rotated into alignment with the **Tazin Lake Fault** ('Tazin River Fault' of Koster, 1965a) to the south, although farther west, it appears to be a late brittle structure (see previous section on Tazin-Tsalwor lakes area). It may have been initiated during late-D3 time and then re-activated as a normal fault during D4 east-west shortening.

## c) Discussion of the Ena Lake Area

The similarity of rock types and proportions, the overall high state of strain and the apparent continuation of aeromagnetic trends (Carson *et al.*, 2001) across the previously defined domain boundary leave little justification for distinct Ena and Zemlak domains. This is supported by mapping at the southeastern extent of the Tazin-Tsalwor lakes area, which identified a very similar suite of rock types and no evidence for substantial displacement along the bounding Tazin Lake Fault.

This study supports the plutonic origin inferred for the 'mafic-mafelsic gneiss' that is coloured green on the 1:1 000 000 scale Geological Map of Saskatchewan



Figure 24 - Porphyritic granodiorite previously referred to as Ena Lake Diorite by Koster (1963); from island in central Ena Lake (UTM 657087 m E, 6646893 m N).



Figure 25 - Tight to isoclinal folds defined by pink leucogranite sheets in granodioritic gneiss; from southern shore of Ena Lake, 2 km east of entrance to Nadir Bay (UTM 654688 m E, 6640351 m N).



Figure 26 - F3 folds exhibiting sheared off limbs; from 1 km northwest of northern end of Ena Lake (UTM 656406 m E, 6653060 m N).

(Macdonald and Slimmon, 1999), but casts doubt on the inferred extent of such rocks. The intermediate to mafic rocks are interlayered with the more extensive granodioritic suite, and probably represent only a minor component of the Ena Lake Domain. One attractive, but unproven, model is that these two rock types are equivalent to the diorite/gabbro inclusions and their granodioritic hosts that make up much of the Nolan Domain.

## 5. Martyn and Morris Lake Areas (Taltson Domain)

Two brief forays into the Taltson Domain at the western extent of the Tazin Lake map area produced results relevant in interpreting the western Zemplak Domain. The areas visited are located at the northern end of Martyn Lake and the eastern side of Morris Lake (Figure 1); both are dominated by the Waugh Lake Group. This supracrustal sequence includes conglomerate, biotitic and sericitic schists and gneisses, and minor quartzite and mafic volcanic rocks, which have been metamorphosed to only greenschist facies conditions. The age of the Waugh Lake Group is bracketed between 2.02 and 1.97 Ga (McDonough and McNicoll, 1997) by the youngest detrital zircon and crosscutting plutonic rocks of the Taltson Magmatic Zone, respectively. This suggests that the group remained at shallow crustal levels during the *ca.* 1.93 Ga high-grade metamorphic event that affected much of the Taltson Magmatic Zone.

Polymictic conglomerates exposed on the northwestern side of Martyn Lake (Figure 27) contain angular to sub-rounded, pebble- to boulder-sized clasts, of fine- to medium-grained (<2 mm) granitoids, as well as minor vein quartz and mafic rocks, in a matrix ranging from grey-green siltstone to phyllite (Figure 28). The granite clasts are up to 0.8 m in their longest dimension, and many have internal fabrics at a high angle to matrix foliation, indicating that they were deformed prior to being incorporated in the conglomerate. White, fine-grained, homogeneous leucogranite in contact with the conglomerate at several localities may represent basement. A several-metre-thick mafic unit within the conglomerate contains millimetre-scale amphibole clots and localized angular quartz-eye rhyolitic fragments up to 20 cm in size. It is interpreted as a mafic volcanic tuff-breccia.

Grey, fine-grained tonalitic rocks containing 20 to 25% hornblende ± biotite crop out along the northeastern shore of Martyn Lake. A few tens of metres to the east, interbedded siltstones and argillites of the Waugh Lake Group (Figure 29) are exposed. The contact was not observed, and both the igneous and sedimentary rocks are variably strained, locally resulting in schistose biotite- and/or chlorite-rich equivalents. The siltstone-argillites extend eastward, through a steep, eastward-increasing metamorphic gradient over about 500 m marked by: 1) the appearance of injected coarse-grained granite sheets containing garnet and green sericite (presumably resulting from partial melting at depth); 2) the development of a paragneiss with an *in situ* melt leucosome, rare sillimanite knots, and more abundant granitic injection; and 3) migmatization (roughly equal abundances of paragneiss and granitic rocks). This latter step coincides with mylonitization (Figure 30) and

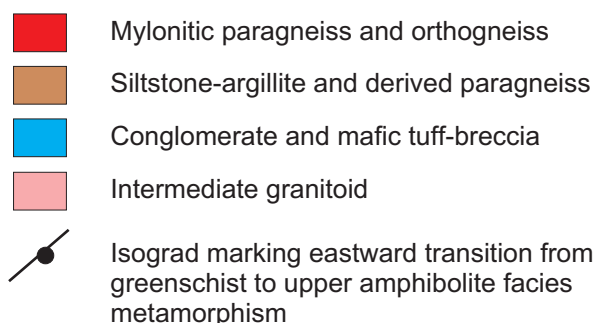
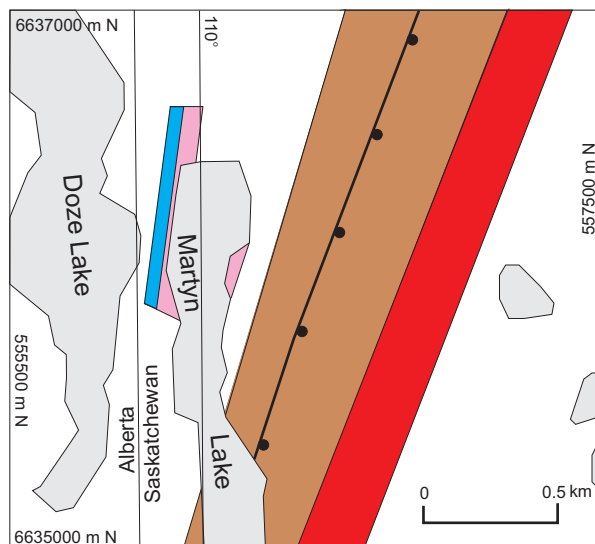


Figure 27 - Simplified geological map of the Martyn Lake area.



Figure 28 - Polymictic conglomerate of the Waugh Lake Group; note angular granitoid clasts with pre-existing foliation near bottom right and top left of photo (black arrows) and mafic clast at top left (white arrow), (UTM 555926 m E, 6636414 m N).



**Figure 29 - Interbedded siltstone and argillite of the Waugh Lake Group; from about 200 m east of northern Martyn Lake (UTM 556246 m E, 6635913 m N).**



**Figure 30 - Mylonitic paragneiss developed from Waugh Lake Group rocks; from about 400 m east of northern Martyn Lake (UTM 556592 m E, 6635897 m N). Arrows denote pink porphyroclastic remnants of injected coarse-grained to pegmatitic granite.**



**Figure 31 - F1 folds with axial planar S1 foliation crosscutting bedding in Waugh Lake Group; from island in Morris Lake (UTM 557971 m E, 6623446 m N).**

the structural intercalation of abundant granitoid rocks of unknown origin to form the western margin of the highly tectonized Zemlak Domain.

Twelve kilometres to the south (Figure 1), the same highly strained, interbedded siltstones and argillites are exposed on islands in Morris Lake and extend westward for 1.25 km, beyond which is medium-grained granodiorite. The latter is homogeneous though well foliated, contains 5 to 10% hornblende and 10% biotite, and is intruded by sheets of pink leucogranite of the type making up much of the Tazin-Tsalwor and Ena Lake areas. Similar granodiorite has intruded the argillite-siltstone on the island in Morris Lake. It was mapped as part of Koster's (1961, 1963) 'western granodiorite complex', which may represent a non-porphyrific phase of the 1971 Ma (McNicoll *et al.*, 1994) Colin Lake pluton. At their easternmost extent, the siltstone-argillites are coarser grained, locally include sericitic schists, and are injected by pale pink anatectic leucogranite, containing about 2% colourless to pale green muscovite.

### a) Structure

Bedding in the greenschist facies component of the Waugh Lake Group outlines close to tight F1 folds with steep to upright, north-trending axial planes. The resulting axial planar S1 foliation crosscuts bedding at an oblique angle (Figure 31) and is in turn deformed into near-upright, north-trending, close to tight F2 folds. Since all of the structures are transposed in the higher grade eastern component of the Waugh Lake Group, it is unclear if the isoclinal folds and mylonitic fabric developed during D1 or D2 folding.

### b) Discussion

Koster (1961) divided the sedimentary rocks at this western extent of the Tazin Lake map area into a 'western metasedimentary and metavolcanic complex', which was later renamed the Waugh Lake Group in Alberta, and a 'pegmatite-migmatite complex' comprising various sedimentary schists with intrusive pegmatite, and migmatitic hornblende gneisses. He went on to point out that 'the relation between' the two was 'not clear'. The rocks making up the 'pegmatite-migmatite complex' appear traceable northwards into lower greenschist to lower amphibolite facies, turbiditic rocks of the 'Hill Island Lake Assemblage' in the Northwest Territories (Bostock and van Breemen, 1994). The Hill Island Lake Assemblage contains detrital zircons as young as 2134 Ma and is intruded by the 1934 Ma Natael muscovite granite (Bostock and van Breemen, 1994). The steep eastward metamorphic gradient recognized during the current study implies that the 'pegmatite-migmatite complex' simply represents a deeper crustal level exposure of the Waugh Lake Group and the probably correlative Hill Island Lake Assemblage.

## 6. Harper Lake Area (Westernmost Zemplak Domain)

The Harper Lake area is centred about 65 km west of Uranium City and 12 km from the Alberta border (Figure 1). It is 15 km southeast of Morris Lake, although work in the two areas was separated by as little as 8 km. Harper Lake is relatively small, affording access to a more restricted area than Ena, Tazin and Tsalwor lakes, although this facilitated the production of a more detailed 1:20 000 scale map. The aims of visiting this area included: 1) having a second look at Koster's (1963) highly magnetic 'Tazin Group Amphibolitic Metasedimentary Rocks' in the northeast; 2) establishing the origin of rocks variously referred to as 'White Lake Complex' by Koster (1963), 'pegmatite-migmatite complex' by Koster (1961), and mylonitic orthogneiss (Ashton and Hunter, 2004); 3) studying the transition from southeast-trending 'red gneisses' to east-trending 'undifferentiated White Lake rocks' in the south; and 4) examining the westernmost Zemplak Domain rocks to see if any inferences can be made about its boundary with the Taltson Domain.

The relevant findings are: 1) as in the Tazin-Tsalwor lakes area, the 'Tazin Group' comprises variably mylonitic, locally porphyritic granitoid rocks (Figure 32); 2) most of the 'White Lake Complex' is ultramylonite derived from granitic rocks, although rare sedimentary rocks are incorporated; and 3) the 'red gneisses' are variably mylonitized, medium-grained, granitic gneisses, whereas the 'undifferentiated White Lake rocks' include a mix of variably mylonitized, coarse-grained, granite and locally porphyritic granodioritic to tonalitic rocks that are probably part of the Taltson Magmatic Zone. The change in orientation of the main structural trend is seen throughout the western part of the Tazin Lake map area and appears to represent the rotation of an early southeast-trending fabric into a more north-south orientation due to tectonic activity at the western margin of the Churchill Province.

### a) Unit Descriptions

**Pink, coarse-grained granite**, characterized by 1 cm grain size, underlies much of the southern White Bay area (Figure 33). It is variably mylonitized such that the coarse K-feldspar grains commonly occur as augen, pancakes or porphyroclasts. Otherwise, it is homogeneous and contains 10 to 15% biotite/chlorite. Similar rocks are exposed in the Tazin-Tsalwor lakes and Uranium City (North Shore Plutons) areas.

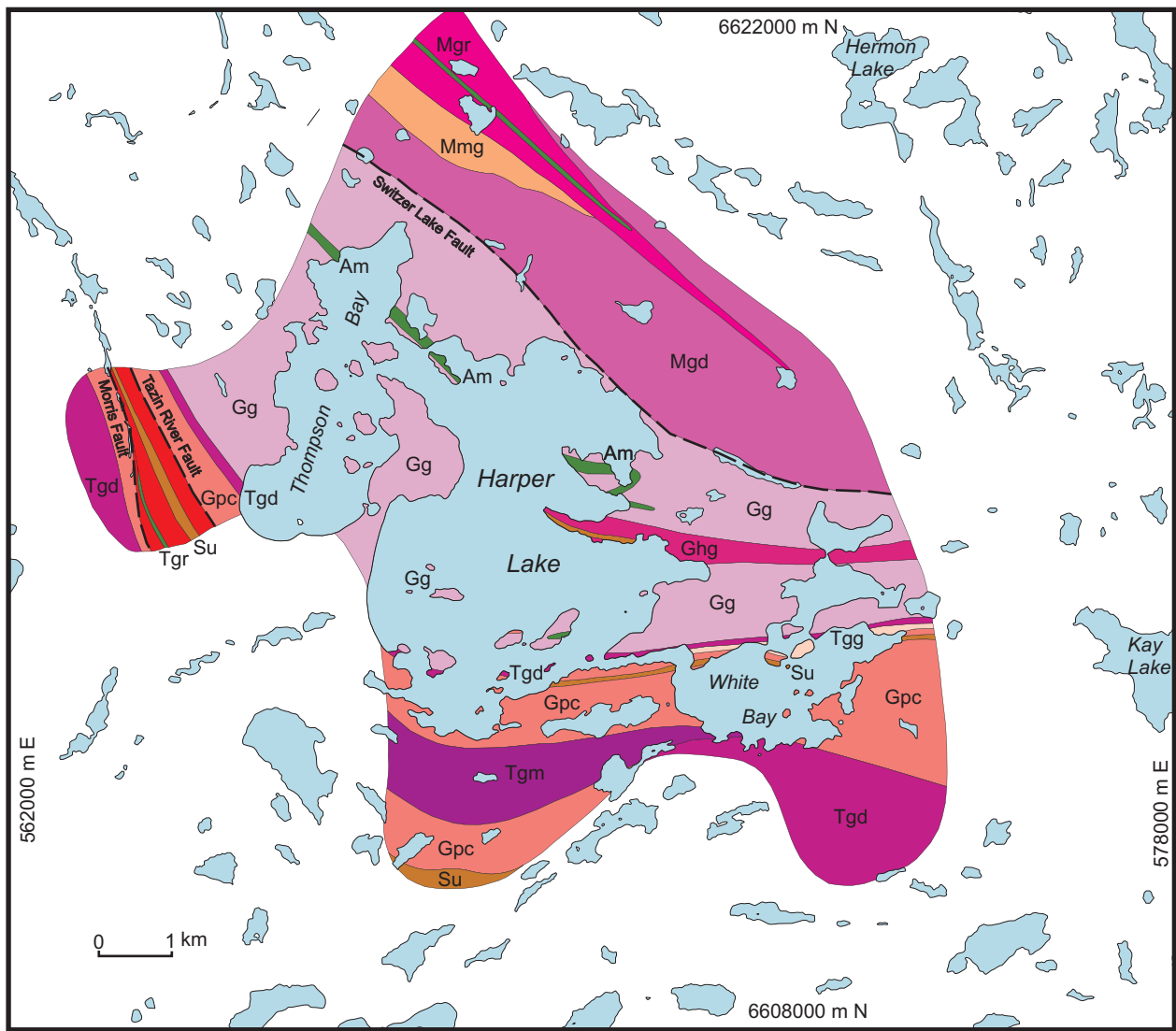
The highly magnetic rocks previously referred to as the 'Tazin Group' are variably mylonitized orthogneisses and have been divided into three units (Figure 32). The most abundant is **porphyritic granodiorite-tonalite**, which is pink-grey, fine to medium grained and characterized by locally preserved feldspar phenocrysts up to 4 cm long that have been flattened into augen and/or pancakes to produce a ribbed weathered surface. It contains 5 to 10% hornblende, 10 to 15% biotite, along with minor magnetite and iron sulphides. Most outcrops are intruded by about 10% pink leucogranite and contain minor mafic inclusions thought to be derived from dykes. **Porphyritic granite** in the north is considered a more felsic phase of the same pluton. It is fine to coarse grained with K-feldspar augen and pancakes up to 1 cm long, 2 to 10% hornblende, 10% biotite, 2% magnetite, and centimetre-scale amphibolitic layers and inclusions. **Migmatite** derived from the injection of abundant leucogranite into the porphyritic rocks is also exposed in the north.

The pink **gneissic granite** exposed in the central area was mainly derived from medium-grained leucogranite with about 2% chlorite, although minor amounts appear to have been originally coarse-grained. Grey centimetre-scale layers with up to 10% chlorite and altered feldspar are the result of shearing, which also locally produced feldspar beading. Most outcrops are magnetic and contain about 10% amphibolite inclusions, along with abundant sheets of medium-grained to pegmatitic granite.

**Hornblendic ultramylonite**, characterized by locally acicular hornblende up to 1 cm long, is exposed within the gneissic granite unit in the south (Figure 32). It is unclear whether it was derived from more granodioritic rocks or from interaction of amphibolitic inclusions with the gneissic granite.

**Supracrustal rocks** form several small units mainly in the west and south. The best exposures include interlayered pelite, psammopelite, amphibolite, and rare quartzite. The pelites comprise a grey-brown to rusty, fine-grained paleosome and a white, fine- to medium-grained, variably dismembered leucosome. They contain 10 to 30% biotite, 0 to 10% sericite, locally pseudomorphed garnet porphyroblasts and trace graphite, and are intruded by medium-grained to pegmatitic granite sheets. The easternmost occurrence of these supracrustal rocks is in a low-strain zone, preserved between two faults. The constituent rock types, together with their location along strike, strongly suggest that they are part of the Waugh Lake Group.

**Amphibolite** with minor pyroxenite also occurs independent of the supracrustal rocks as metre-scale inclusions and discontinuous layers, and forms a mappable unit through Harper Lake. Most is homogeneous, green to black, and fine to medium grained with about 50% hornblende, variably altered to biotite and chlorite. The pyroxenite is also dark green and variably altered to amphibolite. Typical occurrences of the amphibolitic unit are mylonitic and include abundant intercalated white medium-grained granitoid of the gneissic granite unit. The westernmost



**Possible Reworked Rocks of the Taltson Magmatic Zone**

- Tgr Medium-grained granite
- Tgg Grey gneiss
- Tgd Porphyritic granodiorite-tonalite
- Tgm Granodioritic gneiss
- Am Amphibolite, minor pyroxenite
- Su Mixed supracrustal rocks

**Rocks of Unknown Age**

- Gg Gneissic granite
- Ggh Hornblendic ultramylonite
- Gpc Pink coarse-grained granite

**Highly Magnetic Rocks of Former 'Tazin Group'**

- Mgd Porphyritic granodiorite-tonalite
- Mgr Porphyritic granite
- Mmg Migmatite

*Figure 32 - Simplified geological map of the Harper Lake area.*

occurrence is less deformed and spatially related to the mixed supracrustal rocks. This may indicate that the amphibolite was derived from Waugh Lake Group mafic volcanic rocks and feeder dykes.

A broad unit of mylonitized, variably magnetic **porphyritic granodiorite-tonalite with minor medium-grained granitoid** is exposed in the west and south. The granodiorite-tonalite is pink-grey and fine grained with 15 to 20% white feldspar augen and porphyroclasts up to 2 cm (rarely up to 10 cm) long, and 15 to 30% biotite and/or



**Figure 33 - Sheared coarse-grained granite; from eastern White Bay, Harper Lake (UTM 573894 m E, 6613105 m N).**



**Figure 34 - Euhedral plagioclase phenocrysts (arrows) up to 3 cm long in tonalite; from west of Thompson Bay, Harper Lake (UTM 563287 m E, 6615756 m N).**

to tight, north-trending F4 folds dip moderately. Tectonic stretching lineations are locally well developed but variable in orientation, presumably due to rotation during the later folding events. A few show down-dip geometry that may be unaffected by this later folding, but most are gently plunging. Rare intersection lineations tend to be co-linear with the F3 and F4 fold axes.

## 7. Quaternary Erosional Features

About 250 ice-flow indicators, including glacial striae, chattermarks, and roches moutonnées were measured during the 2005 mapping. At **Ena Lake**, the vast majority of striae trend between 220° and 243°, with an average of 230°. Multiple striae directions were noted at three sites, but because these varied by only a few degrees and cross-cutting relationships could not be established, it is not clear whether they represent minor variations in the last major ice flow or separate flow events. An earlier ice advance towards 210° to 215° was recorded at two isolated sites and at a locality where roches moutonnées trending at 210° have superimposed glacial groves at the more typical orientation of 228°.

The 149 measurements in the **Tazin-Taltson lakes area** can be divided into at least three sets in order of decreasing age: 188° to 207°, 210° to 245°, and 250° to 263°. The 188° to 207° set occurs in two zones: one through western Tazin and eastern Tsalwor lakes, where it is clearly older than the main 210° to 245° set, and in the area south of Thluicho Lake where the relative age of the striae could not be established.

hornblende (Figure 34). Most outcrops also contain 15% (but locally up to 60%) medium-grained to pegmatitic leucogranite sheets. A subunit of **granodioritic gneiss** is characterized by having a more layered character and a very high magnetic signature. These porphyritic granodioritic to tonalitic rocks occur in close proximity to Koster's (1963) 'quartz diorite' unit, which forms the margin of his 'western granodiorite complex'. Across the border in Alberta, the westward extension of this complex is termed the Colin Lake Pluton, a quartz diorite phase (previously called Waugh Lake quartz diorite) of which has yielded an age of 1971 Ma (McNicoll *et al.*, 1994).

Homogeneous, pale pink to white-cream, **medium-grained granite** occurs with the mixed supracrustal rocks in a low-strain zone between two faults east of Thompson Bay (Figure 32). It is foliated to lineated, variably sheared, and contains 10 to 15% biotite. Its similarity to the medium-grained granodiorite east of Morris Lake, together with its location more or less along strike, suggests that the medium-grained granite may also be a part of the 1971 Ma Colin Lake pluton. Partially melted and mylonitic **grey gneiss** in the White Bay area may represent a more highly deformed equivalent of the medium-grained granite. It contains feldspar porphyroclasts up to 5 mm in size, 5 to 15% partially shear-induced biotite, and is weakly magnetic.

No late dykes were recognized in the Harper Lake area.

### b) Structure and Metamorphism

The main regional southeast-trending fabric of the southwestern Tazin-Tsalwor lakes area is transposed in the extreme western part of the Harper Lake area to the more northerly trend characterizing the Martyn and Morris lake areas. Rare east- to southeast-trending tight to isoclinal folds are probably synchronous with mylonitization and correlative with the F2 folds in both flanking areas. The dominant southeast-trending F3 folds have moderate to steep axial planes, whereas open

The main 210° to 245° set has an average trend of 230°, similar to the 233° trend of fluting developed in till at the northwest corner of Tazin Lake. At one locality, a set of striae at 220° is overprinted by another at 238°, suggesting that this 210° to 245° set may include data from more than one ice advance or ice-flow event.

The 250° to 263° set of striae were measured from a zone through central and southern Tazin Lake and from one locality at the eastern end of Tsalwor Lake. They overprint the main 210° to 245° set at several sites.

The 240° to 251° set of striae measured at **Martyn Lake** are distinctly different from the two sets at 195° to 210° and 223° to 230° recognized at **Morris Lake**. The relationships between the three sets is not known.

At **Harper Lake**, measurements of 26 features yielded ice-flow directions ranging between 190° and 243°. The majority of these fall between 218° and 243° with an average of 228°. This is thought to represent the last major ice flow direction, but again, the large variation may indicate a more complex history. At one locality, striae at 190° were noted on a protected surface, whereas the main outcrop exhibited striae at 212°. The latter orientation was noted at one other site, suggesting that there may have been two early southward advances.

In summary, ice-flow erosional features indicate: 1) an early advance throughout the area at 188° to 210° in the west and 210° to 215° in the east; 2) a main period of ice flow at 218° to 245° throughout the area; and 3) late-stage ice flow at 250° to 263° along the major lineament defined by Tazin Lake.

## 8. General Discussion and Conclusions

The Nolan Domain appears to comprise part of a *ca.* 2.6 Ga multi-phase batholith that presumably escaped partial melting due to the absence of a fluid phase. Its boundary with the Zemplak Domain is marked by two tectonic fronts, both of which appear to be marked by an abundance of injected pink leucogranite (likely a product of crustal melting due to tectonic thickening), partial melting, and mylonitization. Note that this boundary has been extended westward and southward to better coincide with the onset of pervasive mylonitization (Figure 1). Although the *ca.* 2.6 Ga rocks of the Nolan Domain extend across both tectonic fronts into the Zemplak Domain, there is a strong possibility of there also being 2.3 Ga and 3.0 Ga plutonic rocks, in addition to the injected pink leucogranite, based on the presence of all four suites in the Beaverlodge Domain to the east (Hartlaub, 2004).

The southeasterly trending tectonic front through Tsalwor Lake is the earlier of the two fronts, and appears distinct from both the northerly to northeasterly trend of the Taltson Magmatic Zone and the younger northeasterly trend of the Black Bay straight belt. Assuming the pink leucogranite spatially associated with this front is correlative with the similar pink leucogranite dated at Uranium City, then the front probably records an accretionary event involving southwest-northeast shortening at about 1.93 Ga. Since this is the time at which igneous activity ceased and metamorphism peaked in the Taltson Magmatic Zone, this southwestern tectonic front could represent accretion of the Buffalo Head or some other exotic terrane to the Rae-Hearne craton. There are no metamorphic ages from the vicinity of the tectonic front; however, the two most westerly metamorphic ages from the northern shore of Lake Athabasca are also *ca.* 1.93 Ga, significantly older than the 1.91 to 1.90 Ga metamorphic ages found farther east. The presence of 1.98 to 1.97 Ga arc-type rocks that predate the main period of deformation and metamorphism in the Lloyd Domain and in the basement to the western Athabasca Basin (Stern *et al.*, 2003), also suggests that the original orientation of this continental arc could have been northwest-southeast. In this scenario, transposition from the main southeasterly structural trend into the more northerly to northeasterly trend generally associated with the Taltson Magmatic Zone, would result from later plate interactions to the west.

The southeasterly of the two tectonic fronts marking the Nolan-Zemplak domain boundary is genetically linked to the Black Bay straight belt, which was probably developed at 1.91 to 1.90 Ga based on metamorphic ages in the vicinity of the Black Bay Fault and farther east. This is coeval with the timing of high-pressure metamorphism in the Tantato Domain on the western hanging wall of the Snowbird Tectonic Zone, which has been interpreted as a suture by some workers, along which the Rae and Hearne proto-continents were amalgamated (Walcott and Boyd, 1971; Gibb and Halliday, 1974; Hoffman, 1988). The Black Bay straight belt may be a distal product of that inferred orogen to the east, developed as a fundamental break between dominantly Mesoproterozoic rocks forming the basement to the *ca.* 2.3 Ga Murmac Bay Group in the western Beaverlodge Domain and the Neoproterozoic basement in the Zemplak Domain.

The southeasterly front may therefore represent the western extent of this 1.91 to 1.90 Ga deformational overprint. The corresponding metamorphic grade could be quite low, and may account for the greenschist facies metamorphism documented in the Thluicho Lake Group (Scott, 1978; Hunter *et al.*, 2003, 2004b; Yeo, this volume), which is currently bracketed between 1.93 and 1.82 Ga. Similarly, the pink leucogranite spatially associated with both tectonic fronts was probably derived by crustal melting at 1.93 Ga and is simply overprinted by 1.91 to 1.90 Ga deformation along the southeastern tectonic front.

The Ena Domain appears to comprise the same rock types and in the same proportions as the Zemplak Domain. The Tazin Lake Fault, which forms the boundary between the two, appears to be a late brittle-ductile structure with little significant displacement. Thus, pending geochronological data to test this theory, there seems little reason to distinguish the two domains.

The Taltson Domain in Alberta and the Northwest Territories comprises a mix of *ca.* 3.2 to 3.1, 2.6, 2.4 to 2.1, and 2.0 to 1.92 Ga rocks with  $T_{DM}$  ages ranging from 2.6 to 3.7 Ga (Bostock *et al.*, 1987; McNicoll *et al.*, 2000), consistent with it being a western margin of the Churchill craton into which 2.0 to 1.9 Ga continental arc rocks were emplaced. Its eastern boundary is in part geophysical and in part placed at the eastern extent of recognizable 1.98 to 1.97 Ga arc rocks (Hoffman, 1988; Ross *et al.*, 1991). Based on this study, it is unclear how far east such rocks extend because there appears to be yet another, north-trending, sub-vertical tectonic front located a few kilometres east of the provincial border, marking the eastward transition from weakly deformed and metamorphosed granodioritic to dioritic arc rocks and the Waugh Lake Group, into upper amphibolite facies, mylonitized versions of both. Thus, many of the orthogneisses in the Harper Lake area may be part of this *ca.* 1.98 to 1.97 Ga arc suite, and the pelitic migmatite and diatexite exposed both at Harper Lake and farther east towards Camsell Portage (Ashton and Hunter, 2004) may well represent extensions of the Waugh Lake Group and the probably correlative Hill Island Lake Assemblage.

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