Basement Rocks to the Western Athabasca Basin in Saskatchewan

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Abstract

The EXTECH IV Sub-project 5 was proposed to address poorly understood basement rocks to the Athabasca Basin, west of the Snowbird Tectonic Zone. Those rocks lie within the Archean Rae Province and comprise seven lithotectonic domains and the Carswell meteor impact site. The Beaverlodge Domain is primarily underlain by Murmac Bay Group equivalents and younger intrusive rocks. These rocks may extend to the west into the Zemlak and Forcie domains. Beaverlodge rocks might also extend eastward into the Tantato Domain. Alternatively, the Grease River Shear Zone may represent a major tectonic discontinuity which truncates the Beaverlodge Domain. It is unclear if Beaverlodge-type rocks extend southward under the Athabasca Basin due to the Grease River Shear Zone and an east-west magnetic trend under Lake Athabasca which may truncate them. South of the basin are the poorly understood Western Granulite and Firebag domains, which apparently contain similar rocks and structural trends. The domains are separated by the poorly exposed Clearwater Domain, interpreted to be a magmatic belt.

Preliminary observations about these rocks are:

1) *The northern domains, for the most part, appear to contain a similar package of rock types.*
2) *The Athabasca Lozenge, as it is currently defined, is problematic, particularly along its western margin, which is delineated by at least four distinct entities. Furthermore, rocks from the Western Granulite Domain seem to extend into the Firebag Domain, thus spanning the boundary of the lozenge.*
3) *Rocks in the Carswell metamorphic core have similarities to rocks of the Murmac Bay Group; however, this is problematic because the Grease River Shear Zone is interpreted as a major crustal discontinuity.*
4) *Young, weakly deformed granodioritic rocks become much more prevalent near the Alberta border suggesting that they are derived from the west e.g. Taltson magmatic zone.*
5) *The Clearwater Domain has similar geophysical characteristics and a similar relative age to the Rimbey high in the Alberta basement.*

Future work will entail both field and analytical components. Field studies will include reconnaissance visits to several of the exposed domains and visits to core repositories. Core will be used to create a subcrop map for the western basin. Analytical work will include geochemistry and geochronology. The primary target for analytical work is the Clearwater Domain.

1. Introduction to EXTECH IV Sub-project 5

Compilation mapping of the basement to the Athabasca Basin was initiated by the Saskatchewan Geological Survey in the early 1980s (e.g. Gilboy, 1985). During the tenure of this study, much of the focus was placed on rocks east of the Snowbird Tectonic Zone (Hoffman, 1988) (Figures 1 and 2). Most uranium exploration of the Athabasca Basin has been focussed in this eastern part resulting in the discovery of world-class unconformity-type, uranium deposits (e.g. McGill *et al*., 1993). The Cluff Lake uranium deposits suggest there is potential for more discoveries west of the Snowbird Tectonic Zone. Recent discoveries such as Shea Creek (Rippert *et al*., 2000) confirm this potential. Unlike the eastern Athabasca Basin, however, where the geology and tectonic evolution of rocks in the exposed shield and basement is reasonably well understood, the basement rocks in the west remain enigmatic.

This study (EXTECH IV Sub-project 5) was proposed to improve understanding of the basement to the western Athabasca Basin and to look at the relationships between these rocks and those in the exposed shield to the north and south. Knowledge of the lithologic units and tectonic history of most lithotectonic domains west of the Snowbird Tectonic Zone in Saskatchewan is poor at best. In recent years, new studies have revitalized interest in these western domains. This project represents an extension of studies north of Lake Athabasca (e.g. Ashton *et al*., this volume) and will enhance understanding of the evolution of these domains.

2. General Geology

The rocks which form the subject of this study are situated in the Archean Rae Province (Figure 1), which forms the northwest portion of the Churchill Structural Province (Stockwell, 1961), and extends from

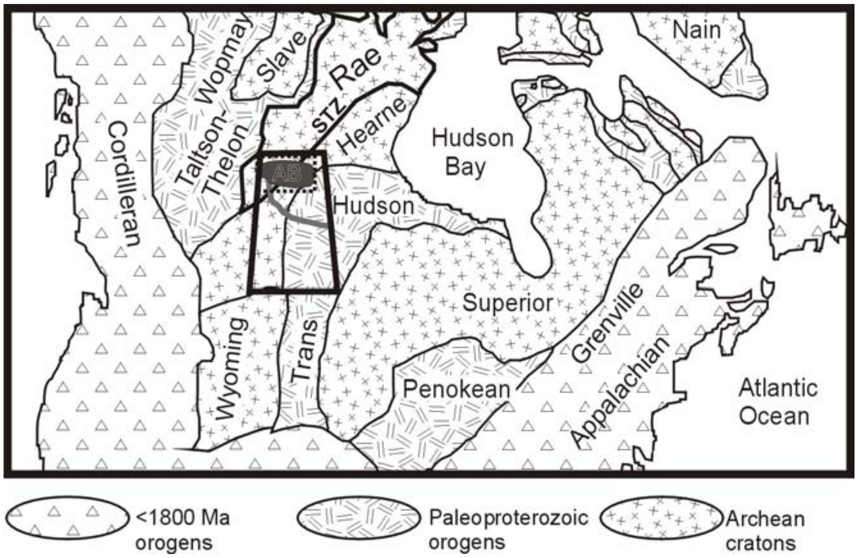

Figure 1 - Orogenic map of North America (after Hoffman, 1988). The Rae Province is outlined with a medium black line. Note the Snowbird Tectonic Zone (STZ). Saskatchewan is outlined with a heavy black line, the Athabasca Basin (AB) is solid grey, and the limit of Phanerozoic cover is a solid grey line. The dashed line encompassing the basin represents the extent of Figure 2.

Greenland to northeast Alberta where it continues beneath Phanerozoic cover. The Rae Province is bounded along its northwest margin by the Taltson and Thelon orogens and to the southeast by the Snowbird Tectonic Zone (Hoffman, 1987), which subdivides the Churchill Structural Province into the Rae and Hearne provinces. It loses continuity in the southwest where geophysical data indicate that the Snowbird Tectonic Zone and the Taltson magmatic zone merge and has a poorly delineated northeast boundary.

In northern Saskatchewan, the Rae Province is bounded to the west by the Taltson segment of the Taltson-Thelon orogen, represented by the ca. 2.02 to 1.91 Ga Taltson magmatic zone (Berman and Bostock *et al*., 1997; Grover *et al*., 1997). To the east, it bounded by the Black Lake and Virgin River segments of the Snowbird Tectonic Zone (Figure 2).

3. Previous Work

Precambrian rocks comprising seven lithotectonic domains and the Carswell Structure provide a template to which the basement rocks sub-cropping beneath the Athabasca Basin can be compared. The following is an overview of these rocks compiled primarily from the existing literature.

a) Beaverlodge Domain

The Beaverlodge Domain has been extensively studied in the vicinity of Uranium City (Figure 2) due to significant mining activity in the area (e.g. Tremblay, 1972). In recent years, the domain has been revisited resulting in new interpretations with regard to the age, origin, and extent of these rocks (e.g. Ashton and Card, 1998). A condensed synopsis of rocks found in the Beaverlodge Domain is presented here. For a more comprehensive review see Hartlaub and Ashton (1998), Hartlaub (1999), Ashton *et al*. (2000), and Ashton *et al*. (this volume). On the basis of recent mapping, Ashton *et al*. (2000) suggested that the Beaverlodge Domain (Figures 2 and 3), formerly defined as small northeast-trending belt of rocks, be expanded based on lithologic similarities across boundaries, to include rocks of the Nevins Lake Block and Black Bay Domain.

The main component of the Beaverlodge Domain is the Murmac Bay Group (Tremblay, 1972), a package of dominantly siliciclastic metasedimentary rocks which underlie much of the area near Uranium City. The Murmac Bay Group unconformably overlies ca. 3050 Ma granitoid basement (Persons, 1983), which constrains the maximum age of the supracrustal package. It is characterized by a rare basal polymictic conglomerate (Ashton *et al*., this volume), which is overlain by quartzite, mafic metavolcanic rocks, silicate-facies iron formation, dolomitic marble, psammite, psammopelite, and pelite (e.g. Hartlaub and Ashton, 1998). The base of the group is intruded by high-level, ultramafic rocks of komatiitic affinity (Schwann, 1985). The Murmac Bay Group is intruded by several suites of granitoid rock, the oldest of which provides a minimum age of ca. 2640 Ma (Hartlaub, unpublished data, 2000). Consequently, the Murmac Bay Group represents an Archean quartzite-komatiite-type sequence (e.g. Bleeker *et al*., 2000). At least two more suites of granite intrude the Murmac Bay Group: 1) ca. 2350 to 2315 Ma plutons (Persons, 1983; Hartlaub, unpublished data, 2000); and 2) the ca. 1990 to 1950 Ma mine granites (Persons, 1983; O'Hanley *et al*., 1994).

The Murmac Bay Group was subjected to upper greenschist- to lower amphibolite-facies metamorphic conditions immediately south and east of Uranium City; however, there is a significant increase in metamorphic grade away from that low in all directions. To the west, grade increases dramatically to upper amphibolite facies across the Black Bay Fault (Ashton *et al*., 2000). To the south, upper amphibolite-facies rocks are encountered at the south end of the Crackingstone Peninsula (Figure 2) (Ashton *et al*., 2000). To the north and northeast, metamorphic grade increases rapidly to upper amphibolite facies. To the east lower amphibolite-facies rocks grade into granulite-facies rocks in what was previously referred to as the Nevins Lake Block. As a result, the relatively

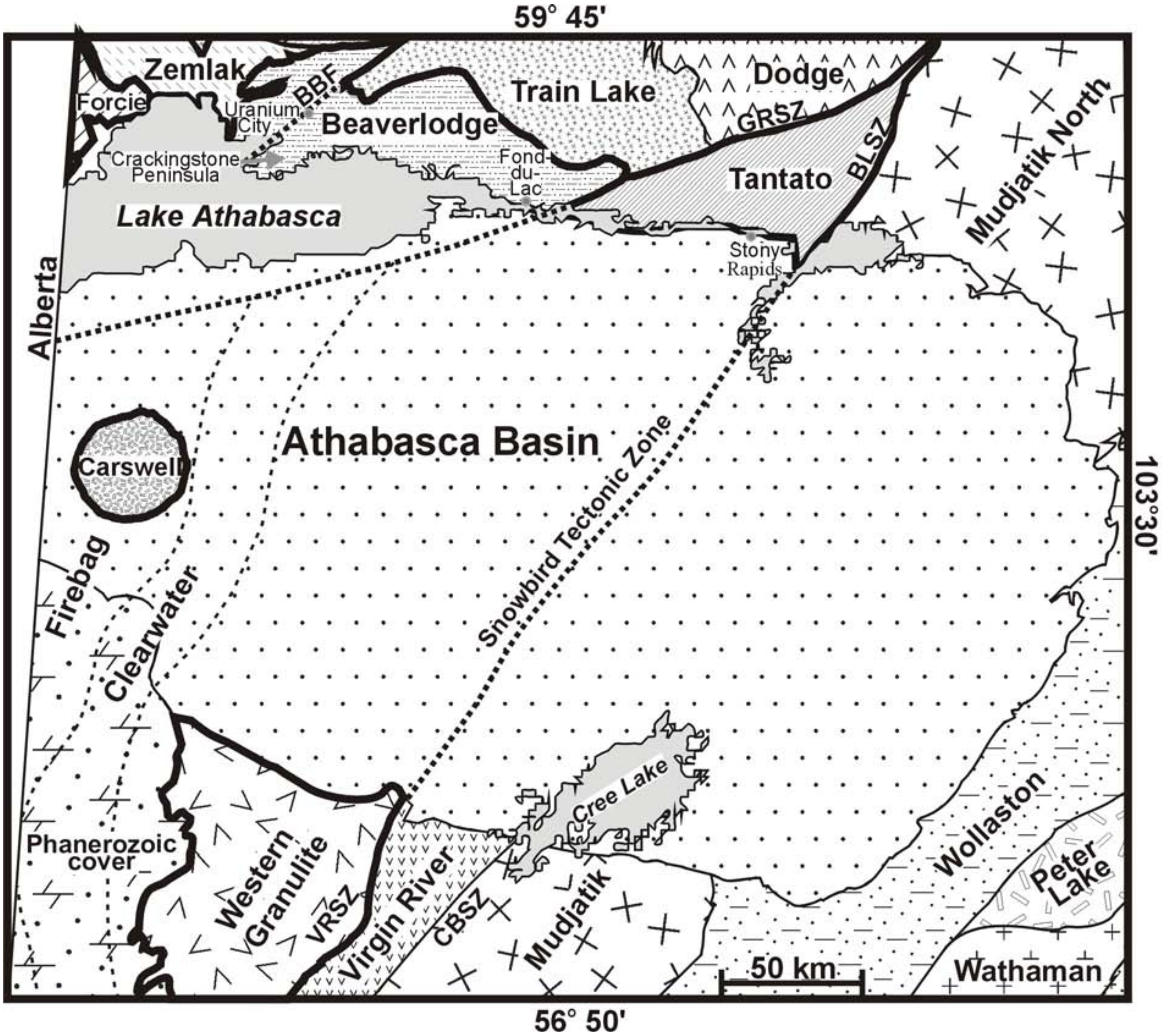

Figure 2 - Domainal map of northwest and north-central Saskatchewan. The focus of this study is west of the Snowbird Tectonic Zone in domains outlined in heavy black. Unexposed domains are outlined with fine dashes and are projected on the map based on their regional geophysical signature. The extensions of the Snowbird Tectonic Zone and the Grease River Shear Zone (GRSZ) beneath the Athabasca Basin are shown with heavy dashed lines. BLSZ, Black Lake Shear Zone; BBF, Black Bay Fault; CBSZ, Cable Bay Shear Zone; and VRSZ, Virgin River Shear Zone.

pristine rocks in the vicinity of Uranium City represent the best opportunity to interpret the geologic history in this domain. The area, however, is intensely deformed, particularly adjacent to the Black Bay Fault, making corresponding stratigraphic restoration a difficult task. Ashton *et al*. (this volume) report four phases of deformation in the region, whereas Card and Bethune (1999) reported five phases in the eastern Beaverlodge Domain.

The Murmac Bay Group and its associated intrusive phases are unconformably overlain by the ca. 1800 Ma(?) Martin Group (Tremblay, 1972). The Martin Group comprises dominantly red sandstone with subordinate conglomerate and basaltic flows. The package is closely folded but unmetamorphosed. The Martin Group is spatially associated with the Black Bay Fault suggesting a cogenetic relationship (pull apart basin?).

b) Forcie and Zemlak Domains

The Forcie Domain is separated from the Zemlak Domain (Figures 2 and 3) by a zone of cataclasis/mylonitisation; however, both domains are underlain by apparently similar rocks. No new geological investigation has been focussed in these domains in the last 20 years, therefore mapping carried out in the late 1960s and late 1970s provides much of our knowledge base for the two domains (Koster, 1963, 1967; Scott, 1978; Harper, 1978, 1979). The Forcie Domain is characterized by an older, possibly Archean, White Lake Complex, and a younger Granodiorite Complex (Koster, 1963, 1967; Harper,

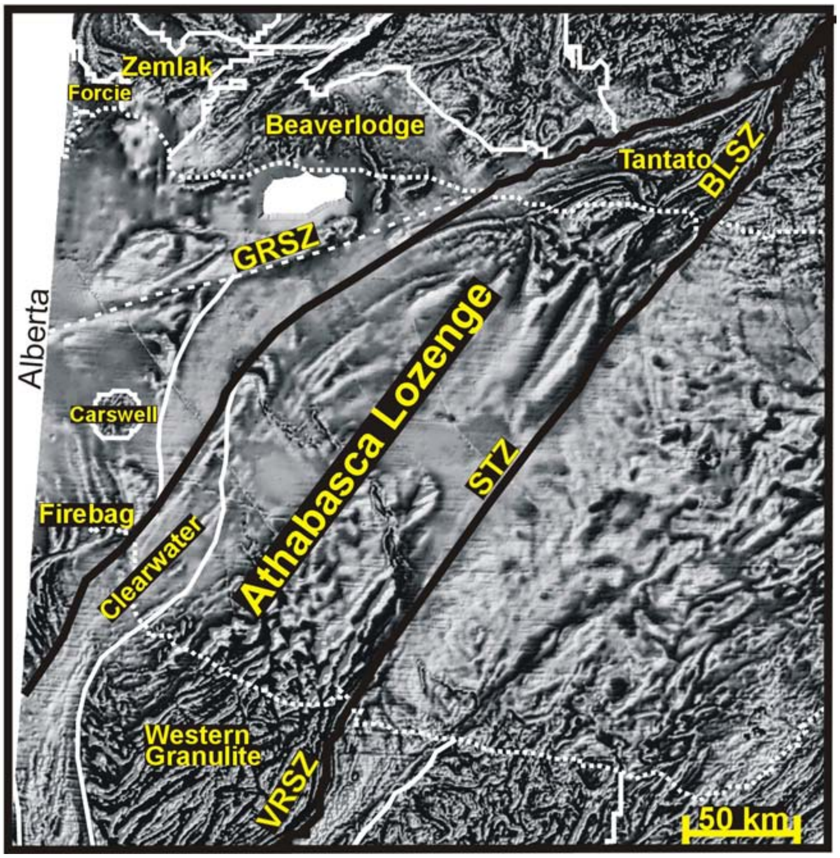

Figure 3 - First vertical magnetic derivative (shadowgram) of the western Athabasca region. The western domains from Figure 2 are outlined in solid white. The margin of the Athabasca Basin is outlined with a dashed line. The Athabasca Lozenge is outlined with a heavy black line. The eastern margin is marked by the Snowbird Tectonic Zone (STZ) including the Black Lake (BLSZ) and Virgin River (VRSZ) segments. Also shown is the extension of the Grease River Shear Zone (GRSZ).

1996). The upper amphibolite-facies White Lake Complex is characterized by migmatitic biotite, psammitic, and pelitic gneisses (Harper, 1996) which have been invaded by granitic sheets, termed red gneisses (Koster, 1967). The Granodiorite Complex comprises younger, greenschist-facies granodiorite and quartz diorite (Harper, 1996).

The Zemlak Domain apparently contains similar rocks. The oldest rocks in the Zemlak Domain are described by Hale (1955) as Tazin Group quartzite and amphibolite, and the White Lake Complex, which ranges in composition from quartzite to garnet-bearing granite and is likely derived from the Tazin Group. It should be noted that in the Uranium City area, Tazin Group rocks have been correlated with, and renamed, the Murmac Bay Group. The Tazin supracrustals and White Lake Complex are intruded by "reddish" granitic gneisses, however, no younger, homogeneous granodiorite suite is present. The White Lake Complex and red gneisses are continuous across the Forcie/Zemlak boundary calling into question the necessity for separate domains. Furthermore, these rocks are described much in the same way as those currently being mapped in the western Beaverlodge Domain (formerly Black Bay) to the east (Ashton *et al*., this volume).

The rock package that distinguishes the Zemlak Domain is the Thluicho Lake Group. The Thluicho Lake Group is characterized by greenschist-facies conglomerate, arkose, and argillite (Scott, 1978). It is distinguished from, and considered older than, the Martin Group based on its higher metamorphic grade and more deformed state, however, its absolute age is unknown. The Thluicho Lake Group was intersected in mineral exploration drilling in the Maurice Bay area (Harper, 1996) of the Forcie Domain, but does not outcrop.

c) Tantato Domain

The Tantato Domain (Figures 2 and 3), also referred to as the East Athabasca mylonite triangle (Hanmer *et al*., 1994), forms the southern segment of the Striding-Athabasca mylonite zone (Hanmer *et al*., 1995) and represents the northeastern part of the proposed Athabasca Lozenge (e.g. Hanmer *et al*., 1995). Systematic mapping in the Tantato Domain began in the early 1960s (e.g. Colborne, 1962) and investigations continued last summer (e.g. Mahan *et al*., this volume). The most recent, significant geological mapping was undertaken by the Geological Survey of Canada in the early 1990s and is summarized in Hanmer *et al*. (1994) and Hanmer (1997).

The Tantato Domain comprises > 2600 Ma pelitic diatexite, mafic granulite, granitoid rocks and the ca. 3150 Ma tonalitic Chipman Batholith, the oldest rock found (Hanmer, 1997). It is bounded by two major shear zones: 1) the Black Lake Shear Zone, a segment of the Snowbird Tectonic Zone, at the eastern boundary (Figures 2 and 3); and 2) the Grease River Shear Zone forming the northwestern boundary (Figures 2 and 3). The magnetic signatures of these structures can be traced beneath the Athabasca Basin where they have been used to define a lozenge-shaped area (Figure 3) of inferred similar rocks, the Athabasca Lozenge, thought to be related to the Snowbird Tectonic Zone, and comparable with the Selwyn and Three Esker lozenges along strike to the northeast (Hanmer *et al*., 1994). Most of the exposed domain is underlain by intensely mylonitised gneisses with the exception of a zone of rocks along its central axis that do not display ubiquitous mylonitisation (Hanmer *et* *al*., 1994). The origin of granulite-facies mylonitisation, and the Grease River and Black Lake shear zones was originally considered to be dominantly Archean with only minor Proterozoic reactivation (Hanmer *et al*., 1994). In contrast, Lafrance and Sibbald (1997) suggest that the Grease River Shear Zone is a Proterozoic structure (also see Mahan *et al*., this volume).

d) Western Granulite Domain

The Western Granulite Domain (Figures 2 and 3) is bounded on the east by the Virgin River Shear Zone, the southwestern segment of the exposed Snowbird Tectonic Zone, and by the Clearwater Domain in the west. Very little geological mapping has been carried out in the domain. Lewry and Sibbald (1977) described these rocks as a series of layered gneisses varying in composition from granitic to gabbroic, but most commonly granodioritic. Metasedimentary rocks, including pelite and quartzite, are a minor component. These rocks are considered to be largely of Archean age (e.g. Scott, 1985). Also present are anorthositic intrusions, but their age continues to be problematic. Recent U-Pb zircon and Ar/Ar hornblende geochronology yielded a ca. 1920 to 1910 Ma age but it is still unclear whether this a crystallization or metamorphic age (Heaman *et al*., 1999; Halls and Hanes, 1999). Ca. 1820 Ma granitic intrusions, such as the Junction granite, intruded mylonitic rocks of the Virgin River Shear Zone and were subsequently mylonitised (Bickford *et al*., 1986).

As is implied by the its name, the Western Granulite Domain is dominated by granulite-facies rocks (Lewry and Sibbald, 1977). In contrast to the Black Lake segment of the Snowbird Tectonic Zone, the Virgin River Shear Zone appears to have formed under lower amphibolite- to upper greenschist-facies conditions (Lewry and Sibbald, 1977), although this may be related only to the late history of the shear zone. The Western Granulite Domain has been interpreted on geophysical grounds as representing the southern extension of the Athabasca Lozenge. Although multiply deformed, the Western Granulite Domain is not intensely mylonitised throughout its extent (Lewry and Sibbald, 1977).

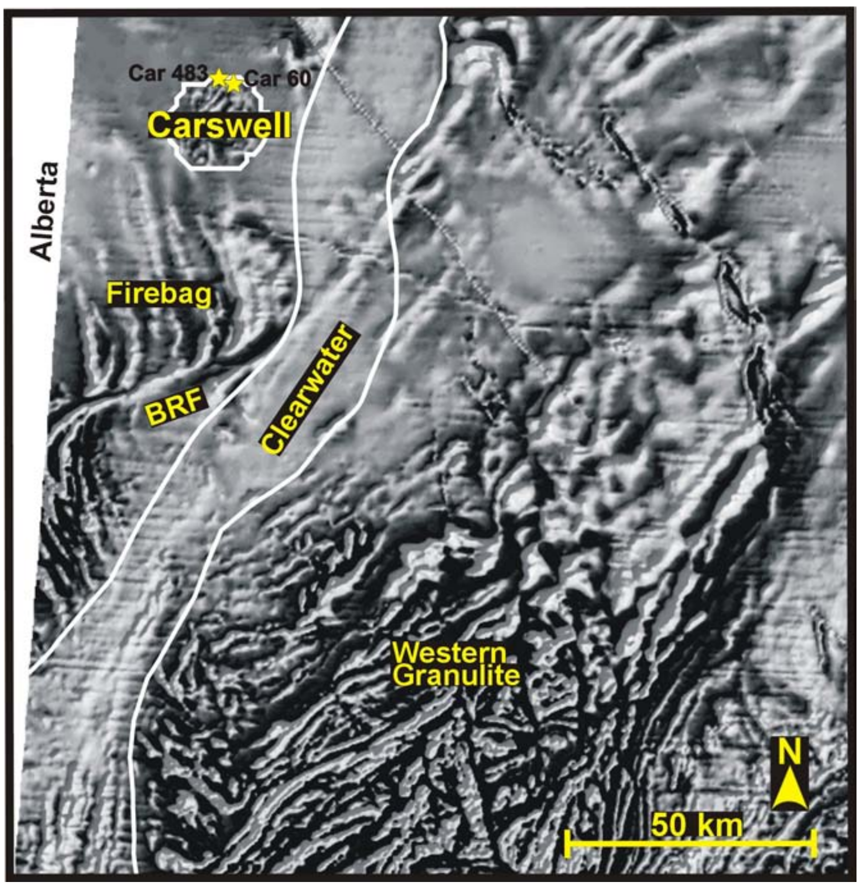

Figure 4 - First vertical magnetic derivative map (shadowgram) of the Beatty River fault (BRF) near the Carswell Structure. The Beatty River Fault has an apparent, dextral sense of displacement. Note how the rocks that constitute the Clearwater Domain seem to intrude rocks of the Firebag and Western Granulite domains. The prominent northwest-trending features are Mackenzie diabase dykes. The locations of drill holes Car 483 and Car 60 are included for reference. The locations of newer drill holes are omitted.

e) Firebag Domain

The Firebag Domain is not exposed in Saskatchewan, but has been penetrated by numerous mineral exploration drill holes (e.g. Rippert *et al*., 2000). It is poorly exposed in northeastern Alberta where retrogressed, granulite-facies rocks are found (Tremblay, 1961). Most of the current knowledge of the Firebag Domain in Saskatchewan has been gathered from the interpretation of geophysical maps (Figure 3). Structural trends in the domain indicate apparent continuity between these rocks and those in the Western Granulite Domain across the Clearwater Domain (see below). Perhaps the most significant subsurface feature in the Firebag Domain is the Beatty River fault; a kilometre-scale ductile shear zone with an apparent dextral offset (Figure 4). Three mineral exploration cores that penetrate the Firebag Domain were examined by the author in June 2001. They were dominated by granitic to granodioritic foliates and gneisses (Figure 5) with subordinate massive to weakly-foliated granite and metabasite.

Figure 5 - K-feldspar-phyric granodiorite from the Firebag Domain. Note the relatively homogeneous appearance when compared to granodioritic gneiss (Figures 7 and 11 below).

f) Clearwater Domain

The poorly understood Clearwater Domain (Figures 2 and 3) is exposed only in the Clearwater River gorge between Gould and Simonson rapids (Sibbald, 1974). Three rock types, equigranular granite, porphyritic granite, and felsic gneisses, were recognized (Lewry and Sibbald, 1977). The felsic gneisses were considered to be similar in character to gneisses in the Mudjatik and Virgin River domains (Figure 2) but dissimilar to those of the Western Granulite Domain. Given that the Snowbird Tectonic Zone (Figure 2) is now recognized as a major tectonic discontinuity separating the Rae (Western Granulite and Clearwater domains) and Hearne cratons (Mudjatik and Virgin River domains) (Hoffman, 1988), it seems more likely that these gneisses are related to the Western Granulite Domain. The granites were considered to be similar in appearance and relative age to the ca. 1820 Ma Junction granite (Lewry and Sibbald, 1977).

The Clearwater Domain (Figure 3) is largely defined on the basis of a positive aeromagnetic anomaly and a negative gravity anomaly, termed the Fond-du-Lac gravity low (Wallis, 1970). The eastern margin of the aeromagnetic trend truncates the magnetic/structural trends of the Western Granulite Domain at a high angle (Figure 3), although those trends apparently re-emerge west of the Clearwater Domain to form the unexposed Firebag Domain. The Clearwater magnetic anomaly is apparently truncated to the north by the Grease River Shear Zone (Figure 3). It is unclear whether a large positive east-northeast-trending aeromagnetic anomaly north of the Grease River Shear Zone and along the south shore of Lake Athabasca represents an extension of the domain or a distinct entity (Figure 6). To the southwest, the magnetic trend is disrupted by the Snowbird Tectonic Zone. The Clearwater Domain has an uncertain origin; however, lithologic, temporal, and geophysical similarities to the Junction granite suggest that it may be a magmatic belt which splits Archean rocks of the Rae Province into the Western Granulite and Firebag domainal segments.

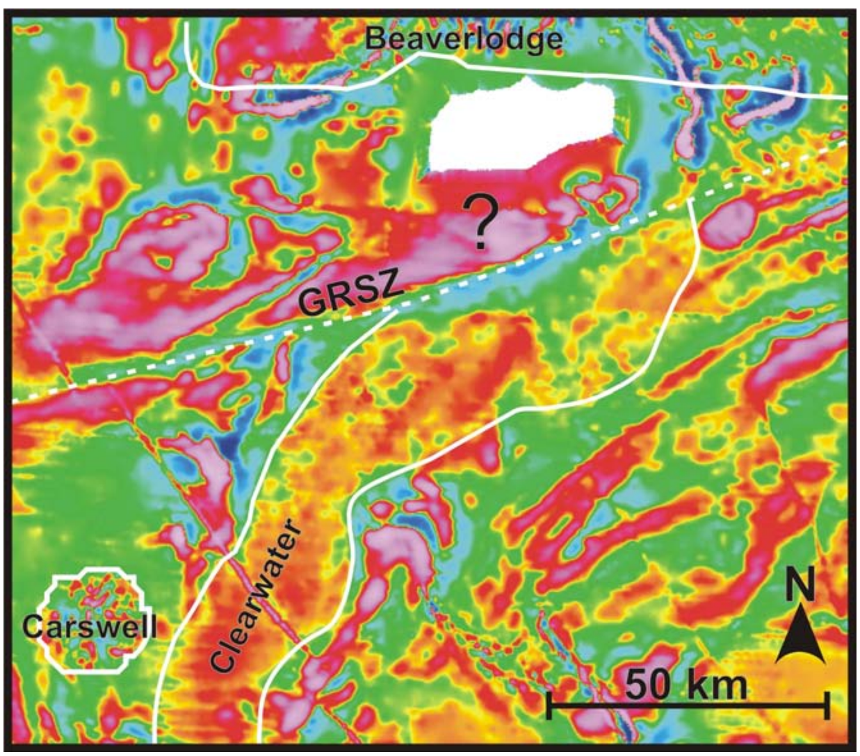

Figure 6 - First vertical magnetic derivative (colour) map of the area south of Lake Athabasca. Note the location of the Grease River Shear Zone (GRSZ), the Carswell Structure, and the Clearwater Domain. Two large, unidentified, positive magnetic anomalies (pink indicates high and blue low) are found just to north of the shear zone. The Beaverlodge and Clearwater domains are outlined with solid lines. Note the northwest-trending magnetic highs which represent the Mackenzie dykes. ? indicates an area of unknown geology.

g) Carswell Structure

The circular Carswell Structure (Figures 2 and 3) is generally regarded as an meteor impact structure, although there are alternative models for its origin, e.g. cryptovolcanic explosion (Pagel *et al*., 1985). It has a diameter of approximately 40 km and a central, metamorphosed basement core about 20 km in diameter (Tona *et al*., 1985). The structure, which has been extensively studied by both exploration (e.g. Tona *et al*., 1985) and survey geologists (e.g. Harper, 1983), provides a unique opportunity to view a basement uplift along the axis of the Athabasca Basin.

Rocks of the basement core include granitic to dioritic gneiss, quartzofeldspathic gneiss comprising dominantly metasedimentary rocks, lean iron formation, pelitic gneiss, and mafic gneiss. These units were intruded by pegmatoid rocks (Harper, 1983). These rocks were later divided into two main groups: 1) the Peter River gneiss and 2) the Earl River Complex. The Peter River gneiss is described by Tona *et al*. (1985) as a unit of aluminous metasedimentary rocks characterized by compositionally layered garnet-cordierite-sillimanite gneiss with some layers containing up to 40% garnet. The Earl River Complex, which structurally underlies the Peter River gneiss, comprises feldspathic gneisses, mafic granulites, amphibolites, granitoids, and pegmatoids (Tona *et al*., 1985). The feldspathic gneisses were considered to have sedimentary protoliths, whereas granitoids and pegmatoids were considered to result from anatexis of metasedimentary rocks (Pagel and Svab, 1985) and the mafic granulites were interpreted as volcanic rocks with chemical similarity to komatiitic rocks (Bell *et al*., 1985). The presence of two-pyroxene mafic granulite suggests that much of this package, with the exception of younger massive granitoid rocks, has been metamorphosed at granulite facies.

Three mineral exploration cores from the Carswell Structure were examined during the summer of 2001. Car 483, from the northern rim of the structure, is dominated by granitic to granodioritic gneiss and intruded by massive to weakly foliated granite (Figure 7). These rocks are quite similar to those found in cores from the Firebag Domain. Athabasca Group basal conglomerates underlie the basement rocks in this core illustrating the structural complexity of the Carswell Structure (e.g. Baudemont and Fedorowich, 1996).

Car 60, also from the northern rim of the structure, exhibits features quite different from Car 483. The upper 60 m of the core is similar, consisting of granitic to granodioritic gneiss; however, the lower 105 m is dominated by metasedimentary rocks, with subordinate mafic granulite. The most common rocks are migmatitic to diatexitic pelites containing 2 to 5 mm garnet and cordierite porphyroblasts. Subordinate garnetite, contains up to 65% deep-red garnet, and a dark amphibole(?) (Figure 8). The garnetite is commonly interlayered with siliceous bands (Figure 8) which represent either transposed quartz veins or primary compositional layering. As the garnetite is interpreted as silicate-facies iron formation, the siliceous layers are probably recrystallized, primary chert layers. Less common metasedimentary rocks include quartzite, psammite (Figure 9) and calcic psammopelite. Mafic granulite is interlayered with the metasedimentary rocks.

The third core, Clu 4587, is from the Cluff Lake mine sequence. The upper 325 m of the core is dominated by aluminous rocks of the Peter River gneiss. The most common rock type is fine- to medium-grained, aluminous psammopelite containing 10 to 15% garnet porphyroblasts. Less abundant are garnet-cordierite migmatites (Figure 10), which are interlayered with the psammopelites. Variation between pelitic and psammopelitic rocks likely represents transposed, primary compositional layering. These rocks are intruded by massive to weakly foliated granites, which commonly bear garnet porphyroblasts. The lower 75 m

Figure 7 - Granodioritic gneiss (1) intrude Figure 7 - Granodioritic gneiss (1) intruded by massive granite (2) (Car 483).

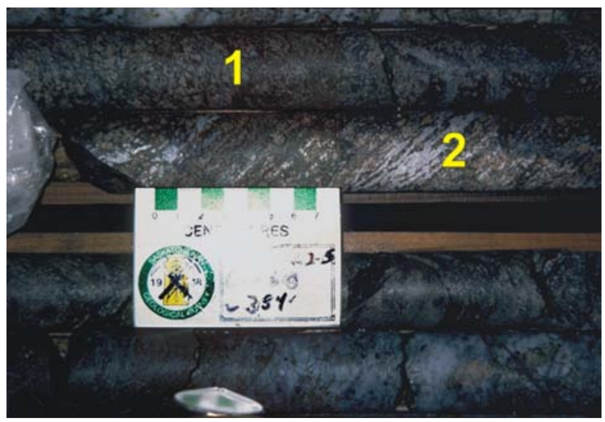

Figure 8 - Silicate-facies iron formation (1) containing 35 to 40% garnet porphyroblasts and a dark amphibole(?). Note the interlayered siliceous bands (2) interpreted to be primary chert layers (Car 60).

Figure 9 - Psammite to quartzite represent part of the metasedimentary rock sequence in Car 60.

comprises mainly granitic (Figure 11) to granodioritic gneiss intruded by massive granite. These gneisses generally mark the transition between the Peter River gneiss and Earl River Complex (Koning, pers. comm., 2001). A strong mylonitised zone was recognized near the base of the core, which is also common near the transition between the Peter River gneiss and Earl River Complex (e.g. Baudemont and Fedorowich, 1996). The granitic gneiss and, more importantly, massive to weakly-foliated granite are entrained in this shear zone (Figure 12). The little-deformed granites likely represent the youngest Proterozoic crystalline rocks suggesting that the shear zone is a relatively late ductile feature.

4. Preliminary Observations

The area north of Lake Athabasca has been divided into several small domains (Macdonald, 1984), with boundaries generally delimited by brittle to ductile structures. Changes in structural style and metamorphic grade across these boundaries apparently formed the

Figure 10 - Garnet-cordierite migmatite is the dominant component of the Peter River gneiss. Note the large garnet porphyroblasts (Clu 4587).

Figure 11 - Typical granitic to granodioritic gneiss. These rocks mark the transition between the Peter River gneiss and Earl River Complex (Clu 4587).

Figure 12 - Mylonitic granodioritic gneiss (1) and massive granite (2). This mylonite zone is common at the transition between the Peter River gneiss and Earl River Complex (Clu 4587).

basis for these subdivisions. New mapping has revealed that some rock units, e.g. the Murmac Bay Group, span many of the current domainal boundaries (Ashton *et al*., 2000). Rocks examined by previous workers in the Zemlak and Forcie domains have similar characteristics to those in the western Beaverlodge Domain. The Murmac Bay Group may be equivalent to the White Lake Complex. Detailed stratigraphic comparison is difficult; however, even at granulite facies, attenuated and dismembered relicts of that stratigraphic sequence are represented, including quartzite, amphibolite, psammopelite to pelite. The red gneisses of the Zemlak and Forcie domains, which intrude the metasedimentary rocks, are similar to pink to red quartzofeldspathic gneisses currently being mapped in the western Beaverlodge Domain (Ashton *et al*., this volume). Although these observations require further ground investigation, it seems likely that Beaverlodge-type rocks extend much further to the west than was previously recognized.

The same may be true east of the Beaverlodge Domain. Much of the Tantato Domain, with the exception of the Chipman Batholith, is underlain by pelitic diatexites and mafic granulite (see Hanmer, 1997). These rocks appear to be similar to lower-grade, albeit granulite facies, less-strained rocks found in the eastern Beaverlodge Domain (e.g. Card and Bethune, 1999). This suggests that the Beaverlodge rocks may be continuous across the Grease River Shear Zone. This provides an alternate view to Hanmer's (1997) suggestion that the Athabasca Lozenge, which includes the Tantato Domain, is distinct from both Rae and Hearne wall rocks and calls into question the tectonic significance and age of the Grease River Shear Zone (see Lafrance and Sibbald, 1997).

The proposed Athabasca Lozenge (Figure 3), which includes the Tantato Domain and the Western Granulite Domain, is problematic. The first problem is the apparent difference in lithological make up (see above) and more importantly, strain state between the Tantato and Western Granulite domains. Rocks in the Western Granulite do not appear to display the spectacular and pervasive mylonitic fabric described by Hanmer (1997) in the Tantato Domain (e.g. Scott, 1985). A second problem is the western margin of the lozenge. In the north, the boundary of the Tantato Domain, is the Grease River Shear Zone. Beneath the Athabasca Basin, the magnetic trend that bounds the lozenge, is not the Grease River Shear Zone, which continues to the southwest into Alberta, but the eastern side of the Clearwater magnetic high. Furthermore, the lozenge margin cuts across the magnetic trend attributed to the Clearwater Domain east of the Carswell Structure before continuing to the southwest. Therefore, the western margin of the lozenge is not defined by a single geophysical trend as is its eastern counterpart (Snowbird Tectonic Zone), but by four different geophysical trends including: 1) the Grease River Shear Zone, 2) the eastern margin of the Clearwater high, 3) an unidentified magnetic high that cuts the Clearwater trend, and 4) the western margin of the Clearwater trend. Also problematic is the relationship between the Western Granulite and Firebag domains. Magnetic trends in the Western Granulite Domain are truncated by the Clearwater trend, but appear to re-emerge in the Firebag Domain (Figures 3 and 4), thereby spanning the western boundary of the proposed lozenge.

The metasedimentary rocks in the Carswell Structure are similar to rocks in the Beaverlodge Domain (Forcie and Zemlak as well?). In particular, the core from Car 60 (see above) appears to contain most components of the Murmac Bay Group, albeit at much higher grade than classic Murmac Bay Group rocks. This is problematic because the geophysical signature of the Beaverlodge Domain does not appear continuous south of the Grease River Shear Zone. A large positive magnetic anomaly north of the shear zone (Figure 4) has no apparent equivalents to the south indicating that: 1) Beaverlodge-type rocks terminate at the Grease River Shear Zone or 2) there is a significant change in depth to basement across the shear zone. The first option would indicate that the Grease River Shear Zone is a relatively major tectonic boundary. The second relies on a steep subcrop gradient from the northern margin to the centre of the Athabasca Basin. No structural contour map of the basement to the western Athabasca Basin in Saskatchewan is currently available, however, a map of the Alberta basement (Wilson, 1986) indicates a steep gradient along the north margin of the basin and a sharp change of slope in the vicinity of the Grease River Shear Zone, perhaps indicating a scarp-like feature. Therefore, differences in magnetic signature in the centre of the basin may result from differences in depth to basement, rather than changes in rock type.

Basement rocks near the Alberta border seem to be dominated by granitoid gneiss (Figures 7 and 11) and massive to weakly-foliated granodiorite (Figure 5). Furthermore, these rocks seem remarkably similar to basement rocks sampled from the Alberta side of the basin (see photos in Wilson, 1986). Neither of these suites of rocks are common further to the east, therefore tectonic activity responsible for the emplacement of both suites may derive from the west. Both may be related to the ca. 2000 to 1900 Ma Taltson orogen with the gneisses representing an older intrusive phase. Alternatively, the gneissic rocks may represent older crust (Archean?) which was intruded by the Granodiorite Complex (Taltson?). Geochronological and geochemical analysis will be necessary to test this hypothesis.

The Clearwater Domain is an enigma. Rocks within it appear to crosscut rocks of the Western Granulite/ Firebag domains indicating an intrusive relationship and suggesting that it may be a magmatic belt. The domain continues south where it appears to be truncated by the Snowbird Tectonic Zone, but it is unclear whether this marks the southern limit of the domain or a minor disruption due to late displacement along the shear zone. One possibility is that the Clearwater Domain is continuous into Alberta and is equivalent to the Rimbey high. Ross *et al*. (1991) implied that the Rimbey high is equivalent to the Junction granite. However, a Rimbey/Clearwater belt crosses the Snowbird Tectonic Zone in the Alberta subsurface. This would call into question the validity of an East Alberta orogen, i.e. the Snowbird Tectonic Zone would not represent a suture (see Ross *et al*., 1991).

5. Plans for Future Work

Mapping the basement to the western Athabasca Basin and follow-up analytical work is an ambitious undertaking. The main hurdle to clear is the lack of data, due to a dearth of mineral exploration cores across much of the western part of the basement. Cores are generally concentrated along specific conductors, therefore mapping the basement from core is a feast or famine task. Mineral exploration properties can be mapped in great detail and compared to property-scale geophysical surveys. These areas of detail, unfortunately, are adjacent to large tracts of basement with no core data, where correlation must rely on use of regional-scale geophysical surveys.

A significant field program has been proposed for the summer of 2002. Field activity will include two components: 1) investigation of mineral exploration core stored on or near the Athabasca Basin and 2) re-investigation of lithotectonic domains surrounding the basin. Geologic maps are available for most of the lithotectonic domains surrounding the basin, but the areas warrant reconnaissance-type visits in order to become familiar with these rocks. Domains of particular interest are the Tantato and Western Granulite domains. The domains to the northwest are currently being mapped by Ashton and field trips to these areas may also be incorporated. Also of interest is the Virgin River Shear Zone. A reconnaissance trip to Careen Lake may be necessary to gain some familiarity with this important structure.

Field based studies will be followed up with geochemical and geochronological studies. The highest priority on the analytical list is the Clearwater Domain. There are currently no U-Pb age dates or geochemical data for the Clearwater granite, although it is implied that the ca. 1820 Ma Junction granite is correlative. Other possible analytical targets include granitic to granodioritic gneiss and granodiorites of the Firebag Domain.

6. Conclusions

This sub-project is currently in its infancy. Much is unknown about the basement rocks to the western Athabasca Basin. A large volume of data collection and synthesis will be required in order to successfully complete this investigation. Planned products include a sub-crop map of the western sub-Athabasca basement, structural and metamorphic interpretations, as well as geochemical and geochronological data and interpretation.

Figure 13 provides some insight into our current knowledge of the western Athabasca basement rocks and the lithotectonic domains to which they belong. The highlights of the figure are as follows:

1) The Tantato Domain is difficult to trace beneath the Athabasca Basin. At first glance the magnetic signature seems traceable to the southwest almost to the axis of the Athabasca Basin. There is a major break in the structural trend, however, just south of the northern basin margin. The rocks south of this break need to be compared with those in the Tantato Domain with regard to lithological make-up, metamorphic grade, and strain state.
2) The Western Granulite Domain can be traced to the northeast almost to the axis of the basin where the magnetic signature becomes vague. It isn't known if these rocks are continuous with those to the northeast.
3) Rocks of the Beaverlodge Domain currently cannot be traced south of the Grease River Shear Zone. It is unclear whether the shear zone represents a major break.
4) The Clearwater Domain appears to be a magmatic belt and may be analogous to the Rimbey high in Alberta. The Clearwater trend appears to terminate at the Grease River Shear Zone.
5) The Firebag and Western Granulite domains have similar magnetic signatures and may contain equivalent rocks.

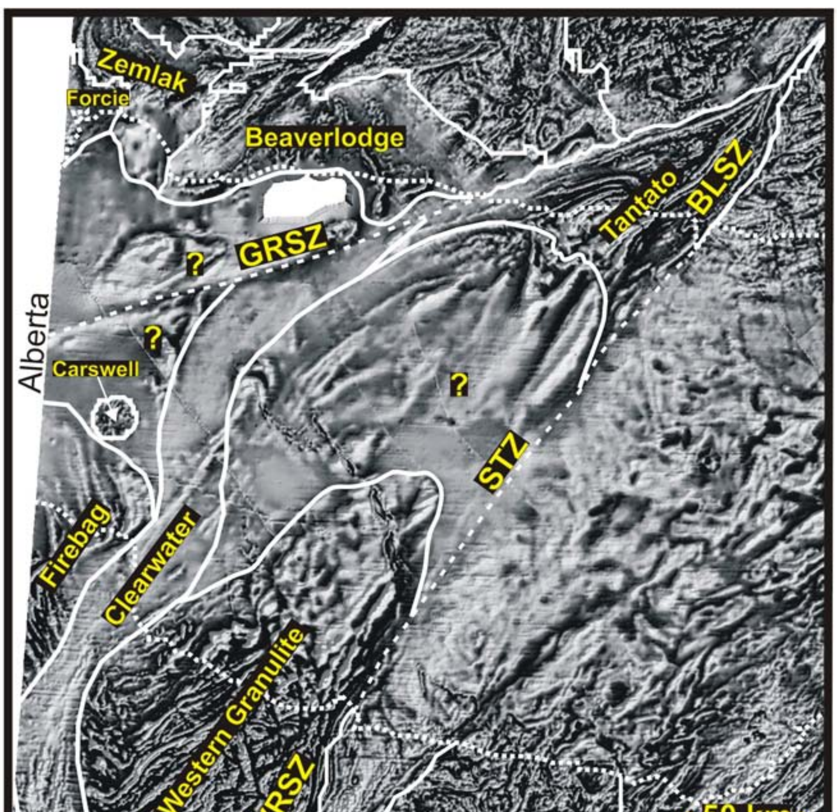

Figure 13 - First vertical magnetic derivative map (shadowgram) of the western Athabasca region. Lithotectonic domains (solid lines) are extrapolated beneath the Athabasca Basin (dashed line). STZ, Snowbird Tectonic Zone; GRSZ, Grease River Shear Zone; BLSZ, Black Lake Shear Zone; and VRSZ, Virgin River Shear Zone. ? indicates areas of unknown geology.

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