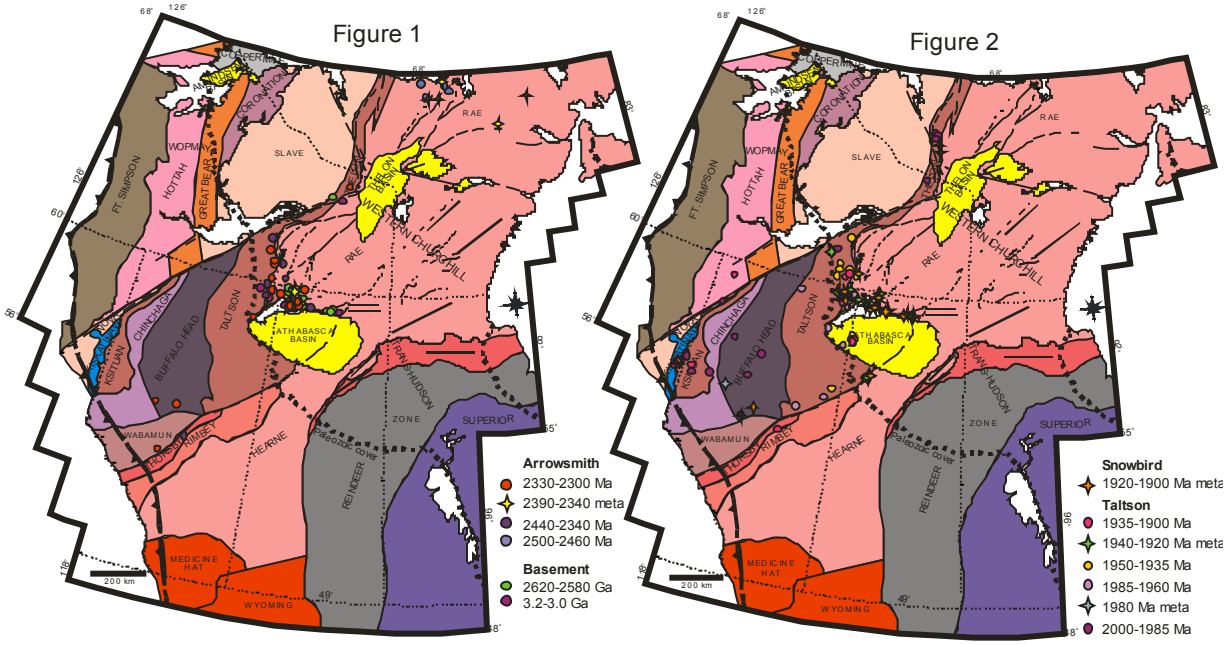
Tectonic History of the Southwestern Margin of the Rae Province in Northwestern Saskatchewan

K.E. Ashton* and C.D. Card
Ministry of Energy and Resources, Northern Geological Survey, 200-2101 Scarth Street, Regina, SK S4P 2H9
e-mail: Ken.Ashton@gov.sk.ca;
R.P. Hartlaub, Department of Mining Technology, British Columbia Institute of Technology, Burnaby, BC V5G 3H2;
K.M. Bethune, Department of Geology, University of Regina, 3737 Wascana Parkway, Regina, SK S4S 0A2; and
N. Rayner, Natural Resources Canada, Geological Survey of Canada, 601 Booth Street, Ottawa, ON K1A 0E8

Summary
The southwestern Rae margin in northwestern Saskatchewan includes 3.01-2.94 Ga and 2.62-2.58 Ga granitoids typical of the Rae Province. The Arrowsmith Orogen produced 2.37 Ga metamorphism and 2.33-2.30 Ga post-collisional granitoid rocks. Initial deposition of the Murmac Bay group at about 2.33 Ga was derived from an unknown Paleo- to Mesoarchean source; higher stratigraphic levels record diverse locally exposed rocks and a 2.2-2.0 Ga suite possibly exposed to the west. Multiple terrane accretions during the Taltson Orogen produced a 1.94-1.92 Ga southeast-striking regional foliation, which was overprinted by a 1.91-1.90 Ga northeast-striking fabric associated with tectonism along the Snowbird Tectonic Zone. Circa 1.84-1.83 Ga terrane accretion farther west and terminal collision in the Trans-Hudson Orogen resulted in widespread faulting, deposition of the Martin Group, and the historic Beaverlodge uranium and gold deposits.

Abstract
Integration of data from the southwestern margin of the Rae Province in Saskatchewan and the Taltson Magmatic Zone to the west is shedding more light on the region's tectonic history. The oldest rocks include 3.01-2.94 Ga granitoids (Hartlaub et al., 2004; Ashton et al., 2009) south of Uranium City and 3.2-3.1 Ga granitoid gneisses in the basement complex to the Taltson Magmatic Suite (McNicoll et al., 2000), which may link under the Athabasca Basin (Fig. 1). Much of the remaining area in northwestern Saskatchewan is underlain by 2.62-2.58 Ga and rare 2.71 Ga granitoid basement, which may not be represented in the Taltson Magmatic Zone but is characteristic of the Rae Province elsewhere (e.g. LeCheminant and Roddick, 1991).

In the northern Rae Province, ca. 2.50-2.46 Ga granitoid rocks emplaced the Queen Maud Block were attributed to rifting by Schultz et al. (2007). Based on subsequent widespread 2.39-2.34 Ga metamorphism (Fig.1; Berman et al., 2005; Schultz et al., 2007), the granitoids were alternatively interpreted as a continental arc by Berman et al. (2007) and the metamorphism attributed to the Arrowsmith Orogen involving terrane accretion on the western flank of the Rae Province (Berman et al., 2005). Early 2.5-2.4 Ga granitoids have not been recognized in northwestern Saskatchewan, but 2.45-2.38 Ga felsic to intermediate plutonic rocks are exposed in the eastern Taltson Magmatic Zone (van Breemen et al., 1987; Bostock and Loveridge, 1988; McNicoll et al., 2000). Late 2.33-2.29 Ga post-collisional granites are emplaced in the Archean granitoids at Uranium City (Hartlaub et al., 2007), and occur as a component of strongly magnetic felsic to intermediate orthogneiss west of Uranium City (Ashton et al., 2007a) and along strike in the easternmost Taltson Magmatic Zone (Bostock et al., 1991; van Breemen and Bostock, 1994; McNicoll et al., 2000). In Saskatchewan, Arrowsmith metamorphism is recorded



by 2.37 Ga zircon overgrowths (Ashton et al., 2009) and by hornblende and biotite K/Ar ages (Koster and Baadsgaard, 1970) from west of Uranium City, suggesting that the terrane accreted to the western Rae margin in the north may well extend southwards.

Initial deposition of the Murmac Bay group may have overlapped emplacement of the 2.33-2.29 Ga post-collisional granitic suite. Rare basal conglomerate is dominated by 2.33 Ga quartz-feldspar porphyry clasts, consistent with erosion of a proximal felsic volcanic centre. A sample of the far more extensive basal quartzite, however, yielded only 3.95-3.41 Ga detrital zircon, whereas a stratigraphically overlying psammitic gneiss contained zircon in the 3.80-2.33 Ga range. Although the source of the pre-3.2 Ga detritus is unknown, ancient crust is known from the western margin of the Rae Province (e.g. Thériault, 1992; McNicoll et al., 2000) making it the most likely candidate. If the 3.01-2.94 Ga basement granites to the Murmac Bay group at Uranium City represent an extension of this Paleo- to Mesoarchean crust, the detrital zircon record preserved within the quartzite and psammitic gneiss could represent its gradual erosion and exhumation. The absence of 2.5-2.38 Ga detritus in these lower stratigraphic units suggests that initial deposition of the Murmac Bay group did not result from erosion of the Arrowsmith Orogen, but rather was more likely a result of rifting. A pelitic rock inferred to represent the highest stratigraphic level analyzed from the Murmac Bay Group yielded detrital zircon ages reflecting the exposed basement rocks at 3.0, 2.7, 2.6, and 2.32 Ga, although 2.5-2.4 Ga detritus also indicates an input from the early Arrowsmith rocks. The largest and youngest mode, however, is at 2.17 Ga, which is within a 2.2-2.0 Ga range of detritus that is also represented in psammopelitic gneiss 65 km east of Uranium City (Ashton et al., 2007b), metapsammite from 225 km further northeast at Snowbird Lake (Martel et al., 2008), and paragneiss of the Rutledge River Basin, the latter of which also underwent high-grade metamorphism at 2.09-2.04 Ga (Bostock and van Breemen, 1994). Potential sources for this detritus include 2.14 Ga granitic rocks in the eastern Taltson Magmatic Zone (McNicoll et al., 2000) and 2.19-2.16 and 2.09-2.01 Ga granitoids in the southwestern Buffalo Head, Chinchaga, and Ksituan domains (Villeneuve et al., 1993). It is unclear whether this 2.2-2.0 Ga event represents terrane accretion or episodic rifting of the southwestern Rae margin.

The exposed Taltson Magmatic Zone (Fig. 2) can be divided into four zones from west to east that are characterized by distinct rock suites: 1) 2.01-1.98 Ga granitic to granodioritic rocks possibly representing an early continental arc, 2) 1.95-1.92 Ga mainly S-type granites, 3) a basement complex including 3.2-3.1, 2.56, and 2.44-2.27 Ga components, and 4) 1.98-1.96 Ga quartz dioritic to granitic rocks (e.g. Bostock et al., 1987; Villeneuve et al., 1993; McDonough et al., 2000; McNicholl et al., 2000) possibly representing a younger arc built on Rae crust. Circa 1.94-1.92 Ga metamorphism in the Taltson Magmatic Zone (McDonough et al., 2000) can be traced eastward into the Rae Province at least as far as the Black Bay Fault, beyond which it is overprinted by a younger metamorphic event. The Thluicho Lake group, a greenschist-facies conglomerate-arkose-argillite succession deposited in an intermontane basin (Hunter, 2007) between 1.92 and 1.82 Ga (Ashton et al., 2009), is probably correlative with the Nonacho group (van Breemen and Aspler, 1994). The earliest regional fabric affecting rocks as young as the Thluicho Lake group in northwestern Saskatchewan strikes southeastward. It is thought to be synchronous with the 1.94-1.92 Ga metamorphic culmination associated with Taltson orogenesis, suggesting that terrane accretion was from the southwest. Westward warping of this fabric into the present north-northeastward trend generally associated with the Taltson Magmatic Zone is attributed to subsequent terrane accretion to the west (e.g. Slave, Hottah).

Farther east in the southern Rae Province, a variably overprinting northeast-striking regional fabric is most intense in the vicinity of major structural discontinuities including the Black Bay Fault, Grease River Shear Zone, and Snowbird Tectonic Zone (Fig. 2). This fabric is attributed to deformation associated with 1.91-1.90 Ga high-T, high-P metamorphism that affects rocks in the hanging wall of the northwest-dipping Snowbird Tectonic Zone (e.g. Baldwin et al., 2003). Debate continues as to whether the Saskatchewan segment of this discontinuity represents a suture (e.g. Walcott and Boyd, 1971; Hoffman, 1988) stitching the Rae and Hearne provinces or an intra-cratonic fault (e.g. Hanmer et al., 1995; Mahan and Williams, 2005).

Younger open north-trending folds and brittle-ductile to brittle faulting is jointly attributed to post-1.84 Ga accretion of the Fort Simpson-Nahanni Terrane to the west and ca. 1.83 Ga terminal collision in the Trans-Hudson Orogen to the east (Fig. 2; Ashton et al., 2009). The Beaverlodge vein-type uranium deposits, lode gold deposits of the Uranium City area, and Cu-Ag-Pb occurrences spatially associated with the Thluicho Lake group were likely formed at about this time.

References

Ashton, K.E., Knox, B., Bethune, K.M., and Rayner, N. (2007b): Geochronological update and basement geology along the northern margin of the Athabasca Basin east of Fond-du-Lac (NTS 74O/06 and /07), southeastern Beaverlodge-southwestern Tantato domains, Rae Province; *in* Summary of Investigations 2007, Volume 2, Saskatchewan Geological Survey, Saskatchewan Ministry of Energy and Resources, Misc. Rep. 2007-4.2, CD-ROM, Paper A-9, 22p.

Ashton, K.E., Card, C.D., Davis, W., and Heaman, L.M. (2007a): New U-Pb zircon age dates from the Tazin Lake map area (NTS 74N); *in* Summary of Investigations 2007, Volume 2, Saskatchewan Geological Survey, Saskatchewan Ministry of Energy and Resources, Misc. Rep. 2007-4.2, CD-ROM, Paper A-11, 8p.

Ashton, K.E., Rayner, N.M., and Bethune, K.M. (2009): New U-Pb zircon ages from the Uranium City area: 2.94 and 2.61 Ga granitic magmatism, 2.37 Ga (Arrowsmith) and 1.93 Ga (Taltson) metamorphism, and 2.17 Ga detritus in a Murmac Bay Group pelite; *in* Summary of Investigations 2009, Volume 2, Saskatchewan Geological Survey, Saskatchewan Ministry of Energy and Resources, Misc. Rep. 2009-4.2, CD-ROM, Paper.

Baldwin, J.A., Bowring, S.A., and Williams, M.L. (2003): Petrological and geochronological constraints on high pressure, high temperature metamorphism in the Snowbird tectonic zone, Canada; J. Meta. Geol. V21, p81-98.

Berman, R.G., Sanborn-Barrie, M., Stern, R.A., and Carson, C.J. (2005): Tectonometamorphism at *ca*. 2.35 and 1.85 Ga in the Rae Domain, western Churchill Province, Nunavut, Canada: Insights from structural, metamorphic and *in situ* geochronological analysis of the southwestern Committee Bay Belt; Canadian Mineralogist, v43, p409-442.

Bostock, H.H. and Loveridge, W.D. (1988): Geochronology of the Taltson Magmatic Zone and its eastern cratonic margin, District of Mackenzie; *in* Radiogenic Age and Isotopic Studies: Report 2, Geological Survey of Canada, paper 88-2, p59-65.

Bostock, H.H. and van Breeman, O. (1994): Ages of detrital and metamorphic zircons and monazites from a pre-Taltson magmatic zone basin at the western margin of Rae Province; Can. J. Earth Sci., v31, p1353-1364.

Bostock, H.H., van Breemen, O., and Loveridge, W.D. (1991): Further geochronology of plutonic rocks in northern Taltson Magmatic Zone, District of Mackenzie, N.W.T.; *in* Radiogenic Age and Isotopic Studies: Report 4, Geological Survey of Canada, Paper 90-2, p67-78.

Hanmer, S., Williams, M.L., and Kopf, C. (1995): Striding-Athabasca mylonite zone: Implications for Archean and Early Proterozoic tectonics of the western Canadian Shield; Can. J. Earth Sciences, v32, p178-196.

Hartlaub, R.P., Heaman, L.M., Ashton, K.E., and Chacko, T. (2004): The Archean Murmac Bay Group: evidence for a giant Archean rift in the Rae Province, Canada; Precambrian Research, v131, p345-372.

Hartlaub, R.P., Heaman, L.M., Chacko, T., and Ashton, K.E. (2007): Circa 2.3 Ga magmatism of the Arrowsmith Orogeny, Uranium City region, western Churchill Craton, Canada; Journal of Geology, v115, p181-195.

Hoffman, P.F. (1988): United plates of America, the birth of a craton: Early Proterozoic assembly and growth of Laurentia; Earth Planet. Sci., Ann. Rev. 1988, v16, p543-603.

Hunter, R.C. (2007): A geological investigation of the Thluicho Lake Group, southwestern Rae Province, Saskatchewan, Canada; unpub. M.Sc. thesis, University of Regina, 125p.

Koster, F. and Baadsgaard, H. (1970): On the geology and geochronology of northwestern Saskatchewan. I. Tazin lake region; Can. J. Earth Sci., v7, p919-930.

LeCheminant, A.N. and Roddick, J.C. (1991): U-Pb zircon evidence for widespread 2.6 Ga felsic magmatism in the central District of Keewatin, N.W.T.; *in* Radiogenic Age and Isotopic Studies: Report 4, Geol. Surv. Can., Paper 90-2, p91-99.

Mahan, K.H. and Williams, M.L. (2005): Reconstruction of a large deep-crustal terrane: Implications for the Snowbird tectonic zone and early growth of Laurentia; Geology, v33, p385-388.

Martel, E., van Breemen, O., Berman, G., and Pehrsson, S. (2008): Geochronology and tectonometamorphic history of the Snowbird Lake area, Northwest Territories, Canada: new insights into the architecture and significance of the Snowbird tectonic zone; Precambrian Geology, v161, p201-230.

McNicoll, V.J., Theriault, J., and McDonough, M.R. (2000): Taltson basement gneissic rocks: U-Pb and Nd isotopic constraints on the basement to the Paleoproterozoic Taltson magmatic zone, northeastern Alberta; Can. J. Earth Sci., v37, p1575-1596.

Schultz, M.E.J., Chacko, T., Heaman, L.M., Sandeman, H.A., Simonetti, A., and Creaser, R.A. (2007): Queen Maud Block: A newly recognized Paleoproterozoic (2.4-2.5 Ga) terrane in northwest Laurentia; Geology, v35, p707-710.

Thériault, R.J. (1992): Nd isotopic evolution of the Taltson Magmatic Zone, Northwest Territories, Canada: Insights into Early Proterozoic accretion along the western margin of the Churchill Province; Journal of Geology, v100, p465-475.

van Breemen, O. and Aspler, L.B. (1994): Detrital zircon ages from Nonacho Basin, western Rae Province, Northwest Territories; *in* Radiogenic Age and isotopic Studies, Report 8, Geological Survey of Canada, Current research, 1994-F, p49-59.

van Breemen, O., Thompson, P.H., Hunt, P.A., and Culshaw, N. (1987): U-Pb zircon and monazite geochronology from the northern Thelon Tectonic Zone, District of Mackenzie; *in* Radiogenic Age and Isotopic Studies: Report 1, Geological Survey of Canada, paper 87-2, p81-93, 1987.

Villeneuve, M.E., Ross, G.M., Thériault, R.J., Miles, W., Parrish, R.R., and Broome, J. (1993): Tectonic subdivision and U-Pb geochronology of the crystalline basement of the Alberta Basin, western Canada; Geol. Surv. Can., Bull. 447, 86p.

Walcott, R.I. and Boyd, J.B. (1971): The gravity field of northern Alberta, and part of the Northwest Territories and Saskatchewan, with maps; Earth Phys. Branch, Gravity Map Series No. 103-111, Ottawa, 13p.