The case for separate Taltson and Thelon orogenies: Evidence from the Shield in western Saskatchewan

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SUMMARY

The Taltson magmatic zone is inferred to be the southern extension of the Thelon tectonic zone; together they are thought to have developed during a ca. 2.02-1.90 Ga orogeny that accreted the Rae and Slave cratons. The continuity between the Thelon tectonic and Taltson magmatic zones is predicated upon the similarity of the ages of igneous rocks and a linear aeromagnetic high that apparently links the two. The Taltson magmatic zone contains two suites of metaplutonic rocks: ca. 1.986-1.1959 Ga continental arc type plutons; and 1.955-1.910 Ga peraluminous plutons. They intruded a basement complex dominated by Mesoarchean to Paleoproterozoic orthogneisses and granitoid rocks. Peak metamorphic conditions were between 1.94 and 1.93 Ga.

New mapping south of the western Athabasca Basin indicates that plutons of generally intermediate composition extend from the Virgin River shear zone beneath the western Athabasca Basin. The limited available geochronological data supports that interpretation as rocks with ages similar to the continental arc type plutons in the Taltson magmatic zone are found near the Virgin River shear zone, beneath the western Athabasca Basin and along basin’s western margin. Plutons of similar age and composition to the peraluminous plutons of the Taltson magmatic zone and similar metamorphic ages are found in the basement to the western Athabasca Basin and the exposed Shield to the south.

These data indicate that the Taltson magmatic zone extends into Saskatchewan, and is not spatially related to the Taltson aeromagnetic high, which represents the signature of the Taltson basement complex and not the igneous rocks of the Taltson magmatic zone. The wide distribution of rocks similar in age to those of the Taltson magmatic zone suggest that the Thelon orogeny is more complex than implied in most published models and likely included multiple magmatic arcs and accretionary events. This inference is supported by differences structural characteristics and metamorphic ages along the proposed orogenic belt.

INTRODUCTION

Taltson magmatic zone

The Taltson magmatic zone has historically been considered an extension of the magmatic component of the larger Thelon orogeny (Hoffman, 1988), which is thought to record the accretion of the Slave craton and a variety of exotic terranes to the western margin of the Rae craton between 2.02 and 1.90 Ga. Within the Thelon tectonic zone are poorly dated granodiorites and derived migmatites with maximum ages between 2.02 and 1.96 Ga (e.g. van Breemen et al., 1987) that were interpreted to represent a continental magmatic arc. Those rocks were deformed and metamorphosed at granulite facies between 2.00 and 1.95 Ga (van Breemen et al., 1987).

The Thelon tectonic zone exhibits an anomalously high aeromagnetic response that extends south to the Great Slave Lake shear zone/McDonald fault. The aeromagnetic high apparently continues southward into northeastern Alberta where it disappears below Phanerozoic cover. The aeromagnetic high south of the McDonald fault was interpreted as the Taltson magmatic zone (Ross et al., 1991).

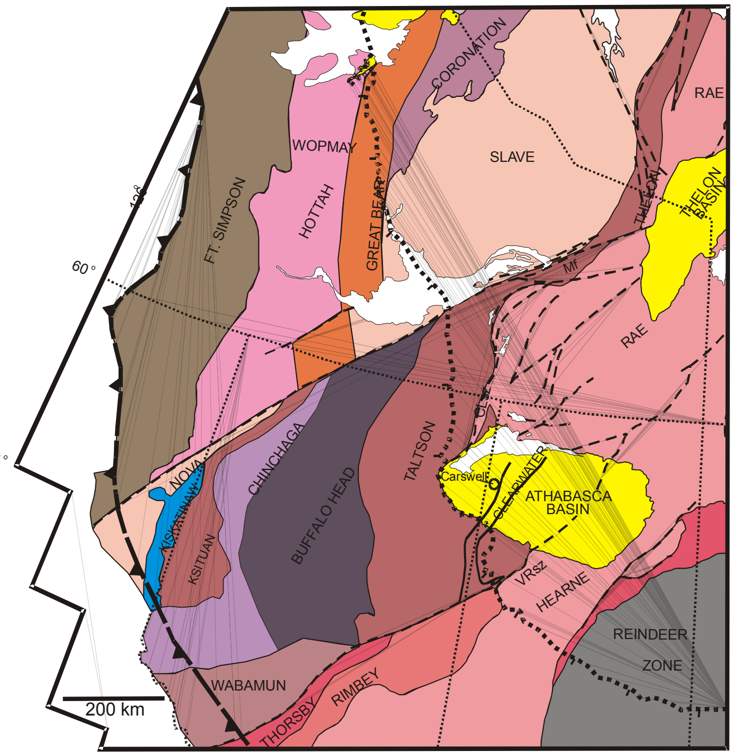

Figure 1: Map of the various tectonic elements of western Laurentia, including those mentioned in the text. The Taltson magmatic zone has been extended into Saskatchewan based on the work presented herein. CLsz = Charles Lake shear zone; VRsz = Virgin River shear zone; Mf = McDonald fault. Long, heavy dashed line = Cordilleran front; heavy dotted line = northern limit of Phanerozoic cover; light dotted line = provincial and territorial boundaries.

The Taltson magmatic zone contains a wide belt of meta-plutonic rocks that can be split into ca. 1.986-1.959 Ga magnetite-series, "I-type" or continental-arc plutons (e.g. Bostock et al., 1987; McDonough et al., 2000) and ca. 1.955-1.910 Ga "S-type" or peraluminous plutons (e.g. Bostock et al., 1987; McDonough et al., 2000) that together comprise a "composite batholith" (Hoffman, 1988). These plutons intruded a narrow belt of Mesoarchean to Paleoproterozoic orthogneisses and granitoid rocks (e.g. McNicoll et al., 2000), termed the Taltson basement complex. A succession of dominantly pelitic metasedimentary rocks, deposited between 2.13 and 2.09 Ga, is intercalated with and presumably deposited on the older gneiss complex (Rutledge River basin of Bostock and van Breemen, 1994). A high-grade metamorphic event, which peaked between 1.94 and 1.93 Ga (e.g. McDonough et al., 2000), is, in part, synchronous with the suite of peraluminous plutons.

The Rae Province and basement to the western Athabasca Basin

Rocks south of, and underlying, the western Athabasca Basin have historically been included in the Rae Province (e.g. Ross et al., 1991); however, Wilson (1986) proposed that many of the basement rocks of the Athabasca Basin in Alberta appeared similar to plutons of the Taltson magmatic zone. These rocks extend from the northwest-dipping Virgin River shear zone, the most southwesterly exposed segment of the Snowbird tectonic zone, northwestward to the Taltson aeromagnetic high.

NEW WORK SOUTH OF THE WESTERN ATHABASCA BASIN

Mapping in the Rae Province south of the Athabasca Basin mapping indicates that the region northwest of the Virgin River shear zone is dominated by granodioritic to dioritic rocks, termed the 'quartz diorite suite', that intruded a succession of dominantly pelitic sedimentary rocks. Both generally contain granulite-facies assemblages and exhibit a gently northeast or southwest dipping S_1/S_2 gneissosity and are gently folded around steeply dipping, northeast/southwest-striking axial planes (F_3). Where strain is most intense F_3 interlimb angles are tighter and strain is focussed on the limbs, where discontinuities such as the Virgin River shear zone were developed. Where D_3 deformation was most intense granulite-facies assemblages were replaced by amphibolite-facies assemblages. The quartz diorite suite disappears abruptly in the Virgin River shear zone, where it gives way to a narrow panel of the Virgin schist group, which is dominated by pelitic rocks with a subordinate, generally mafic volcanogenic component. To the southeast are dominantly felsic gneisses of the Hearne Province.

Very limited geochronological data is available for the region northwest of the Virgin River shear zone. Two members of the quartz diorite suite, a quartz diorite and a leucogranodiorite, from within a few kilometres of the Virgin River shear zone (Careen Lake) were dated using the SHRIMP. The U-Pb zircon crystallisation ages from these rocks were 1985±11 Ma and 1975±5 Ma, respectively (Stern et al., 2003). A further two samples from the basement to the Athabasca Basin in Alberta, a 'Wylie-type' granodiorite from near the Alberta-Saskatchewan border and a sample of Fishing Creek quartz diorite from just east of the Charles Lake shear zone returned crystallisation ages of 1974±5 Ma and 1968±5 Ma, respectively (Stern et al., 2003). A U-Pb ID-TIMS age determination on a sample of tonalite collected a few kilometres northwest of Careen Lake returned a crystallisation age of 2006±34 Ma (Bickford et al., 1994). These ages are similar to those of the 'I-type' plutons of the nearby Taltson magmatic zone. Ion microprobe age determinations were also performed on two suites of granitoid rocks collected from drill holes at the Shea Creek uranium prospect, just south of the Carswell structure in the western Athabasca Basin (Brouand et al., 2003). A suite of four pegmatitic granite samples yielded crystallisation ages between 1937 and 1927 Ma with errors between ±4 and 11 Ma. The second suite were high-K, calc-alkaline granitoid rocks of which the four best analyses yielded crystallisation ages between 1918 and 1911 Ma with errors ranging between ±9 and 18 Ma. These rocks are all within the age range of the younger S-type suite of intrusive rocks in the Taltson magmatic zone. Limited metamorphic age data is also similar to that in the Taltson magmatic zone. A single SHRIMP, U-Pb monazite age from a pelite in the core of the Carswell structure gave an age of 1932±14 Ma (R. Berman unpub. data, 2005). U-Pb zircon ages for metamorphic zircon from the I-type quartz diorite and leucogranodiorite were 1941±24 Ma and 1897±8 Ma, and 1927±34 Ma, respectively. The available metamorphic data, save for the youngest age, which is probably related to the Virgin River shear zone, are within the range of ages common in the Taltson magmatic zone.

DISCUSSION

Based on the mapping and age data it seems clear that the Taltson magmatic zone extends beneath the western Athabasca Basin and continues eastward on the exposed Shield to the Virgin River shear zone. The internal structural grain of the Taltson magmatic zone in Saskatchewan, determined from measured S_1/S_2 foliations and the trend of the aeromagnetic signature, is northwest/southeast. That grain continues nearly to the Alberta-Saskatchewan border where it warps to the north, parallel to the trend of the Taltson aeromagnetic lineament.

The extent of the Taltson magmatic zone, in particular the 1.986-1.959 Ga part that is dominated by magnetite-bearing, intermediate rock types that are thought to constitute the continental-arc plutons, is not well known. In fact, if the rocks in Saskatchewan are considered, most of the known plutons are not in or even close to the Taltson aeromagnetic high where they were generally thought to reside (e.g. Hoffman, 1988). This is because the axis of the aeromagnetic lineament is defined by rocks of the Taltson basement complex and not the magmatic-arc plutons. Therefore, it should probably not be considered an extension of potential magmatic arc rocks contained within the Thelon tectonic zone. Rocks that fall within the range of magmatic arc rocks of the Thelon tectonic zone and Taltson magmatic zone (2.020-1.959 Ga) are common elsewhere, hosted by a variety of aeromagnetic domains, including the Kiskatinaw, Ksituan, Nova, Buffalo Head and south Taltson domains (Villeneuve et al., 1993; Simandl and Davis, 2004) beneath Phanerozoic cover. The wide distribution of these plutons suggests that the Thelon orogeny was somewhat more complex than is implied in existing models (e.g. Hoffman, 1988) and likely contained multiple magmatic arcs.

We suggest that the Taltson magmatic zone is not an extension of the magmatic arc in Thelon tectonic zone but a separate entity. This is supported by the distribution of magmatic-arc plutons south of the Athabasca Basin and the tectonic grain of the orogen in Saskatchewan, and subtle differences in age relationships (e.g. metamorphic peaks, >1.95 Ga in the Thelon, 1.94 Ga or younger in the Taltson). The northwest/southeast grain of the Taltson magmatic zone in Saskatchewan suggest that the orogeny included an element of northeast-directed accretion along the southern margin of the Rae Province and was not directly related to the westward approach of the Slave craton as is proposed in most previous models.

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