

## The Great Slave Lake Shear Zone – Implications for Exploration in NW Alberta and NEBC

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### Introduction

The Hay River Fault is identified by many authors (e.g., Ross et al., 1994) as a major strike slip fault in NW Alberta and in NE British Columbia (NEBC). Generally speaking, it runs in a northeasterly direction from the Williston Lake area in NEBC to the Great Slave Lake in the Northwest Territories (NWT) and joins the McDonald Fault. It passes just northwest of Buick in NEBC, just northwest of Hamburg, just southeast of the Rainbow Basin and just southeast of the Steen River impact structure, all in Alberta, and near the Pine Point lead-zinc mine near Great Slave Lake.

We reinterpret the Hay River Fault as being the most northwesterly main fault trace of a shear zone that is about 50 km or more wide. We refer to this zone as the Great Slave Lake Shear Zone (GSLSZ), see Figure 1, after Hoffman (1987) and Burwash et al. (1994). Within the GSLSZ there are several major right lateral strike slip faults and accumulated offset of about 535 km. There are striking geometric parallels between the GSLSZ and the San Andreas Fault in California (Fig. 2).

The identification of terranes in NEBC (e.g., Ross, et al., 1994) becomes less confusing when interpreted using the concept of a GSLSZ. The Fort Simpson Terrane can be carried south of one of the northern splays of the GSLSZ in the Williston Lake area. We correlate the area south of the southern splay of the GSLSZ to the Great Bear magmatic arc in the Northwest Territories. There are Early Proterozoic and Archean ages from well cores within the GSLSZ that we correlate to similar age terranes about 350 km to the northeast in the Northwest Territories.

The Hamburg Field lies within the GSLSZ, and the closure there is set up by reactivation of the faults within it. It is likely that the same reactivation caused extension along complementary northwest-striking faults in the Rainbow Basin and played a role in localizing reef development and the flow of hot fluids causing hydrothermal dolomitization. Similar fault controlled fluid flow is likely to have occurred in NEBC along northwesterly striking faults in NTS grid 94H.

### Reconstructing movement along the Hay River Fault, the GSLSZ and the McDonald Fault

The Geological Survey of Canada makes available a 2 km grid of magnetic data for all of Canada on a CD-ROM at a nominal price. The quality of the leveling between numerous old surveys and the spectral fidelity of the resulting grid has been markedly improved over the last

several years compared to the digital data previously available from the National Geophysical Data Centre. Figure 3 shows a large portion of that data for the WCSB and the Northwest Territories. Our interpretation of the Hay River Fault and the GSLSZ and various terranes is shown as red and green lines.

The Early Proterozoic tectonic history of the northern part of the WCSB is summarized below:

- **Prior to 2.2 Ga:** The Slave, Rae and Chinchaga/Buffalo Head Terranes existed as separate Early Proterozoic micro-continents. The Buffalo Head Terrane is older in the west (2.07 – 2.32 Ga as compared to 1.95 – 2.02 Ga in the east), and may have been divided in two along the Buffalo Head lineament. The Chinchaga Terrane is of similar age to the western portion of the Buffalo Head Terrane.
- **2.03 – 1.95 Ga:** This is the period of ductile movement along the GSLSZ (Bowring et al., 1984), representing the period of a “continental transform” between the Slave and Chinchaga/Buffalo Head Terranes. The older Simpson Islands Terrane (Archean) and the Wilson Island Terrane were also caught up in this collision, with parts of these terranes becoming incorporated in the GSLSZ. We correlate the Thelon magmatic arc (2.02 – 1.91 Ga), north of the GSLSZ, to the northern portion of the eastern portion of the Buffalo Head Terrane, south of the GSLSZ. Although this particular portion of the terrane is undated, the Buffalo Head Terrane further to the south has the same age as the Thelon magmatic arc (Villeneuve, et al., 1993).
- At the same time, collision between the Slave Terrane and the northern part of the Rae Terrane was occurring, as represented by the Thelon magmatic arc (2.02 – 1.91 Ga, van Breemen et al., 1987a, 1987b) and Queen Maud Uplift (Hoffman, 1987).
- **1.98 – 1.90 Ga:** At a slightly later time, collision between the Chinchaga/Buffalo Head and Rae Terranes was occurring south of the GSLSZ, as represented by the Taltson magmatic arc (1.9 – 1.98 Ga, Villeneuve et al., 1993). Again at the same time, on the western side of the Chinchaga Terrane, the Ksituan Terrane was colliding and dipping eastward under the Chinchaga Terrane (Eaton et al., 1999). The Kiskatinaw Terrane, whose age is not known, may have been involved in this collision as well.
- **1.94 – 1.86 Ga:** Subduction of an oceanic plate was occurring on the western side of the Slave Terrane (Hildebrand et al., 1987).
- **1.88 – 1.84 Ga:** The Hottah Terrane collided with the Slave Terrane, as represented by the Great Bear magmatic arc (Wopmay Orogen). Parts of the Great Bear magmatic arc extended south of the GSLSZ and collided with the Kiskatinaw Terrane, as implied by Hoffman (1987). During this time there was a continuation of major transcurrent motion along the Hay River Fault at a time when motion along the GSLSZ was relatively minor (see below).

- At the same time the Nahanni Terrane was colliding with the western side of the Hottah Terrane, as indicated by the Fort Simpson magmatic arc and the Johnny Hoe Suture (Hoffman (1987).
- **Post 1.86 Ga:** There was a further 75 – 125 km of movement on the brittle McDonald Fault (Hoffman, 1987 and references cited therein); we suggest 80 km based on matching magnetic anomaly patterns on either side of the fault. Similar amounts of offset occurred at the same time within the Great Bear magmatic arc on splays off the GSSLZ and on the Fort Simpson magmatic arc on a splay off the GSSLZ.
- At the same time a set of left lateral faults related to the Bathurst Fault in the NWT developed in the Thelon magmatic arc, further absorbing east-west shortening north of the GSSLZ that was occurring at this time (Hoffman, 1987).
- **1.267 Ga:** The Mackenzie dike swarm cut across the Slave Terrane and the McDonald Fault into the Rae Terrane. These dikes place a minimum age (LeChaminant, et al., 1989) on any major offsets along the GSSLZ, and by extrapolation, along the GSSLZ.

It is interesting to make a comparison of the structural fabric of the GSSLZ, as interpreted from the HRAM data, and the structural fabric of the San Andreas Fault system of southern California. A figure from Spotila and Sieh (2000), showing the San Andreas Fault System of Southern California, is rotated and shown in Figure 2. The figure was rotated so that the San Andreas Fault System orientation is NE and its right lateral displacement is made similar to the orientation and sense of motion of the GSSLZ. A number of the faults that compose the San Andreas fault system have been highlighted but many more are present. Two major features are evident: (1) its width is about 60 kms or more and (2) it includes a complex set of strike slip, reverse and normal faults. Examples of each are highlighted. One might speculate that the characteristics of the GSSLZ within the Precambrian of NEBC may resemble the San Andreas Fault System. This complexity of structure within the GSSLZ would have different affects on later deformation, including the development of the PRA, the Dawson Creek Graben System and movements in the Antler and Laramide orogenic events.

### Exploration Significance of the GSSLZ

A recent interpretation of HRAM data in the vicinity of the Hamburg and Cranberry fields in NTS grid 84E (Charterers et al., 2000) demonstrated the presence of at least four major sub-parallel strike slip faults in the GSSLZ between the Chinchaga Terrane and the Hottah Terrane to the NW. The NE/SW wrench fabric of the underlying basement is critical in setting up the structural control on which the Slave Point reefs nucleated.

Regional carbonate alteration controlled by major structures is well known in the mineral industry. Wickham et al. (1994) describes the relationship between major shear zones and extensive, regional dolomitization using an example from India. The Pine Point ore body, on the south side of the Great Slave Lake, is a Mississippi Valley type Pb-Zn deposit within the dolomitized Presqu'île Barrier Reef. At this location it lies within the GSSLZ. The age of dolomitization and metallic mineral deposition is still vigorously debated. However, its association with the sedimentary brines and structure is more widely accepted (Nesbitt and Muelenbachs, 1994; Grant and Sverjensky, 1994). The dolomitizing events debated by these authors are the same events associated with development of hydrocarbon reservoirs. In fact, Muir and Dravis (1992) demonstrated a direct relationship between Laramide re-activation of the GSSLZ and development of dolomitization along structures in the Rainbow Zama Basin. They suggest that some right lateral movement along the GSSLZ opened NW trending faults and the dolomitizing fluids move along these faults. The result was good reservoir development along this NW direction in the Keg River Reefs. Lonnee and Al-Aasm (2000) note that, in the South Rainbow Basin, the hydrothermal dolomitizing fluids show a mixing of Phanerozoic and Precambrian fluids and are Laramide in age. The basin lies close to the NW side of the GSSLZ. They further state that the matrix dolomite was introduced in the Mississippian to Jurassic time interval.

Most of the major wrench systems in Western Canada have experienced some minor reactivation during the Laramide Orogeny. With the recognition of the GSSLZ as a broad band of faults that may have been reactivated to create relatively young trapping structures and/or a pathway for young dolomitizing fluids, an exploration fairway in the GSSLZ is created along a zone several townships wide on the southeast side of the Hay River Fault, as traditionally mapped.

### Summary

The concept of a shear zone is re-introduced for the portion of the Hay River-Great Slave Lake-McDonald fault systems. This is not new for the exposed portion of the faults in the Northwest Territories, but it does represent a distinct change of emphasis for the portion of the system in Alberta and NEBC.

The significance of this fault system is particularly apparent in the Hamburg area where several major gas fields have structural control that is set up by the underlying wrench-style tectonic fabric.

Using the concept of a shear zone for the Hay River fault system allows one to rationalize the nature of the terranes at the southwestern end of the fault system. In particular, the Great Bear magmatic arc is interpreted to extend well south of the GSSLZ.

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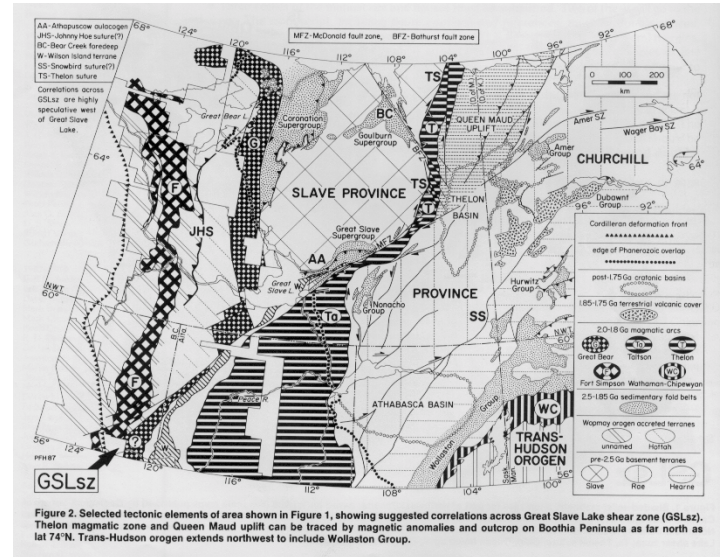


Figure 1. A preliminary interpretation of the terranes of Western Canada and the Great Slave Lake Shear Zone (Hoffman, 1987).

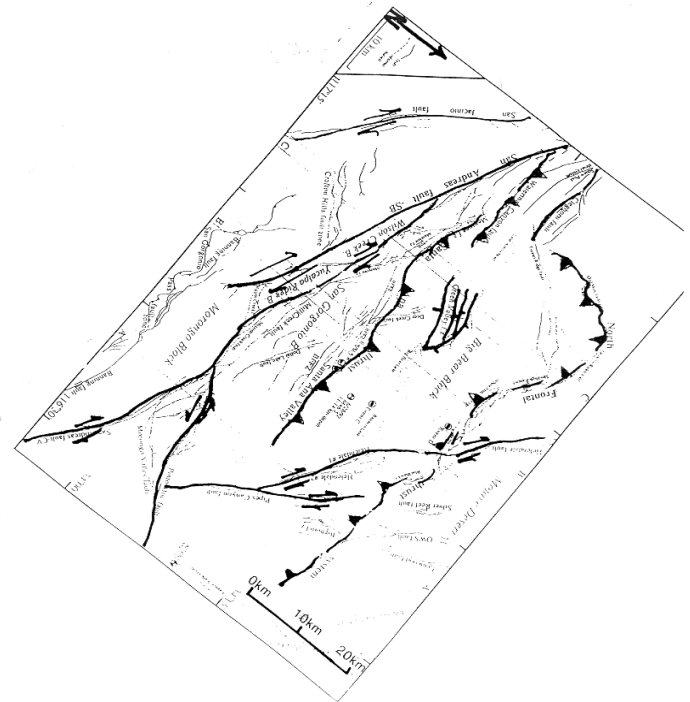


Figure 2. Structures associated with the San Andreas strike slip fault system of California, rotated to the same orientation as the Great Slave Lake Shear Zone (after Spotila and Sieh, 2000, p. 591).

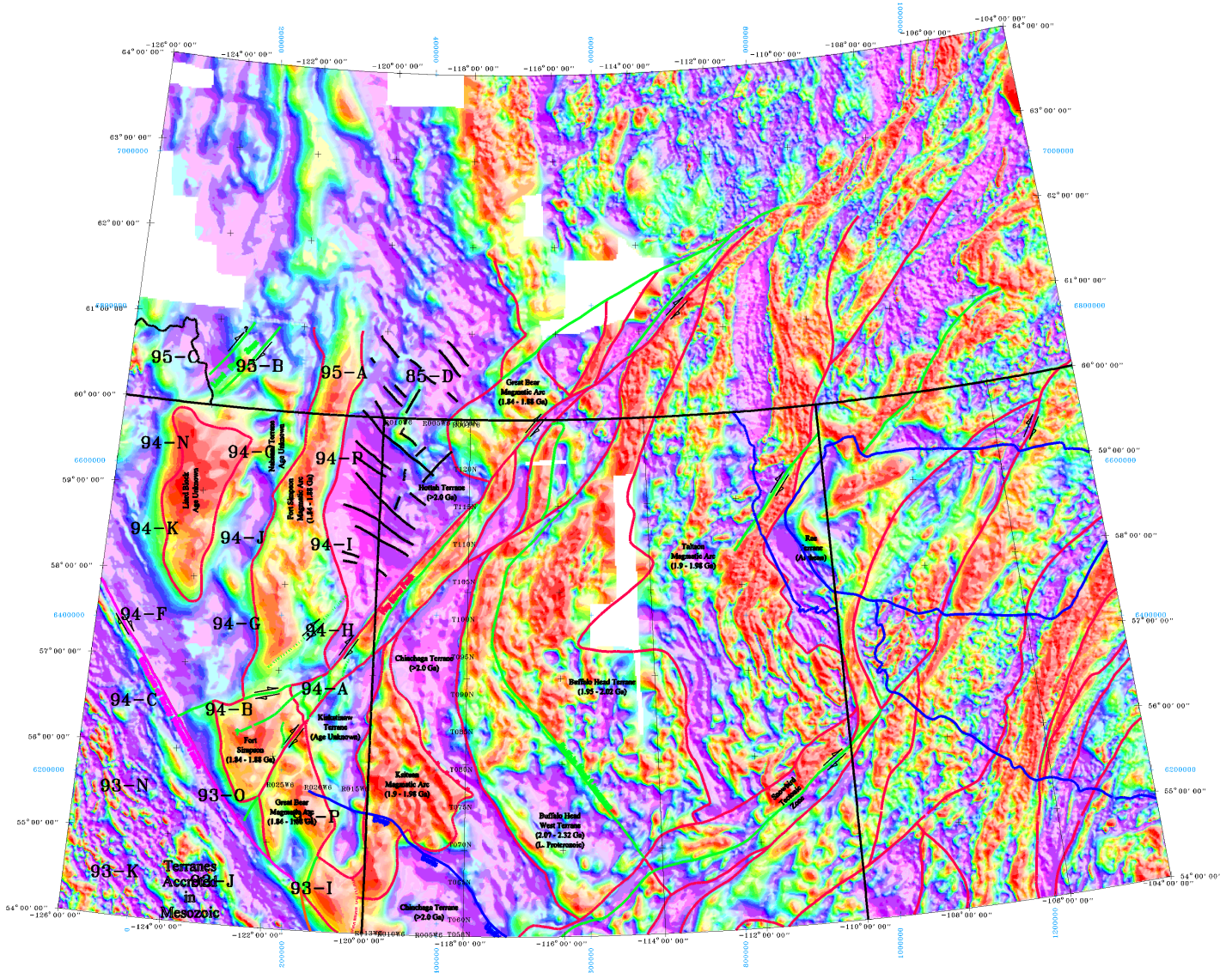


Figure 3. Total Field image from GSC aeromagnetic compilation for the northern part of the WCSB and adjacent Precambrian Shield. Red lines are terrane boundaries, green lines are major lineaments, black lines are Hottah dykes, as interpreted by GEDCO. The blue lines show the up dip edge of the WCSB and the Athabasca Basin