Rare Earth Element Mineralization in the Athabasca Group - Maw Zone

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The Maw Zone rare earth element (REE) occurrence was discovered near Williams Lake, 5.5 km northwest of Russell Lake - Wheeler River by Agip Canada Ltd., during a 1982 uranium exploration program in the Athabasca Basin (Figure 1). Yttrium values of 300 to 5000 ppm were obtained together with significant values for the heavy rare earth elements in drill core samples. Dravitic tourmalinization and drusy quartz silicification associated with the anomalous REE content is apparent both in core and outcrop (Agip Canada Ltd., 1982-1984). The zone is described as containing 336,000 tonnes of 0.25 percent yttrium oxide (Agip Canada Ltd., 1985; Energy Mines and Resources, 1989).

1. Geological Setting

The Maw Zone lies in an area of moderately well exposed quartz sandstones of the Athabasca Group, Manitou Falls Formation. Exposures are small, but evenly distributed. Surrounding glacial overburden consists of drumlins of sandstone debris. The Maw Zone itself occupies the northern end of a northeast-trending ridge of intermittent outcrop that coincides with the crest of a low amplitude anticline. Stripped of its overburden, the zone forms a prominent and conspicuous landmark.

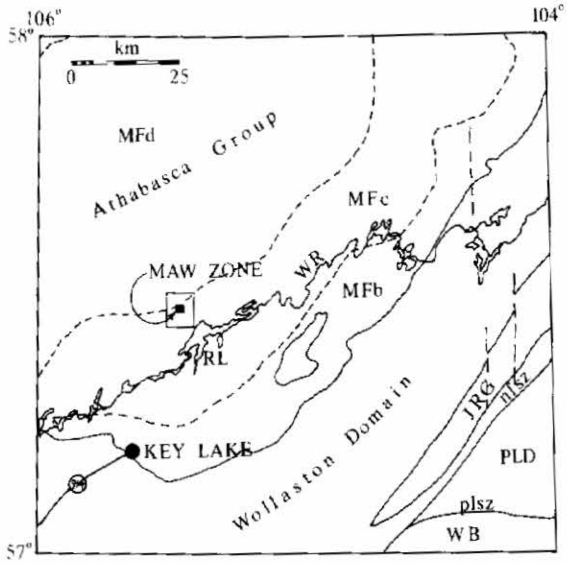

Figure 1 - Regional setting of the Maw Zone: MF - Manitou Falls Formation; MFb - fluviatile conglomerate; MFc - clean sandstone member; MFd - intraclast-rich member; RL - Russell Lake; WR - Wheeler River; JRG - Johnson River Granite; PLD - Peter Lake Domain; WB - Wathaman Batholith; nfsz - Needle Falls Shear Zone; plsz - Parker Lake Shear Zone.

The Manitou Falls Formation in the eastern part of the Athabasca Basin comprises basal fluviatile conglomerates, a middle clean sandstone member and an upper intraclast-rich member (Ramaekers, 1990). The Maw Zone is within the middle clean sandstone member, near its transition to the overlying intraclast-rich member. At Williams Lake, most of the outcrop on the northeast-trending ridge is of cross-bedded, commonly ripple marked and lightly silicified quartz sandstones, whereas away from the ridge, the outcrop consists of unsilicified, cross-bedded quartz sandstones. Outcrop at the Maw Zone shows the greatest degree of silicification and variety of sedimentary features and lithologies. The sandstones are remarkably uniform in appearance except for single grain-diameter grit bands.

The most striking lithology at the Maw Zone is a white to pink to reddish breccia-conglomerate which is not recognized anywhere else in the region. Texturally it varies from breccia, made up of 2 to 40 cm angular quartz sandstone fragments set in a slightly lighter coloured and less durable matrix, to conglomerate, in which the well-rounded fragments are of banded siltstone or hematite stained quartz sandstone lithologies foreign to the immediate area. The breccia ranges from one extreme - "jigsaw breccia" in which the original fit of the fragments can be seen, to a jumbled mass of angular material that includes large (40 to 90 cm) cross-bedded slabs.

Elsewhere the quartz sandstones form a regular, near horizontal stratigraphic sequence bedded at 10 to 30 cm intervals; the bedding planes being marked by either rip-up clay clasts or ripple marks. Rip-up clay clasts about 1 cm thick and 4 cm diameter are composed of white to grey, moderately hard amorphous material which weathers out relatively easily to leave a pock-marked bedding surface. Where weathering has removed the clay, the quartz grains that originally surrounded the clast are seen to be olive green, perfectly spherical and frosted.

The breccia-conglomerate is not confined to any definite narrow linear zones that could be interpreted as faults, but generally forms part of the stratigraphic sequence as continuous beds or as small (60 x 30 cm) discontinuous pockets. In one place breccia containing large slabs of ripplemarked quartz sandstone or sandstone with rip-up clay clasts, and smaller angular sandstone fragments set in a cross-bedded matrix, is banked against regularly stratified outcrop.

Evidence concerning the origin of the breccia-conglomerate is equivocal as one or more of the following interpretations may be applicable: a) talus slope breccia, b) solution collapse breccia, c) frost-shattered or desert pavement and d) shoreline pavement.

2. Alteration and Mineralization

Alteration is expressed as pervasive silicification and by a subtle green colouration along hairline fractures lined with dravite and drusy quartz, and in the matrix of the sandstone and breccia-conglomerate. The REE mineralization is not obvious; rare drusy quartz-lined cavities up to 10 cm across, yellow-brown limonite and clay-coated fractures and clay-filled cavities which occur within the mineralized zone may or may not be related to the mineralization. A weak radioactivity gives readings of 140 to 440 cps (4 to 11 times background) over the strongly stained and clay-altered fractures. In thin sections of the silicified sandstones the original boundaries of the well-rounded quartz grains are outlined by a fine opaque dusting. Needles of dravite (0.05 to 0.1 mm) radiate from the old grain surfaces into the former pore space and are themselves overgrown by quartz that completely fills the interstices and is in optical continuity with the original grains. Clay that fills cavities, coats fractures and forms rip-up clasts, is largely composed of a meshwork of microscopic radiating 'snowflake' dravite clusters and minor randomly oriented illite flakes.

In the breccia, the "snowflake" dravite is concentrated in the matrix, where it composes up to 50 percent of the groundmass. Smaller quartz grains in the matrix are angular and do not have a surface dusting of opaque to mark the position of former grain boundaries. Breccia cracks do not cut across quartz grains, showing that brecciation occurred prior to silicification and before the rock was well-cemented. Some interstices are filled with aggregates of dravite needles and a granular golden to brown, translucent isotropic, unidentified mineral (monazite?).

The greatest concentration of dravite occurs at the Maw Zone where it makes up a significant proportion of the breccia-conglomerate matrix and in some cases the clasts themselves. Lesser amounts of dravite occur in quartz sandstones from other parts of the northeast-trending ridge and decreases to negligible amounts away from the ridge and to the southwest. Outcrops west of Williams Lake contain no dravite needles. Silicification follows the same pattern as dravite.

Geochemical results show that the dravite alteration can be readily detected by boron analysis (Table 1). Boron values of up to 3200 ppm (the Maw Zone) and 1410 ppm (southwest along the ridge) coincide with those samples showing the most dravite in thin section. Yttrium values do not echo those of boron, so that the local degree of dravitization is not a guide to the distribution of yttrium. Yttrium values at the Maw Zone reach 4270 ppm; elsewhere they only reach a maximum of 20 ppm.

Table 1 - Trace Element Analyses Maw Zone & Williams Lake Area

Sample Number	P_2O_5 %	B ppm	Y ppm
90106	0.02	406	10
90107	0.03	236	6
90108	0.02	429	7
90109	0.02	3200	218
90110	0.03	707	991
90111	0.02	215	17
90112	0.02	561	31
90114	0.03	767	4270
90115	0.02	635	29
90116	0.02	502	29
90117	<0.01	124	12
90125	0.01	1410	20
90127	0.01	242	6
90130	0.01	295	8
90131	0.02	230	12
90133	0.01	61	15
90135	0.01	45	9

3. Conclusions

More than one event may have formed the breccia-conglomerate. Its coincidence with mineralization may be fortuitous and thus the lithology may be more widespread, but was made obvious by the silicification that accompanied mineralization. Given the shallow-water fluvial nature of much of the Manitou Falls Formation, it is reasonable to suppose that the deposits were in part exposed and subjected to various fragmentation processes, both soon after deposition and later when more consolidated. Solution collapse processes are more difficult to account for as it is uncertain what would have dissolved to allow the collapse.

The current model for unconformity type uranium deposits (Sibbald, 1985; Sibbald *et al.*, 1990) invokes a low temperature hydrothermal circulation system in the Athabasca sandstones as the conveyor of many elements, particularly uranium, that ended up in the deposits. Key ingredients in their precipitation are the interaction with a basement-derived fluid emanating from faults that disturb the unconformity and the presence of basement graphitic pelites. Developed above the uranium deposits are alteration envelopes typified by illite, chlorite, kaolinite, hematite, silica and dravite. Hoeve and Quirt (1984) envisage Maw Zone type quartz precipitation and REE phosphate mineralization as the outermost, near surface effect of the diagenetic-hydrothermal convective system above developing unconformity-type uranium deposits.

4. References

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