Mn-Ilmenite and Alteration Products in Horton River Area of Lena West

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Introduction

Mn-ilmenite was recognized as a kimberlite indicator mineral (KIM) in the Lena West diamond region of the Northwest Territories [2] as shown in figure 1. It includes compositions that match those found as inclusions in diamonds from an area of Brazil where diamonds are largely type IIa [3] and formed in the lower mantle. The recent determination [5] that large, high value type IIa diamonds like the Cullinan, Koh-I-Nor, etc. also formed in the lower mantle increases the importance of Mn-ilmenites not only as a KIM that is resistant to tropical weathering but as a possible indicator of large high value stones. The Mn-ilmenite alteration products, pseudorutile ($Fe_2Ti_3O_9$) and ferropseudobrookite ($FeTi_2O_5$), may also be used as KIMs and provide useful additional information (figure 1)

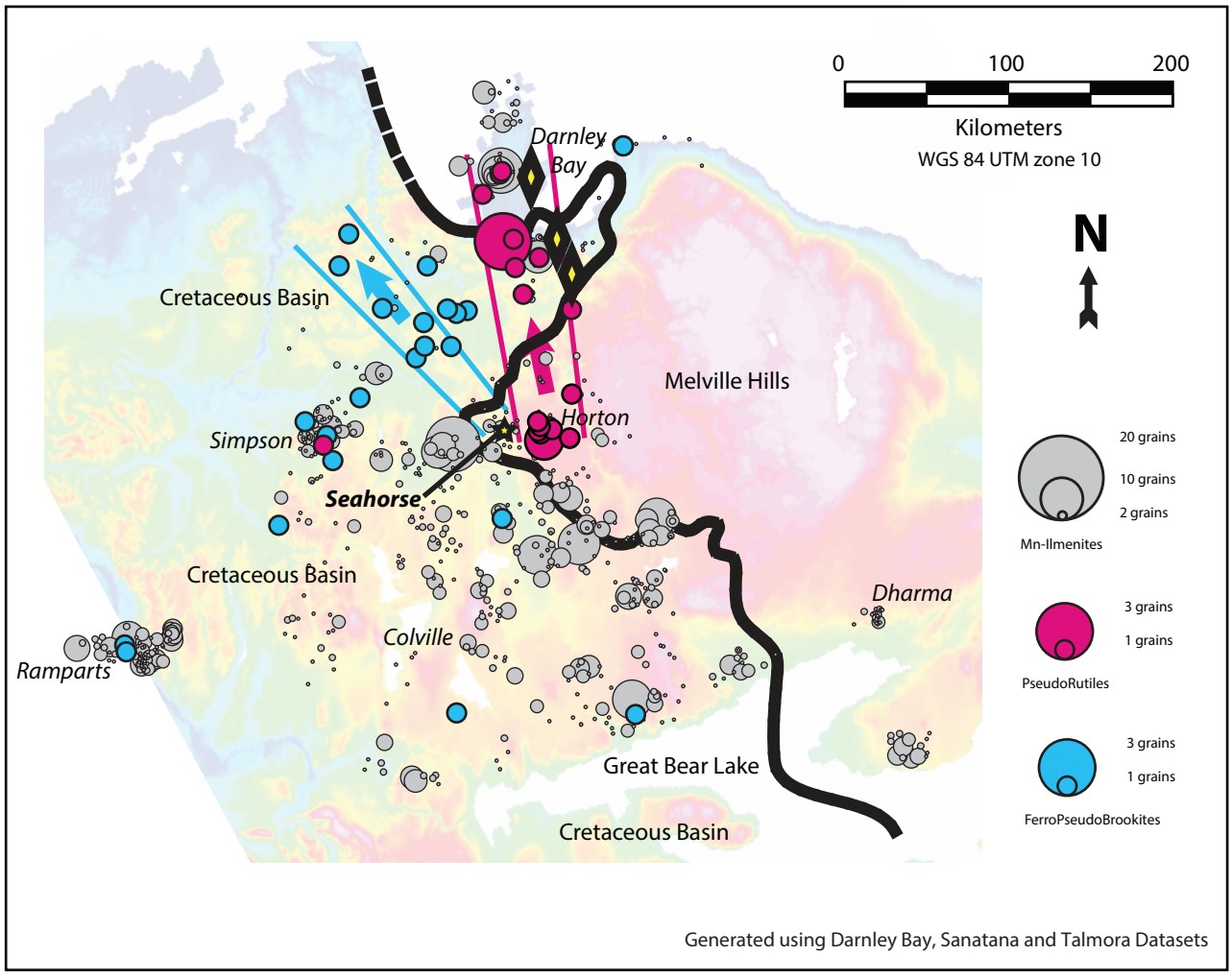

Figure 1: Location of Talmora's Horton River and Seahorse project areas outside the Cretaceous Basin. Distribution of Mn-Ilmenite across the Lena West superimposed on topography from low (blue) to high (red) elevation.

Source of Lena West KIMs

Diamondex exploration team [1] published a paper that showed that many, if not all, of the Lena West KIMs were derived from the base of the Cretaceous basin and entered the basin from the east from kimberlites of probable Jurassic age (~164 Ma).

The Horton Area Kimberlite Anomalies

Talmora located a cluster of magnetic anomalies outside the Cretaceous basin on the west side of the Horton River valley and recently recognized a very large magnetic anomaly further west beneath Seahorse Lake. The Seahorse anomaly is at the focus of a train of kimberlite pathfinder elements coincident with a NNW trending KIM train characterized by Mn-ilmenite, picro-ilmenite and chromite. A parallel train of similar KIMs is focused on the west side of the cluster of smaller anomalies to the east (figure 2).

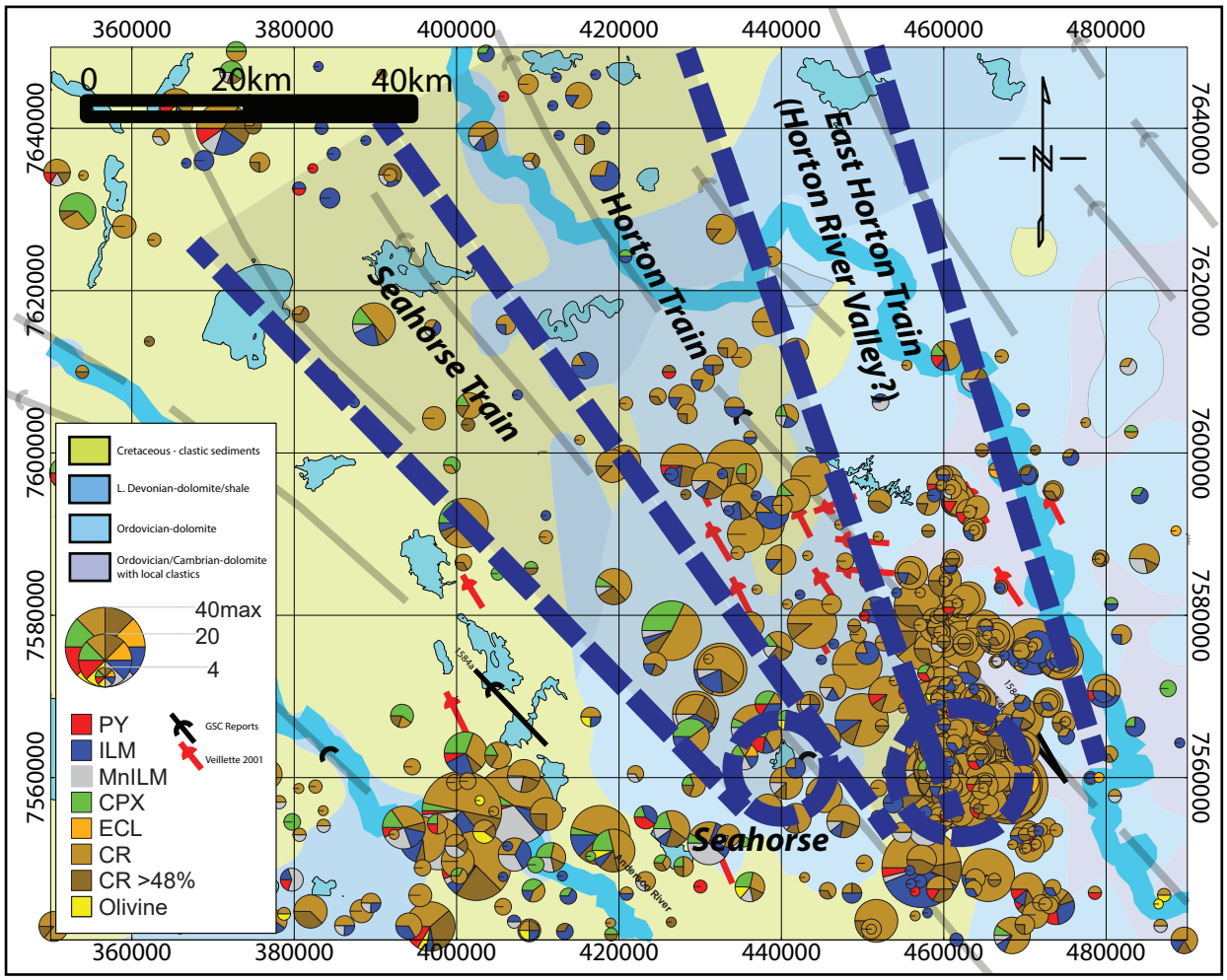

Figure 2 : Train of KIMs off Seahorse anomaly and parallel train off the cluster of anomalies to the east.

Characteristics of mantle derived Mn-ilmenites

For practical reasons we have used Cr2O3 < 0.15 wt %, MnO > 0.42 wt% and MgO < 1.50 wt% for Lena West Mn-ilmenite. Mn-ilmenites found in kimberlites that are chemically similar to those included in diamonds derived from the lower mantle are generally anhedral megacrysts with homogeneous internal structure [4]. They are a primary mineral phase and not rims on earlier grains or fine-grained late-crystallizing euhedral groundmass crystals.

Altered Mn-ilmenites

Mn-ilmenite in the Horton area shows alteration towards pseudorutile and ferropseudobrookite compositions (figure 3). The alteration products of ilmenite ($FeO.TiO_2$) involve either the oxidation of all the ferrous iron to the trivalent state and then the leaching of one third of the ferric iron to form pseudorutile ($Fe_2O_3.Ti_3O_6$) or the loss of iron without oxidation (reducing conditions) to ferric iron to form ferropseudobrookite ($Fe.Ti_2O_5$)

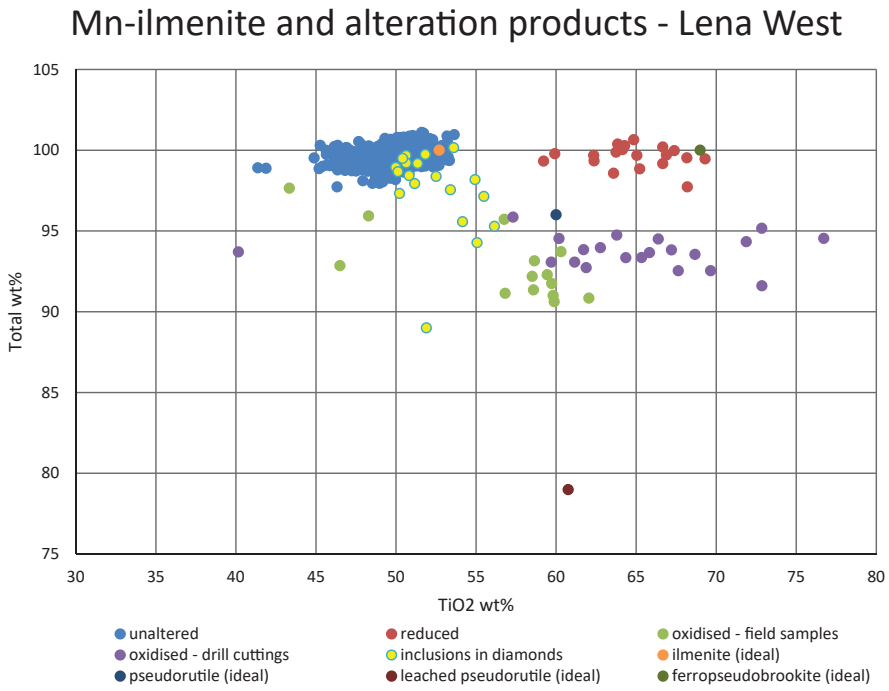

Figure 3: TiO_2 content of Mn-ilmenites in the Horton area showing oxidised alteration products with totals < 98 wt% (pseudorutile) and reduced alteration products with totals > 98% wt% (ferropseudorutile). Pseudorutile alteration >60 wt% TiO_2 are from drill cutting of a magnetic anomaly.

Distribution of Lena West Mn-ilmenite

Mn-ilmenites are found in tills across Lena West in and outside the Cretaceous basin. Those in the Darnley Bay area differ in terms of TiO_2 vs total weight percent from those of Lena West in the Cretaceous basin whereas the Horton Mn-ilmenites show similarities to both as shown in figure 4. Those in the Seahorse train match those in the Lena West Cretaceous basin.

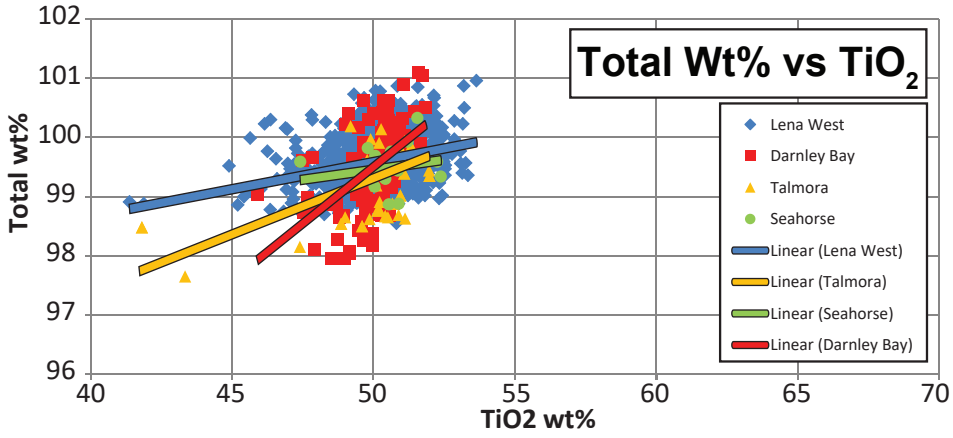

Figure 4: Comparison between Mn-ilmentites from Lena West, Darnley Bay, Talmora and Seahorse

Distribution of altered Mn-ilmenites (Totals = < 97wt%) - Pseudorutile

Pseudorutile is apparently related to paleo-lateritic weathering. Their absence within the basin west of Horton is presumably because the Mn-ilmenites, like the silicate KIMs, were deposited in the basin prior to lateritic weathering and were sheltered from weathering by the covering Cretaceous sediments.

The pseudorutiles near Darnley Bay are not likely related to the unweathered Darnley Bay kimberlites but appear to be part of a train down-ice of the Horton area anomalies. The pseudorutile train includes three macrodiamonds found in till up-ice of the DBR kimberlites.

Distribution of altered Mn-ilmenite (total = > 98.5 wt%) – Ferropseudobrookite

Ferropseudobrookite is found scattered across Lena West mostly within the Cretaceous basin but there is a concentration about 100 kilometers down-ice in the mineral trains coming off the Seahorse anomaly and from the west side of the cluster of smaller Horton anomalies respectively. The concentrations coincide with the dispersion of anomalous iron in the dolomite fan down-ice of Horton believed to reflect laterite capping kimberlites that was first scraped off by the advancing ice.

Discussion

The traditional KIMs do not relate to superdeep diamonds and most minerals that characterize the lower mantle do not survive at the earth's surface. Mn-ilmenite is an indicator of the possibility of superdeep diamonds because it has been found with majoritic garnet and CaTi-perovskite in a diamond in the Juina area of Brazil where about 45% of the diamonds are type IIa [3]. More work needs to be done on the stability of Mn-ilmenite and what characterizes its formation in the lower mantle.

The alteration products of Mn-ilmenite in the Horton area are separated geographically. Pseudorutile is confined to the Horton River drainage and to the glacial train that follows the Horton River to Darnley Bay and ferropseudobrookite is found as occasional grains across the Cretaceous basin and as a concentration at the down-ice end of the Seahorse train.

The presence of ferropseudobrookite in the basin indicates that it formed early and was dispersed by the Cretaceous sea. Its presence about 100 kilometers down-ice of the Horton anomalies coincident with anomalous iron in tills suggests that it formed near surface and was still present with laterite in the tops of kimberlites at the onset of glaciation. Both ferropseudobrookite and laterite were the first materials removed by the ice. Pseudorutile is found only in the Horton River valley and down-ice to Darnley Bay but it appears to have been present throughout the weathered zone eroded by the ice.

Conclusion

Mn-ilmenite is a useful KIM in areas of tropical weathering and is also an indicator of rare large high value diamonds. The distribution of pseudorutile and ferropseudobrookite suggests that the alteration of Mn-ilmenite is to pseudorutile where the post-Cretaceous uplift provided sufficient local relief for oxygen carrying groundwater to penetrate the tops of kimberlites but where local relief was absent only ferropseudobrookite formed near surface under reducing conditions.

References

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