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SUBJECT: **Potential Significance of the Neave Fault for Antrim-hosted Magmatic Ni-Cu-PGE Sulphides**

SUMMARY

Marked differences in geochemistry between Antrim basalts immediately north and south of the Neave Fault indicate that the fault was present as an escarpment before the first basalts in this area were extruded. Mapped geology shows that the Neave Fault and related West Baines and Blackfellow Creek Faults which are splays off the long-lived crustal-scale Halls Creek Fault, disrupt the Antrim basalt sequence. These data strongly suggest that these faults were active before, during and after Antrim magmatism and may have acted as magma conduits during basalt extrusion.

That the Neave Fault was a magma conduit is confirmed by the presence of the only known Antrim vent that is located on the NE extension of the fault on Wave Hill station. In this area the basalt pile is relatively thin probably due to thermal uplift and inflation as magma was injected into the region during basalt volcanism.

Based on the geology of the Noril'sk area mineralized sub-volcanic sills may be present within 0-6 km on either side of the Neave Fault (and by inference the West Baines and Blackfellow Creek Faults) located within the sedimentary sequence underlying the basalt volcanic pile. The daunting exploration challenge in the Antrim terrain is the need to explore through the 100->500 m thick, moderately magnetic basalt pile to locate sills buried within the underlying sedimentary sequence up to ~500 m below the basalts.

Introduction

The Noril'sk Ni-Cu-PGE sulphide deposits are located in sub-volcanic sills within relatively flat-lying sediments beneath a thick pile of basalt flows (the Siberian Trap). The deposits are adjacent to a crustal scale fault, the Kharaelakh Fault, which is interpreted to be the crustal conduit for basalt magma that is the parental to both the sulphide deposits and overlying basalt flows. The mineralized sills are located a 0.3-6 km from the Kharaelakh Fault. These sills acted as trap sites for the dense magmatic sulphide liquid that was initially contained within the parental basaltic magma (Naldrett et al. 1995).

The Antrim basalts (and many of the mafic rocks of the larger Kalkarindji Flood Basalt Province) are depleted in chalcophile elements (Ni, Cu, Co, PGE) and contaminated by crustal material (Glass 2002; Gole and Ashley 2003; Gole and Thornett 2006) in a very similar manner as parts of the Siberian Trap sequence (Arndt et al. 2003; Lightfoot and Keays 2005). These geochemical signatures are intimately associated with the magmatic processes that formed the sulphide deposits themselves (Li et al. 2009).

The geochemistry of the Antrim is certainly highly indicative of the presence, somewhere within the magma plumbing system, of vast amounts of magmatic sulphide that is missing from the basalts. However because the basalt sequence is mostly flat-lying the original eruptive centres (vents and fissures) are buried. This greatly hinders (or indeed makes impossible) the recognition of the most likely loci for sub-volcanic sills, that is near the vents and feeder structures. How such sites and any associated sub-volcanic sills can be identified is, however, a major exploration challenge.

Antrim Basalts Vent

The only known Antrim-related vent is at the western termination of the Wave Hill Rille, a >120 km long, 0.5-4 km wide and ~50 m deep trough etched into the top basalt flow preserved on Wave Hill station (Figures 1 and 2). This is a thermal erosion channel formed by the last basalt lava flow that vented from the intersection of a NW fracture system and the apparent NE extension of the Neave Fault (Figure 2). The lava flowed eastward within a huge channel of its own making for >120 km without crystallising implying that a vast volume of lava issued from this vent that went to form basalt flows well to the east (i.e. the vent and the deposition of related basalts are widely separated). Thermal erosion channels of this magnitude are known from the Moon (Lunar Sinuous Rilles) where they were first described (Oberbeck et al. 1969 and numerous more recent references) but the Wave Hill Rille is the largest known on Earth.

The locations of other earlier Antrim basalt vents are unknown. Based on vent locations in other continental flood basalt provinces these vents could be widely scattered. Some may have been located elsewhere along the Neave or along other faults. However all appear to have been buried by later flows.

Neave Fault

The Neave, West Baines and Blackfellow Creek Faults are all NE to ENE-trending structures that originate from the Halls Creek Fault, a major crustal structure that has been active over a very long time – probably from the Palaeoproterozoic to the Alice Springs Orogeny (1800 Ma to 300 Ma).

On geological maps and on magnetic images the Neave, West Baines and Blackfellow Creek Faults are all seen as disrupting the Antrim Basalt sequence and thus have been active since the eruption of these rocks at 506 Ma (Glass, 2002). However the geochemistry of basalt from the basal flows north and south of the Neave Fault is markedly different (Figure 3). This indicates that the Neave Fault was a feature that

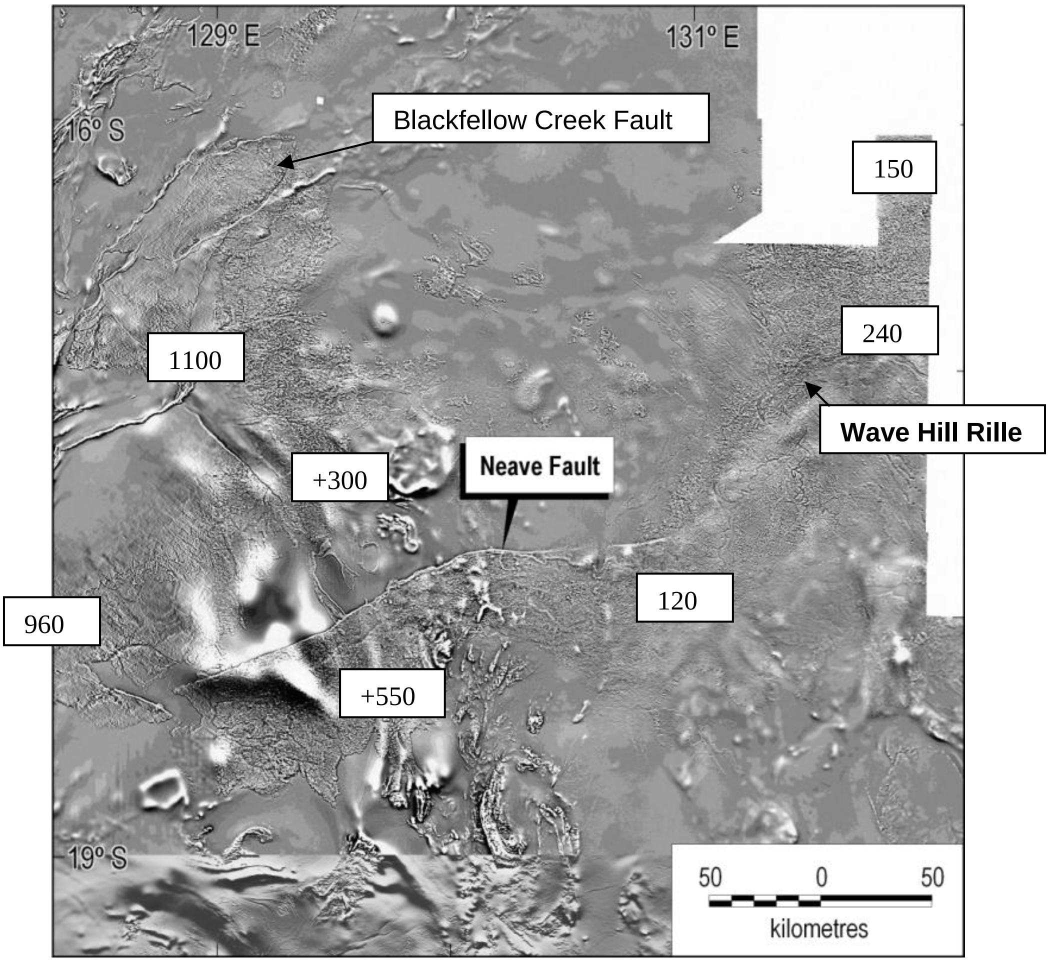

Figure 1. Magnetic image for the Wave Hill-Limbunya-Birrindudu area of the Northern Territory showing the Neave and Blackfelow Creek Faults and Wave Hill Rille. Thicknesses in metres of the Antrim Basalt also shown (data from Bultitude, 1971; Mory and Beere 1988; Gole and Ashley 2003). Mottled pattern on image reflects Antrim Basalt.

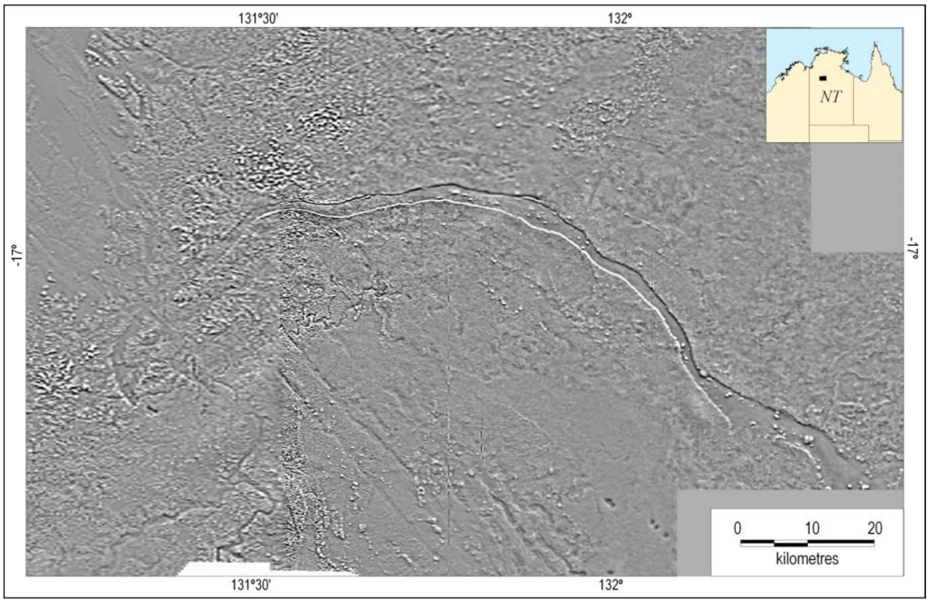

Figure 2. Magnetic image of Wave Hill Rille. Note possible vent at western termination.

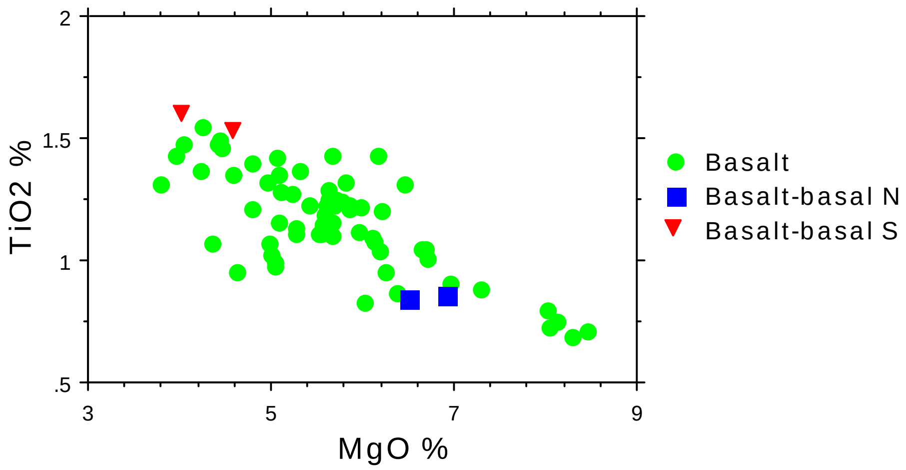

Figure 3. The composition of the lower-most basal Antrim basalt flows to the north and south of the Neave Fault compared to basalt higher in the volcanic pile. All samples from drill holes. Data from Gole and Ashley (2003); see also Gole and Thornett (2006).

influenced the deposition of the initial Antrim basalt flows in this area and thus was present, perhaps as an escarpment, before Antrim basalts were emplaced. It thus appears that the Neave Fault, and other related faults (i.e. West Baines and Blackfellow Creek Faults), were active, prior to, during and after Antrim magmatism. Because these faults are linked to the major crustal-scale Halls Creek Fault it is possible that they played a part in the transfer of Antrim magma within the upper crust. That this did indeed happen is indicated by the presence of the Wave Hill Rille and related vent located on the extension of the Neave Fault.

Antrim Basalt Thickness

The thickness of the Antrim Basalt is shown on Figure 1. Most values are measured thickness of the original pre-erosion thickness of the basalt pile. Values with plus are current, eroded thicknesses. Well to the east of the region shown in Figure 1 (i.e. central Northern Territory) the correlative basalt sequences is only ~50 m thick (Glass, 2002).

The thickest part of the basalt pile, ~1100 m, is near the Halls Creek Fault and this has been used to suggest that this Fault was the main vent area (Mory and Beere 1988; Glass 2002). However the only known vent, the Wave Hill Rille vent (Figure 2), is located where the basalt pile is relatively thin (~200 m). This may reflect thermal uplift and inflation associated with intrusion of magma into the crust prior to and during eruption. That the vent was a high point is indicated by the flow of magma within the Rille away from the vent (Figure 2).

Conclusions

The Neave Fault, and by inference the West Baines and Blackfellow Creek Faults, were active before, during and after Antrim basalt magmatism. The only known Antrim vent is located along the NE extension of the Neave Fault strongly suggesting that this and probably related faults were magma conduits during basalt volcanism.

Based on the geology of Noril'sk mineralized sub-volcanic sills may be present within 0-6 km laterally from the magma conduit/fault located within the sedimentary sequence underlying the basalt volcanic pile (Naldrett et al. 1995).

The major exploration challenge in the Antrim terrain is the need to explore through a 100->500 m thick, moderately magnetic basalt pile to locate and then be able to target sills buried within the underlying sedimentary sequence up to ~500 m below the basalts.

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