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Geology and Exploration History of the Aviat Kimberlite Cluster, Northern Rae Craton, Melville Peninsula, Nunavut, Canada

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Introduction

Kimberlites of the Aviat cluster were first discovered on the Melville Peninsula, Nunavut, in 2002. The Aviat Project is located on the northern portion of the Melville Peninsula, N69.27° W83.32°, approximately 60km WSW of the hamlet of Igloolik, and 3100km NE of Vancouver. The Aviat kimberlite bodies intruded into the Archean basement rocks of the northern Rae craton between 500 and 560Ma. The 10km by 3km cluster comprises sheets and pipe-like bodies with variable styles of emplacement occurring in different areas.

Geological Setting

The project area is underlain by Archean tonalite-granodiorite gneisses, metasedimentary and metavolcanic rocks of the northern Rae craton. Ordovician dolomites unconformably overly the Archean assemblages and form extensive exposures on the eastern flank of the Aviat Property. Property scale geology is comprised of variably magnetic upper amphibolite facies Archean gneiss and granitoids occurring as narrow panels forming a regional layering. The pronounced layering is revealed in the regional topography and the aeromagnetic data. Three broad tectonometamorphic events are recognized; (i) development of gneissosity/foliation; (ii) isoclinal folding of lithological panels and gneissosity; and (iii) development of basin-and-dome interference patterns. The area is marked by numerous NW and WNW-striking faults, and where resolved sinistral strike slip and southwest-side-up movements are demonstrable. Two sets of prominent joints are present, a subvertical NE striking set and a set with shallow (< 20°) dips preferentially toward the southern or SW quadrants.

Exploration History

Reconnaissance scale heavy mineral sampling of till, eskers and beaches over the northern portion of the Melville Peninsula commenced in 2001. Follow-up sampling and prospecting resulted in the discovery of the outcropping AV-1 kimberlite in late August of 2002. Land acquisition continued through to early 2003.

In excess of 80 000 line kilometres of airborne geophysics have been flown and approximately 11 000 surface samples have been collected across the property. Complex magnetic bedrock responses limit the usefulness of airborne surveys in identifying kimberlite. Combined sample campaigns revealed a kimberlite indicator mineral-rich zone approximately 65km long and 10km wide, trending 286°, parallel to the dominant glacial-flow direction. This regional scale indicator mineral train is referred to as the Tremblay Corridor and all presently known kimberlites occur within a 10km long by 3km portion at the eastern terminus of the Tremblay Corridor.

The greatest success in identifying kimberlite occurrences has come through intensive prospecting and detailed infill sampling in the immediate vicinity of anomalous till samples. Some 500 individual kimberlite float occurrences have been documented on the Aviat property. Each of the kimberlites, with the exception of AV9, has been discovered through mineral sampling and prospecting techniques.

Drill campaigns in late 2003 and early 2004 focused on sampling and delineation of the AV1 kimberlite, and discovery drilling on the AV2, AV3, and AV4 kimberlites. Drilling in 2005 focused on regional airborne targets and initial drilling of the AV5, AV6, and AV8 bodies. Drilling in 2006 and 2007 concentrated on understanding the geometry of apparently disparate kimberlite exposures. The resultant interpretation of drill data generated the current model that links the various exposures and drill intercepts into an extensive sill/sheet complex.

Kimberlite Geology

Two distinct geometries of kimberlite intrusions are observed within the 10km x 3km eastern portion of the Tremblay corridor: pipe-like intrusions and subhorizontal sill-like intrusions. Three kimberlite pipes have been identified along a 4km strike length, within and south of a NW-trending sinistral strike-slip regional fault zone. North of the fault zone, kimberlite sheet complexes comprise sets of stacked, subhorizontal to shallow-dipping hypabyssal kimberlite intrusions which have been delineated over a 10 km^2 area. The eastern sheet complex forms a broadly conical to radial pattern dipping inward toward the

NW-trending fault system. Two pipe-like intrusions, AV1 and AV9, occur proximal to and immediately south of a NW-trending regional, sinistral fault zone (AV167 Fault). The AV4 pipe-like intrusion occurs proximal to a secondary splay south of the AV167 Fault. The main sheet complexes (AV267, AV2 Upper, AV3, and AV8) occur on the northeast side of the AV167 fault zone (Fig. 1). Subhorizontal sheets are also present south of the AV167 fault zone (AV5 and proximal to AV9).

Pipe Geology

The three small pipe-like bodies (AV1, AV4, and AV9) are infilled with similar lithologies, with textures ranging from hypabyssal kimberlite to tuffisitic kimberlite breccias and a spectrum of transitional textures between these end members. Intersections of country rock (granite gneiss) also occur in all phases but more commonly within transitional zones.

The AV1 kimberlite discovery outcrop lies on the north shore of an NW-SE elongate narrow lake and is expressed by a 77m by 13.5m exposure of hypabyssal kimberlite. Ground magnetics over the body define a 135m by 35m bilobate prominent magnetic high signature that is elongated in a NW-SE direction. The magnetic high response is attributed to hypabyssal material. Transitional kimberlite breccia material is not evident in the magnetic data. Hypabyssal kimberlite is the most predominant in the northern part of the AV1 body and development of transitional hypabyssal and tuffisitic kimberlite textures and phases occurs in the southern portion of the body. Surface and drill data indicate that the AV1 kimberlite is a complex, irregular but overall elongate body that measures 225m by 50m and trends northwest-southeast, with additional kimberlite sheets. Narrow (<2m) hypabyssal phases were intersected in drillholes along the eastern and western limits of the AV1 body, suggesting an association with sheet-like intrusions of hypabyssal kimberlite. The AV9 kimberlite lies 3.5km southeast of AV1 and has a complex, lobate NW-SE trending gradient magnetic low, measuring 100m by 50m. Preliminary drilling indicates a southerly plunge to the overall pipe geometry. Texturally, AV1, AV4, AV9 all display a spectrum of hypabyssal, transitional hypabyssal to tuffisitic, and tuffisitic breccia phases.

Sheet Geology

Drill intersections of hypabyssal kimberlite indicate the occurrence of stacked kimberlite sheets at AV2, AV267, AV3, AV5, and AV8. Locally the sheets are planar features, however in a regional context variable attitudes indicate corrugations in the overall sheet geometry. The sheets are dominated by olivine macrocrystic phlogopite-carbonate hypabyssal kimberlite, with localized development of hypabyssal kimberlite breccia along hangingwall contacts of thicker (>4m) horizons. An individual sheet is composed of multiple phases or injections of kimberlite, with widths ranging from decimeter to metre scale. The envelope of kimberlite injections varies, with maximum widths of up to 11m.

The AV267 sheet has been traced through surface exposures and drill intersections over an area of 1.3km^2, from surface to a depth of 100m. This sheet is manifested by two lobes, an eastern segment trending 065°/10°, and a western segment trending 110°/8°; the lobes join along a NNE/SSW hinge/rollover zone. The AV267 sheet has been intersected south of the AV167 fault zone, at a depth 50m below the predicted depth, suggesting that the dyke persists, but has interacted with the fault zone, as a step or climbing feature. The rollover zone projects through a surface exposure of the AV267 sheet and the surface expression of the AV9 kimberlite, across the AV167 fault zone. The AV267 body thins, to less than 1m up dip toward the NE and NW and thickens, locally to 7m, toward the southern boundary with the AV167 Fault Zone.

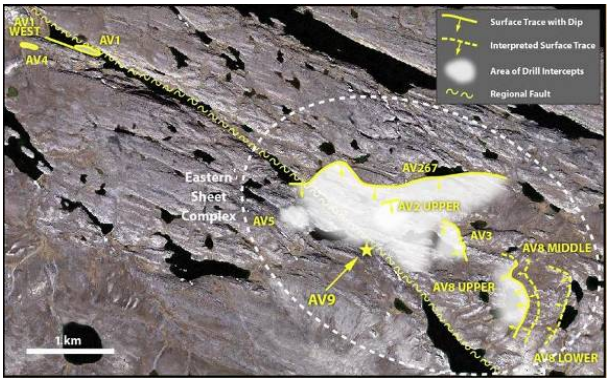

Fig. 1. Location of Aviat kimberlite pipes and complexes; clouded area represents drilled portions of sheet complex.

The AV3 zone has been traced over a 300m x 500m area and two distinct sheets have been identified with a general northerly trend dipping gently to the west. At AV8 three distinct sheets have been identified over an area measuring 200m x 300m. An outcrop of the upper sheet displays a 210°/20° attitude. The individual kimberlite horizons at AV3 and AV8 are separated by 20m to 30m of country rock devoid of kimberlite injections.

Mantle Sample

Kimberlite indicator minerals of mantle provenance have been recovered from surface sediment samples and from kimberlite discoveries. The full suite of mantle derived garnet, clinopyroxene, chromite, orthopyroxene, olivine and kimberlite-derived ilmenite are present. The recovered garnets include significant proportions of high-Cr and low-Cr types. The high-Cr (>2 wt.% Cr_2O_3) population is dominated by lherzolitic garnets with CaO contents greater than the G9-G10 line. The harzburgitic or G10 population contains a significant proportion that lie on the high Cr_2O_3 side of the diamond graphite line as defined by Grütter and Sweeney (2000) and Grütter et al. (2006). There is also a population of Ti-enriched megacrystic garnets. High Cr chromites are recovered in tills and kimberlite

samples, a significant proportion (with >0.7 wt.% TiO_2) display increasing TiO_2 contents with decreasing Cr_2O_3, indicative of the phenocryst suite of chromites. A proportion of chromites with < 0.7 wt.% TiO_2 have Cr_2O_3 contents of >59<69 wt.% and may be considered as sourced from a diamondiferous spinel-peridotite paragenesis.

Pressure-temperature (P-T) values have been calculated according to Nimis and Taylor (2000) for clinopyroxene recovered from the AV1, AV9 and AV267 bodies. Subtle differences are noted between clinopyroxene from the AV1 kimberlite and that of the AV9 and AV267 bodies. AV1 derived clinopyroxene have a P-T range of 38-45 Kbar and 850°-1050°C and lie mainly in the graphite stability field and define a relatively warm geotherm of 38-42 mW/m^2. The AV267 and AV9 bodies define a temperature array of 800°-1150°C and 40-58 Kbar, fall predominantly within the diamond-stability field and define a cooler geotherm of 36-40 mW/m^2. Fresh orthopyroxene is relatively rare but has been recovered from the AV267 and AV9 bodies. These grains have low Ca/(Ca+Mg) and Al_2O_3, and indicate sampling of garnet-peridotite and diamond-bearing harzburgite lithosphere. Variation in kimberlite indicator mineral abundance and compositional populations is evident between the pipes and sheet complex bodies, indicating that the variability is attributable to different phases of emplacement.

All kimberlite bodies discovered at Aviat are diamond-bearing. A total of 59 tonnes have been processed from the AV1 kimberlite, and a total of 51.95 carats recovered for an indicated grade of 88 carats per hundred tonne (cpht) for all stones >0.850mm. The AV267 sheet has been sampled from surface and 20.6 tonnes returned 33.36 carats for an indicated grade of 163 cpht for all stones >0.850mm. Diamond endowment and characteristics, however, do not display significant variation between the different textural end members within the pipe-like bodies, nor between the pipes and sheet occurrences.

Emplacement Discussion

The eastern sheet complex bodies bear no obvious correlation with local bedrock foliation, joint, or fault orientations. Dyke emplacement theories indicate that planar sheets (dykes or sills) will propagate more or less perpendicular to the least compressive stress, σ_3 (e.g. Rubin, 1995). This suggests that during sheet emplacement at Aviat σ_3 was orientated sub-vertically, and thus subparallel to the force of gravity and the overburden load. In this scenario the ambient σ_3 cannot be extensional, and as such σ_1 and σ_2 must have greater compressive values. Therefore during sheet emplacement, circa 500-560Ma, the region was in an entirely compressive regime. The driving force for sheet emplacement is deemed to be by magma overpressurization, with propagation along self-induced fracture planes, as the magma pressure exceeds the subvertical σ_3 at relatively shallow crustal levels.

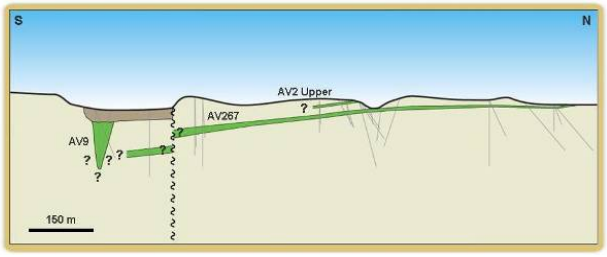

Fig. 2. Schematic Cross Section through AV267 and AV9 kimberlites.

The presence of pipe-like bodies at Aviat requires a model whereby pipes intrude into a compressive regime, or whereby the stress regime was transient during the 60m.y. span of emplacement. Given the close proximity of the pipe-like bodies to a regional scale, subvertical fault system, the fault zone may have accommodated a different stress regime, acting as a preconditioned conduit, exploited by ascending kimberlitic magmas. The proximity of pipe-like kimberlites to the inferred focal point of the conical sheet complexes implicates the pipes as possible magma sources/conduit for the sheets (Fig. 2).

References

Grütter, H.S. and Sweeney, R. J., 2000. Tests and constraints on single grain Cr-pyrope barometer models: some initial results. Extended Abstracts, GeoCanada 2000: The Millenium Geoscience Summit, 29 May–2 June 2000, Calgary, Abstract 772, 4 pp.

Grütter, H.S.; Latti, D., and Menzies, A., 2006. Cr-saturation arrays in concentrate garnet compositions from kimberlite and their use in mantle barometry. Journal of Petrology, 47, 801-820.

Nimis, P. and Taylor, W.R., 2000. Single pyroxene thermobarometry for garnet peridotites. Part I. Calibration and evaluation of the Cr-in-pyroxene barometer and enstatite solvus thermometer. Contributions to Mineralogy and Petrology, 139, 541-554.

Rubin, A.M., 1995: Propagation of magma-filled cracks. Annual Review of Earth and Planetary Sciences, 23, 287-336.