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Kimberlite intrusion into competent and unconsolidated materials: contact relationships within the Koala pipe, Ekati Diamond Mine, Canada

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Late-stage cross-cutting kimberlite intrusions are not commonly documented in the literature and where they are observed they tend to have occurred post-lithification of the kimberlite host forming dykes. An example of a late-stage kimberlite intrusion occurs within the Koala pipe, Ekati Diamond Mine, NWT, Canada (Crawford et al., 2006; Porritt, 2008).

Koala Geology

The Koala pipe is dominantly filled by fragmental kimberlite, with both pyroclastic and resedimented facies present (Figure 1).

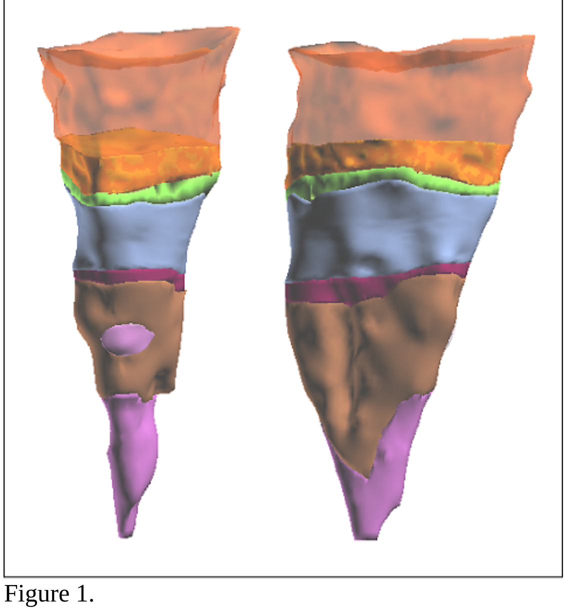

Figure 1.
3D images of the Koala pipe showing the layer-cake stratigraphy, images are taken looking east and south respectively. The basal purple unit represents the late stage intrusive, macrocrystic olivine-rich, coherent kimberlite (Phase 7); the brown represents a massive olivine-rich column collapse lapilli-tuff (Phase 6); the narrow mauve layer is a granodiorite cobble-boulder breccia (Phase 5b); the blue represents a mud-rich massive poorly sorted volcaniclastic facies (Phase 5a); the green layer is a laminated, wood-rich fine grained silty-sandstone facies (Phase 4); the orange is the multiply bedded, normally graded, olivine rich, volcaniclastic facies (Phase 3); and the pink is the mega-graded volcaniclastic facies (Phase 1).

The lowermost fragmental deposit (Phase 6) is a massive, poorly sorted, olivine rich-pyroclastic unit, interpreted to have been deposited en masse into the pipe from the collapse of a waning-stage eruption column (Porritt, 2008). An irregularly shaped body of macrocrystic olivine-rich, coherent kimberlite (Phase 7) has been found underlying this column collapse deposit (Figure 1), and is interpreted as a late-stage intrusion based on its irregular morphology, coherent nature, absence of evidence of welding textures, and paucity of country rock xenolithic material which is found within all fragmental facies.

Coherent Kimberlite

The coherent unit is irregular in morphology and characteristically competent, dense, dark, and weakly magnetic, containing fresh olivine, both macrocrystic and phenocrystic, set in a groundmass dominated by serpentine and carbonate with abundant opaque minerals (generally magnetite). It is generally devoid of country rock fragments except at the pipe margins where invasive fracturing of the granodiorite is seen.

Coherent – Pyroclastic Contact

A 5-10 m zone showing rapid alternations (dm scale) between coherent and fragmental kimberlite is observed in drill core as the main intrusive body is approached. This zone is interpreted as a series of intrusive apophyses linked to the main intrusion. The edges of these apophyses may be fresh and sharp to altered and unclear (Figure 2), and are generally irregular rather than planar. Increased concentrations of fine-grained opaque minerals are observed within the coherent kimberlite along the contact.

Coherent – Country Rock Contact

In contrast, the contact between the main coherent kimberlite body and the granodiorite pipe walls is often brecciated. Veins of kimberlite have intruded the granodiorite and appear to have hydraulically fractured the country rock creating a narrow zone of angular lithic fragments supported in coherent kimberlite along the contact (Figure 3). Carbonate alteration of the granodiorite is often observed, though varies greatly in intensity, with quartz and feldspar generally altered more intensely than biotite or amphibole.

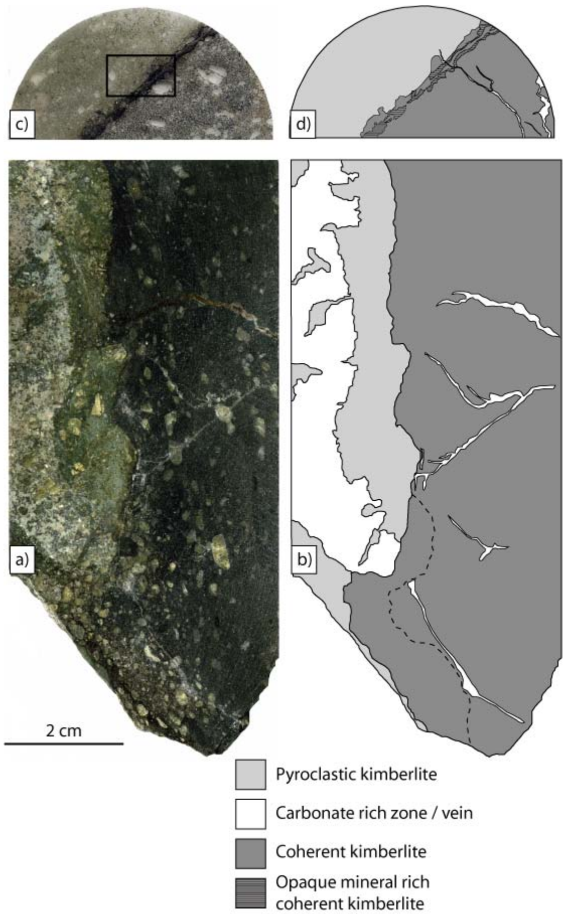

Figure 2.
Contact between the pyroclastic kimberlite (Phase 6) and coherent kimberlite (Phase 7). An example from KUG 2091-05 polished slab and interpretation (a & b), macroscopic view of a thin section and interpretation (c & d).

Thin carbonate veinlets are common and appear to be precursors to the thicker kimberlite veins; carbonate also lines and fills large vugs which are occasionally observed within the kimberlite along the contact with the host rock.

Discussion

The contradictory nature of the observed intrusive contacts relates to the difference in physical properties of the fragmental kimberlite and the granodiorite. The fragmental kimberlite was most likely unconsolidated at the time of the intrusion and may have been water saturated. The coherent kimberlite was able to push through the sediments as lobate intrusions, with any exsolving carbon dioxide escaping from the contact through the overlying sediment, contributing to alteration intensity. Differences in porosity and permeability of the pyroclastic pile and temperature and viscosity of the intruding magma could lead to differences in observed textures, with peperitic textures expected where hot magma interacts with water laden pyroclastics. Where the competent granodiorite was encountered the kimberlite was not able to easily move through and the low porosity of granodiorite prevented exsolving carbon dioxide from escaping. Instead carbonate pooled along the boundaries of the intrusion creating vugs and, where the overpressure was sufficient, hydraulically fractured the granodiorite enabling the kimberlite magma to inject into the country rock. This hydraulic fracturing and stoping mechanism may be one of the mechanisms by which kimberlite magma rises to the surface through the brittle rocks of the continental crust.

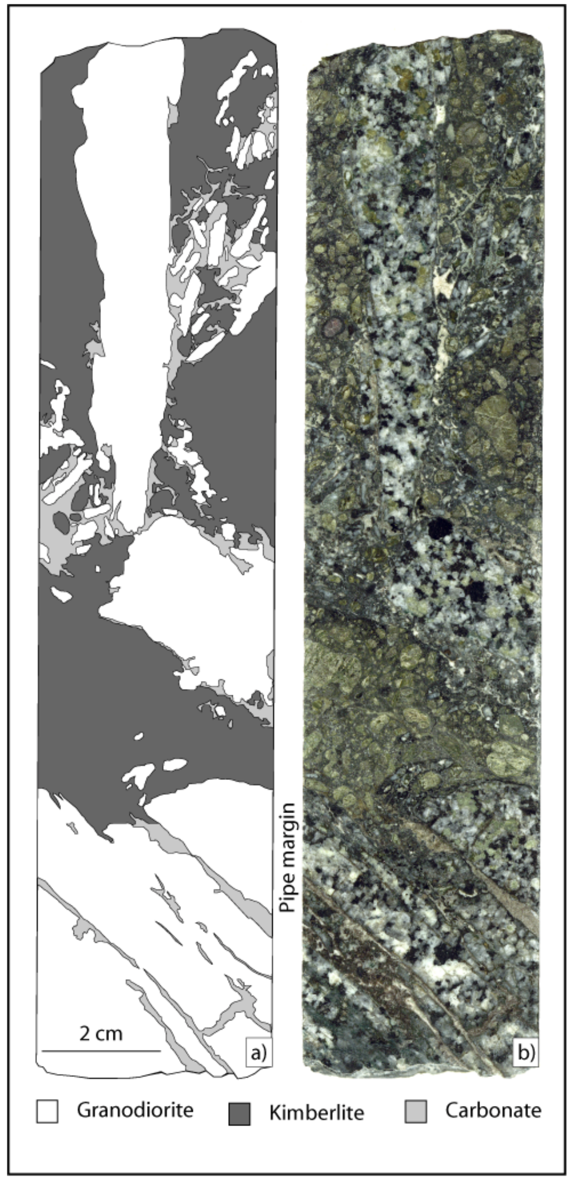

Figure 3.
Pipe margin contact between the macrocrystic olivine-rich coherent kimberlite (Phase 7) and the granodiorite host rock, polished slab and interpretation, KUG 2091-09 327 m (a and b). Extensive carbonate deposition in fractures and around the edges of the granodiorite fragments, indicating carbonate rich fluids were present during kimberlite emplacement and were likely responsible for hydraulically fracturing the host rock.

References

Crawford, B., Porritt, L.A., Nowicki, T.E., Carlson, J.A., 2006. Key geological characteristics of the Koala kimberlite, Ekati Diamond Mine, Canada, 2006 Kimberlite Emplacement Workshop. Long Abstracts, Saskatoon, Canada.

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