Emplacement history of the Jericho kimberlite pipe, northern Canada

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The Jericho kimberlite (JD-1) is a diamondiferous pipe located 60 km south of the Arctic Circle in the barrenlands of northern Canada. It was discovered in February 1995 beneath 10 to 35 m of till, and it intrudes Archean granitic country rocks of the Slave craton. Rb/Sr ages from phlogopite indicate kimberlite emplacement occurred 172 Ma (Heaman, *et al.*, 1997), which is considerably older than the Late Cretaceous and Early Tertiary kimberlites 100 km to the south near Lac de Gras. The Jericho kimberlite, along with a contemporaneous small satellite pipe (JD-2) 250 m north and a larger pipe (JD-3) 7 km southwest, are thus part of a separate kimberlite field from those at Lac de Gras. Extensive exploration efforts at Jericho have helped elucidate the process and history of pipe emplacement.

Since its discovery, the Jericho kimberlite has been sampled by 86 drill holes and an underground excavation in order to evaluate the feasibility of mining. The drill core delineated the pipe to a maximum drill depth of 350 m below the surface and was tested by caustic fusion to estimate diamond grades in different parts of the pipe. The underground sample extracted an estimated 14,550 tonnes of kimberlite from a decline tunnel more than 4 m^2 that advanced 257 m through the kimberlite, after 500 m of advance in the granite country rock (Fig. 1). A representatitve 9,401 tonnes of extracted kimberlite wereprocessed by the claims holders Lytton Minerals Ltd and New Indigo Resources, who recovered 10,539 carats of diamonds for an average grade of 1.18 carats per metric tonne (Cts/T) and an estimated value of $60 US per carat (Lytton Minerals Ltd press release, December 1997). Different parts of the pipe yielded grades between 0.31 and 1.96 Cts/T. In addition to providing the basis of the diamond tests, the extracted sample is an excellent geologic database that has permitted detailed geochemical, crustal, and mantle xenolith studies (Kopylova *et al.*, in press; Cookenboo *et al.*, 1997), as well as allowed reconstruction of Jericho's emplacement history, as described herein.

The main Jericho kimberlite (JD-1) is an elongate body with a straight and near vertical eastern wall, from which 3 lobes with inward dipping walls emerge to the west (Fig. 1a). A one meter wide kimberlite dike extends from the eastern edge 250 m north to the small satellite pipe (JD-2). Core logging and underground mapping resulted in identification of three petrographically distinct kimberlite phases characterizing different parts of the pipe.

Competent blue-gray to dark gray kimberlite with unserpentinized olivine macrocrysts and a groundmass composed of finely disseminated calcite, serpentine and tiny oxides (most <20 microns) occurs along the eastern wall. This kimberlite has the highest magnetic susceptibility, density, and volatile content at Jericho. It also has the lowest diamond grade, and supracrustal limestone xenoliths are less common here than elsewhere. Textures suggest a hypabyssal origin, and this phase is interpreted as a "blow" up to 10 m wide on a dike that extends more than 500 m from the south end of the pipe to the small satellite pipe JD-2. This dike phase lithified prior to emplacement of the other phases at Jericho, as shown by the occurrence of autoliths of similar kimberlite in the later lobes, and by cross-cutting relationships, where the dike has been apparently cut away during subsequent emplacement events (Fig. 1b). The hypabyssal phase thus formed as a precursor dike, analogous to those identified at many of the deeply eroded pipes in the Kimberley area of South Africa (Clement, 1982). Probably this precursor dike was emplaced by fracture propogation along the pre-existing structural trend defined by the regionally exstensive Mackenzie mafic dike swarm, one of which parallels the precursor dike 40 m to the east.

The second phase at Jericho was the first pipe-forming event. It fills the carrot-shape northern lobe, which has the steeply inward dipping (≈85°) contacts typical of kimberlite diatremes, and contains numerous autoliths of hypabyassl kimberlite, which are especially large and abundant near the precursor dike. The kimberlite is dark green with a mostly serpentine groundmass and mostly to completely serpentinized olivine macrocrysts. Relative to the precursor dike, this second phase has much lower magnetic susceptibility (probably reflecting its dearth of tiny groundmass oxides), somewhat lower density , and less abundant volatiles (Kopylova *et al.*, 1997). The diamond grade, in contrast, is higher than the precursor dike but lower than the central lobe. In addition to olivine, macrocrysts of Cr-pyrope (lherzolitic) garnet, chrome diopside, ilmenite, enstatite, orange (eclogitic) garnet, and (to a lesser extent) chromite are common. This kimberlite also contains abundant, very well preserved mantle xenoliths (including eclogite and peridotite), and crustal fragments including fossiliferous (Middle Devonian) limestone xenoliths. Based on counts made during core logging and underground mapping, chrome diopside megacrysts are more abundant than ilmenite megacrysts. Phlogopite megacrysts are rare.

Kimberlite in the northern lobe (Fig. 1c) has a fragmental texture characterized by minor spherical structures (pelletal lapilli) consisting of a nucleus surrounded by a thin rim of aphanitic kimberlite. A breccia of large crustal blocks (some more than 3 m across) occurs around the southern margin of the northern lobe including metaturbidite and limestone supercrustal rocks no longer preserved adjacent to the pipe. The crustal xenoliths change from metaturbidites near the granite contact to mostly limestones towards the center of the pipe, suggesting the breccia preserves a crude stratigraphy of the now-eroded Archean and Devonian sediments that must have covered the pipe at the time of emplacement.

The northern lobe formed after magma moving along the pre-existing dike vented to the surface through the now-eroded Paleozoic limestone cover rocks. Presumably, the magma devolatized rapidly, excavating a diatreme-shaped body back down into the Archean basement. Late in the emplacement event, large crustal blocks slumped into the pipe along the southern margin. The southern lobe contains kimberlite similar to the northern lobe, with a similar mantle sample, and is interpreted to have formed during the same emplacement event. The southern lobe formed as a magmatic blow on the precursor dike which may or may not have vented to the surface.

The third phase formed a central volvanic vent in between the northern and southern lobes (Fig. 1d). This central pipe has near vertical to slightly overhanging walls where it cuts through granite, and less steeply dipping contacts where it cuts pre-existing kimberlite. The kimberlite is medium greenish-gray to light brown with unserpentinized olivine macrocrysts set in a serpentine groundmass, and 10 to 15% crustal fragments, including limestone xenoliths down to at least 350 m below the surface. Magnetic susceptibility is variably higher, and competency generally lower than the second phase. Pelletal lapilli are abundant, giving the third phase a more fragmental appearance than earlier phases. A crudely developed preferred orientation of elongate clasts dips 10° to 30° towards the center of the pipe. The mantle sample differs from earlier phases, as demonstrated by a higher diamond grade, abundant phlogopite megacrysts, and ilmenite megacrysts that outnumber chrome diopside. Upward projection of the walls of the northern and central lobes suggests they coalesced into a single pipe at the time of emplacement, before being eroded to the current subcrop level within the lower part of the diatreme-zone.

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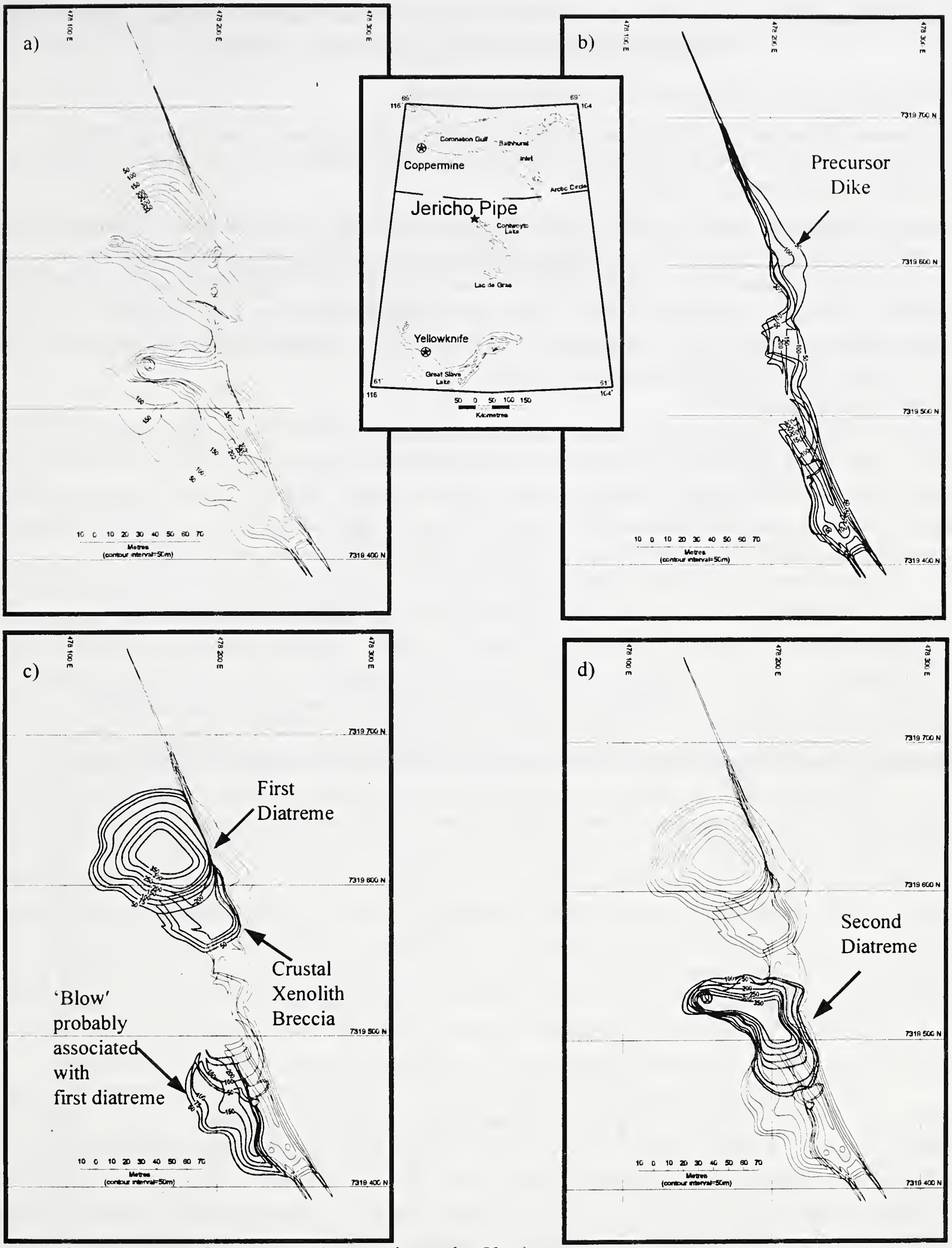

Figure 1: Sub-surface contours (contour interval = 50 m).
for the Jericho Kimberlite in northern Canada: a) Kimberlite-granite contact; b) precursor dike phase; c) first diatreme forming phase in bold; and d) second diatreme forming phase in bold.