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Petrology, geochemistry, and geochronology of the Pikoo Kimberlites, Saskatchewan

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The Pikoo kimberlite cluster of east-central Saskatchewan, discovered in 2011 by North Arrow Minerals, comprises at least ten discreet bodies, predominantly dikes, thought to have erupted through the Sask Craton, a small cratonic nucleus enclosed within the Paleoproterozoic Trans-Hudson Orogen. The Sask craton has a Paleoproterozoic diamondiferous mantle root (Czas et al., 2020). Since the Sask Craton also plays host to the 70+ bodies of the diamondiferous Cretaceous Fort à la Corne kimberlites erupted in the Cretaceous (Kjarsgaard et al., 2017), which are among the largest kimberlites in the world, significant interest lays in unraveling the genesis of the Pikoo bodies. This study presents the first detailed examination of the petrology and geochronology of the Pikoo kimberlites.

Microdiamond analysis for the PK150 body reported by Kupsch (2017) revealed a total of 487 stones recovered from 321.4 kg of dry material and a later sample of 582.05 kg of dry material returned 1,308 total stones. The PK346 body yielded 22 stones from 157.3 kg of dry material (http://www.northarrowminerals.com/projects/pikoo/). PK150 has the coarsest size distribution; 0.673 carats > 0.85 mm size were recovered of 1355 total stones (Kupsch, 2017).

Kimberlite Petrography and Mineral Chemistry

A combination of petrography, major and minor element chemistry was employed to characterize the Pikoo samples as archetypal coherent (hypabyssal) kimberlite, though comprehensive textural classification is hampered by intense alteration (Smyth, 2019). The intrusive bodies typically contain altered rounded olivine and ilmenite macrocrysts set in a crystalline groundmass of olivine, phlogopite, apatite, spinel-group minerals, +/- perovskite, calcite and sulfide.

Groundmass mica analyses for Pikoo intrusives show a range of chemistry, from bodies dominated by phlogopite plotting within the kimberlite groundmass mica field (PK150) to those with mica that have Fe-rich compositions extending into the ‘Orangeite’, plus also kimberlite (Kjarsgaard et al., 2022) field. Most spinel from Pikoo bodies plots most closely with kimberlite Trend 1 spinel, with a portion of PK151 analyses corresponding to Trend 2.

Traditional criteria for diamond preservation were applied to the Pikoo ilmenite by assessing their MgO, Fe_2O_3, and MnO contents. Pikoo ilmenites have high MgO and low Fe_2O_3 within the grain interiors (Fig. 1) and rims with elevated MgO and MnO in PK150, PK151, PK314, and variably elevated in PK312. The high-Fe mineral compositions of PK346 contrast with the trends of the other Pikoo intrusions, suggesting that PK346 formed from an oxidized, high-carbonate late pulse of previously fractionated magma. The differences in magma evolution can explain the striking petrographic and chemical distinctions highlighted between the two most significant intrusions, PK150 and PK346, as well as the notably less favourable microdiamond results reported for PK346. More details are given in Smyth (2019).

Kimberlite Wholerock Chemistry

Whole rock geochemistry results indicate PK150 and PK346 have relatively high SiO_2 (40.8 and ~35 wt%, respectively) and TiO_2 (4.24 and 4.77 to 4.97 wt%, respectively) compared to other kimberlites (e.g., Pearson et al., 2019). The FeO content is also elevated at 15.3 wt% (PK150) and 13.6 wt% (PK346),. The other oxides measured are within expected ranges of kimberlite. The slightly elevated Al contents of PK150 and PK346 (approximately 2.21 and 2.85 wt% Al_2O_3, respectively) suggest crustal contamination when compared to low Al_2O_3 (< 2 wt%) in uncontaminated kimberlites.

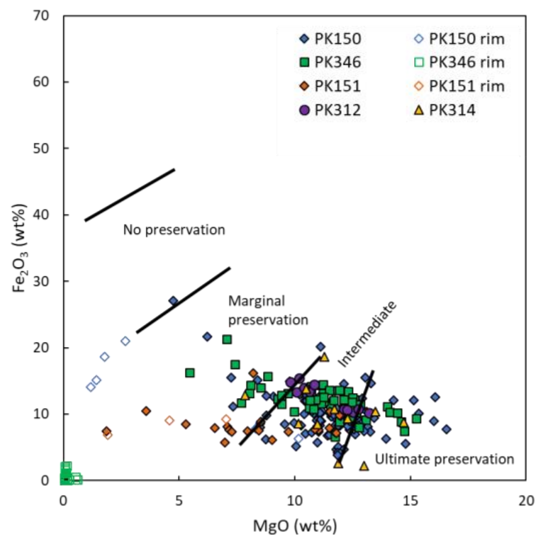

Fig. 1: Plot of Fe_2O_3 vs MgO for Pikoo ilmenite. A negative correlation between ilmenite composition and the preservation potential of diamond as higher oxygen fugacity leads to greater resorption. Pikoo ilmenite plots dominantly in the intermediate to ultimate preservation fields. 'Rim' indicates the ilmenite composition of the outermost margin, distinct from the core composition.

Geochronology and tracer isotopes

We present the first available emplacement age estimate for the Pikoo kimberlites, determined on perovskite from PK150, via in situ via U-Pb LA-ICP-MS. The resulting early Devonian age of 417 +/- 14 Ma is distinctly different from the nearby FALC kimberlites (Kjarsgaard et al., 2017) but overlaps with some occurrences in the Slave Craton, Russia, and Namibia (Heaman et al., 2019). This may suggest more widespread diamond-bearing kimberlite activity in late Silurian to early Devonian times. Tracer isotopes measured on wholerocks yield a range of εNdi values (+3.3 to -3.0), whereas the εNdi values determined for PK150 perovskite by LA-ICPMS are more restricted (+2 to – 2) and broadly conform to the global trend of mildly depleted to chondritic through time, providing an important tie-point at ~ 400 Ma (Woodhead et al., 2019).

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