Palaeomagnetically determined emplacement temperatures of pyroclastic deposits can provide insights into the relative roles of magmatic gases and external water in driving fragmentation during explosive volcanic eruptions and can differentiate between volcanogenic deposits emplaced at elevated temperatures (e.g., pyroclastic density current deposits) and those emplaced at ambient temperatures (e.g., volcanic debris flows). Here, we successfully apply this technique to a range of vent-filling, crater-filling and extra-vent pyroclastic and volcaniclastic deposits from three contrasting kimberlite pipes in Botswana (the Cretaceous A/K1, B/K9 and D/K2 pipes). The results indicate that lithic clasts sampled from vent-filling pyroclastic deposits in the B/K9 and D/K2 pipes were emplaced at >530°C to >590°C. Results from A/K1 provide emplacement temperatures of >570°C for vent-filling pyroclastic breccias and 200–440°C for crater-filling pyroclastic flow deposits. Lithic clasts within epiclastic talus breccias and volcaniclastic breccias were emplaced at <180°C. The initial bulk temperature of the pyroclastic mixture of cold lithic clasts and juvenile kimberlite magma is calculated to be 760–920°C and therefore the vent-filling deposits could have been 300–400°C hotter than the palaeomagnetic estimates. These temperatures are comparable to those obtained for pyroclastic deposits in silicic volcanic systems. The emplacement temperatures fall within the proposed stability fields for common interstitial alteration mineral assemblages within vent-filling volcaniclastic kimberlites. These results, together with the evidence for the welding and agglutination of juvenile pyroclasts in the B/K9 and D/K2 deposits strongly suggest that phreatomagmatism did not play a major role in the generation of the sampled pyroclastic deposits.