TIMING OF EMPLACEMENT OF VREDEFORT GRANOPHYRE DYKES. E. Kovaleva[1], M. S. Huber[1], M. Clark[1] and F. Fourie[2], [1]Department of Geology, University of the Free State, 205 Nelson Mandela Drive, 9300 Bloemfontein, South Africa, kovalevae@ufs.ac.za, [2]Institute for Groundwater Studies, University of the Free State, 205 Nelson Mandela Drive, 9300 Bloemfontein, South Africa.

Introduction: Impact melt created by basin-forming impact events are found as thick sheets, dykes and irregular bodies on top of and within the country rocks beneath the impact crater floor [1]. One such expression of impact melt is found in the Archaean basement of the deeply-eroded 2.02 Ga Vredefort impact structure. Impact melt dykes at Vredefort, referred to as "granophyre dykes", have an intermediate to felsic composition [2,3,4]. The dykes were previously shown to have formed later than impact-related pseudotachylite bodies [1,5,6,7], to contain clasts of shocked target rocks [7,8], and have a Re-Os signature indicative of a meteoritic component [9]. Based on these lines of evidence, the general understanding is that the granophyre dykes represent remnants of the impact melt sheet that propagated downward along fractures in the basement rocks during the final post-impact modification stage [6,8,10,11]. The nature and timing of the event(s) that led to melt emplacement remain contentious.

Here, we examine the depth of penetration of granophyre dykes, as well as their chemical compositions and textures. We infer the timing of the emplacement of granophyre dykes, with implications for the development of large impact basins on Earth, the Moon, and other rocky bodies of the solar system.

Methods: Four granophyre dykes, namely the Kopjeskraal dyke, located at the boundary between the granitic core and the metasedimentary collar of the Vredefort structure (the "core-collar boundary"), as well as the Daskop, Lesutoskraal and Holfontein dykes, located in the granitic core of the structure, were investigated by electrical resistivity tomography, a non-destructive geophysical method described in [11]. Samples from the core-collar dyke and core dykes were analyzed with X-ray fluorescence for bulk chemical composition, according to the methodology described in [4].

Results: *Geophysical data.* The resistivity of the granophyre dykes (>2000 Ωm) is distinctly higher than that of adjacent country rocks, which have resistivities <1000 Ωm. Resistivity variation in the host rock is consistent with its variation in composition, ranging from granite to dolerite [11]. The >2000 Ωm resistivity zone of the Kopjeskraal granophyre dyke extends downward past the 50 m depth of the profile. Thus, the terminus of this dyke at depth has not been determined (Fig. 1A). The resistivity models of the core dykes are broadly similar to one another (Fig. 1B-D). The resistivity model of the Holfontein granophyre dyke shows that the dyke terminates at ~5 m below the surface (Fig. 1B). Similarly, the resistivity models of the Daskop and Lesutoskraal granophyre dykes indicate that the dykes do not penetrate beyond 3 m below surface (Fig. 1C-D).

Geochemical data. Our data of the core granophyre dykes show that the compositions are generally dacitic, in the compositional range of ~64-72 wt.% SiO_2 and 4-6 wt.% Na_2O+K_2O, in agreement with [4,12,13].

The Kopjeskraal granophyre dyke locally contains two distinct textural and geochemical phases, the Kopjeskraal granophyre A (KGA) and Kopjeskraal granophyre B (KGB). Abundant clasts of the granite host are incorporated into the KGA. Compositionally and texturally, the KGA is similar to the core dykes. The KGB is located approximately in the central part of the Kopjeskraal dyke, and is present as a finer-grained and darker-colored phase of the granophyre. A contact between the KGA and KGB runs parallel to the contact between the KGA and the host granite. Rounded clasts of the KGA are included within the KGB (Fig. 2). The KGB is andesitic in composition being more mafic than other measured granophyre samples.

Discussion: The core-collar dyke is at the same elevation as the core dykes, but is wider and penetrates significantly deeper (Fig. 1), suggesting that the emplacement mechanism affected the core-collar dykes differently than the core dykes. The same mechanism may have resulted in the similar penetration depths of all of the dykes in the core.

The consistent narrow range of geochemical compositions present in the core dykes and KGA suggests that they were derived from the same melt source. The comparatively felsic composition indicates that this was the homogeneous impact melt sheet prior to differentiation. The KGB has a more mafic composition than the core dykes, with a compositional range similar to the Sudbury Offset Dykes, suggesting that the KGB was emplaced after the melt sheet started to differentiate. Clasts of the KGA captured by the KGB indicate that KGA crystallized prior to KGB emplacement, showing that the KGB was emplaced significantly later than the KGA. Thus, the granophyre emplacement process occurred in a minimum of two discrete phases over an extended timeframe [3].

The timing of the two stages of the granophyre emplacement process can be constrained by comparison with the cooling history of the Sudbury melt sheet. The emplacement of undifferentiated melt occurred within ~10^1-10^2 y of the impact event [14]. The emplacement of differentiated melt must have happened after the beginning of differentiation, but before the melt sheet reached the solidus, i.e. within ~10^2-10^4 y [14].

The geophysical results demonstrate that the current exposure of the core dykes represents the lowermost termination of the dykes, and thus the first stage of intrusion. In contrast, the core-collar dyke is not at its lowermost termination, which is consistent with the presence of the second intrusion stage (KGB) and the prolonged emplacement history that it represents.

The penetration depths of the granophyre dykes (Fig. 1) in combination with timing constraints on melt intrusion stages can be explained by a post-impact process analogous to isostatic rebound [6], which drove the granophyre emplacement. Crustal re-equilibration was necessary after the removal of a significant amount of upper crustal material during the impact event. Crustal re-equilibration occurred in discrete pulses, causing fractures to open in the crater floor. Driven by the negative pressure gradient, granophyre melt was emplaced within the fractures, thereby sampling the composition of the melt sheet at the time of the fracturing event.

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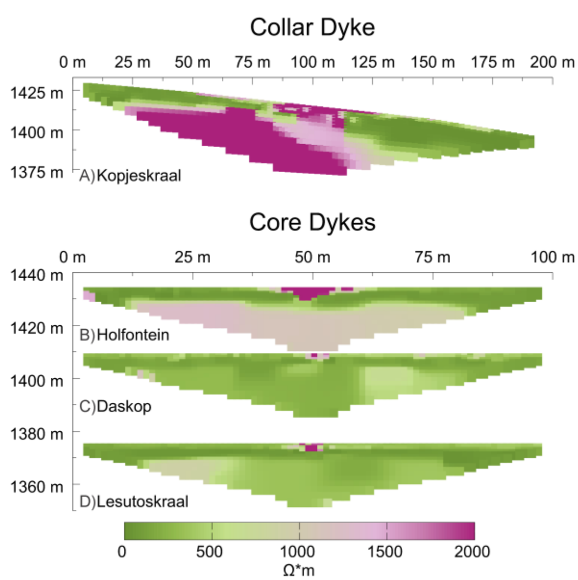

Fig. 1: Resistivity profiles of the granophyre dykes examined in this study. Highly resistive material (interpreted as granophyre) is shown in pink and the surrounding rocks are shown in green.

Fig. 2: Field photograph of Kopjeskraal granophyre A and Kopjeskraal granophyre B contact, with clasts of Kopjeskraal granophyre A included within Kopjeskraal granophyre B. Finger for scale.

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