PETROCHEMISTRY OF THE DEEPER SECTION OF THE IMPACT-MELT SHEET, MOROKWENG IMPACT CRATER, SOUTH AFRICA: EVIDENCE FOR A 250 m BASAL CHILL ZONE. S. Misra[1], D. Ray[2], M. A. G. Andreoli[3] and A. H. Wilson[3], [1]SAEES, University of KwaZulu-Natal, Durban-4000, South Africa (misras@ukzn.ac.za), [2]PLANEX, Physical Research Laboratory, Ahmedabad- 380 009, India, [3]School of Geosciences, University of Witwatersrand, Johannesburg 2050, South Africa.

Introduction: The Morokweng impact crater situated in the North West Province of South Africa was formed ~145±2 Ma ago by an impact of LL-6 chondrite [1-5]. Recent studies on the satellite imagery and geophysical data are consistent with a present-day crater diameter of ~240 km [6, 7]. The target rocks at the time of impact included Archaean granitoids, and mafic gneisses, dolomites and BIF of the overlying early Proterozoic Griqualand West Supergroup, and the Dwyka Group diamictite of Karoo Supergroup [2].

The Morokweng structure is mostly buried under the continental sediments of the <70 Ma Kalahari Group [2], hence samples of impactite (melt rocks, suevites, and impact breccias) are only available for study from drill cores made for mineral and/or groundwater exploration. The stratigraphic and petrographic investigations on samples from about 15 such drill cores conclusively show that by the end of the Cretaceous the impactites of Morokweng crater were exposed over a roughly circular area (D ~33 km) of about 800 km^2 [6]. However, the original, pre-erosional extent and thickness of the impactites remain undetermined. Among all the drill cores, the M3 borehole is the deepest (depth: 1076.13 m) and intersects the probable autochthonous basement at a depth of ~870 m [8]. This drill core also provides the thickest intersection of fully crystallized meteorite impact-melt rocks (~74 m to 872 m) outside the Sudbury Complex.

Despite its exceptional interest, detailed geochemical data of the Morokweng impact-melt sheet have been published only on four boreholes drilled close to the crater center, namely WF3 [End of Hole (EoH) ~130.2 m], WF 4 (EoH ~189.3 m), WF 5 (EoH ~220 m) [2] and M3 (the upper ~350 m) [4]. However, the lower ~725 m section of the M3 drill core remains poorly documented. In the present study, we report our preliminary observations on the M3 drill core samples from depth between 813.82 and 829.14 m. These samples, in fact, represent the basal, clast-laden “chill zone” of the Morokweng impact-melt sheet that extends from 700 to 870 m [8].

Petrography: An impact-melt core sample from a depth of 813.82 m is extremely fine grained in nature, and contains clasts of a relatively coarse-grained, recrystallized quarto-feldspathic rock, probably basement granite (Fig. 1, 3). The sample of impact-melt from 813.98 m also shows the similar type of texture except for the presence of numerous transparent subhedral, prismatic pyroxene crystals and subhedral, opaque grains disseminated throughout the impact-melt without any preferred orientation (Fig. 2). The pyroxene grains in the impact-melt samples from 814.13 m form continuous rims around the quartzo-feldspathic clasts (Fig. 3).

Our preliminary observations on the impact-melt samples from 802.97 m are also similar. This impact-melt is extremely fine grained and contains isolated sub-rounded clasts of relatively coarse-grained, equigranular and completely recrystallized, quartzo-feldspathic target rocks. Some ring-shaped remnants of undetermined dark coloured minerals (Fig. 4) were also found scattered throughout the thin section.

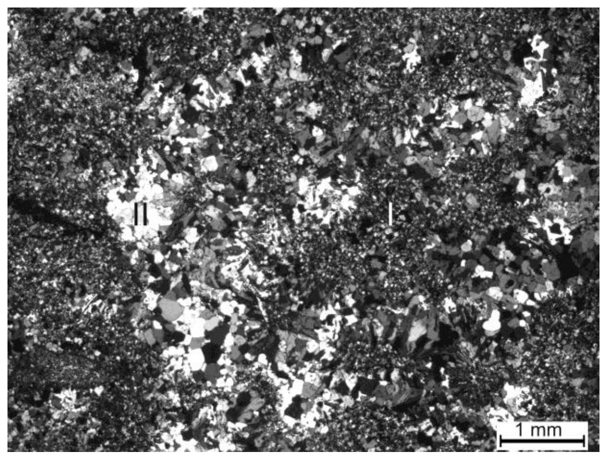

Fig. 1. Photomicrograph of impact-melt from M3 drill core from a depth of 813.82 m showing extremely fine grained silicic melt (I) containing relatively coarse grained quartzo-feldspathic clast (II) (xpl).

Geochemistry: Three samples of the impact-melt sheet from depth between 803.18 and 813.38 m were analyzed for bulk composition using XRF techniques at the University of Witwatersrand, South Africa. The average major oxide composition of our limited number of impact-melt sheet samples from the “chill zone” of the M3 drill core is dacitic. It is also very similar to the shallower melt sheet samples from boreholes WF3, WF4, WF5, and from the upper part (≤ 250 m) of M3 [2, 4]. The pyroxenes present in the impact-melt sheet sample from a depth of 829.14 m of the M3 drill core have been analyzed using a Cameca SX100 Electron

Microprobe at the PLANEX, Physical Research Laboratory, India. The analytical details of our analyses are available in [9]. We captured not less than 21 analyses on 8 grains of pyroxene, and our preliminary data show that they are enstatite in nature and ranging in composition from $Wo_{1.41}En_{56.07}Fs_{34.75}$ to $Wo_{2.57}En_{63.61}Fs_{41.88}$. The magnesium numbers [Mg#: 100*molar Mg/ molar($Mg+Fe^{2+}$)] of the pyroxenes vary from 57 to 65.

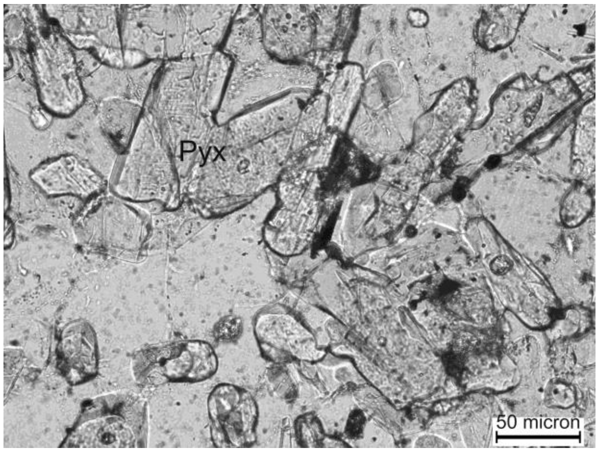

Fig. 2. Enlarged view of impact-melt from M3 drill core from a depth of 813.98 m showing presence of numerous subhedral, prismatic pyroxene grains (Pyx), (pp).

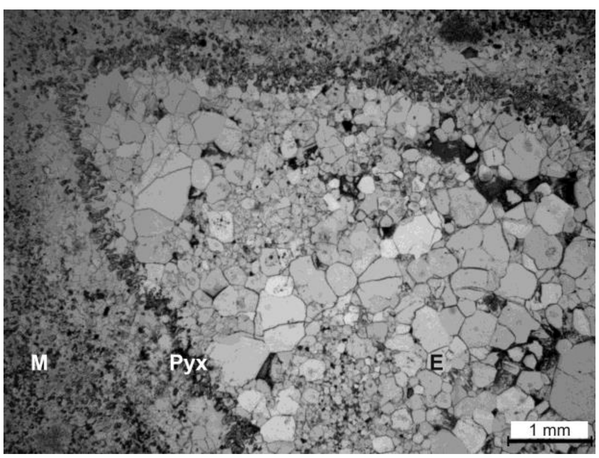

Fig. 3. Photomicrograph of impact-melt from M3 drill core from a depth of 814.13 m showing pyroxene grains (Pyx) forming continuous ring along contact between quartzo-feldspathic clast (E) and fine grained matrix (M), (pp).

Discussion. The M3 drill core has primarily been subdivided from hand specimen and petrographic observations into an upper zone (between ~74 to 701 m) where the impact-melt is relatively clast-poor and crudely differentiated, and a lower zone (~701 to 872 m), which is felsic, quenched and laden with clasts of basement rocks and, at least in one case, with a meteorite [8]. Our present observation supports the earlier proposals that the M3 drill core below 700 m is the chilled margin of the impact-melt sheet, and is laden with highly recrystallized basement clasts (Fig. 1, 3). Although there is evidence that the bulk of Morokweng impact-melt sheet experienced some degree of differentiation [2], our three whole-rock analyses suggest that the relatively chilled bottom part and coarser grained top portion of the impact-melt sheet may be similar in composition. Apart from the grain size, the major difference between the two sets of impact-melt sheet samples is the additional presence of calcic pyroxene higher in the stratigraphy.

The subhedral prismatic orthopyroxene present in the lower part of M3 drill core samples indicates show cooling prior to final chilling of the impact-melt sheet. If we assume that a vertical section of ~1.5 km was eroded from the Morokweng crater in the Cretaceous, the computed pressure at the base of the impact-melt sheet was close to 600 bars (assuming density of granite 2.75 gm/cc). Comparison with C-type magmas [10] and albite-forsterite-silica experimental system at low pressure [11] constrain the crystallization temperature of Morokweng impact-melt could be greater than 1000^{o}C.

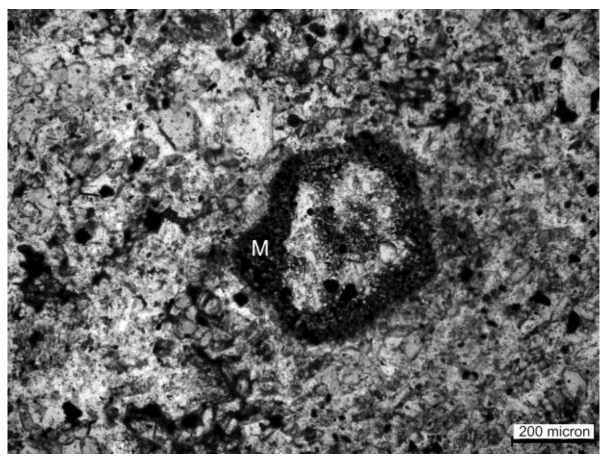

Fig. 4. Photomicrograph of impact-melt from M3 drill core from depth 802.77 m showing presence of relict decomposed component (M) of possible impactor meteorite (pp).

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