Ni- and PGE-ENRICHED QUARTZ NORITE IN THE LATEST JURASSIC MOROKWENG IMPACT STRUCTURE, SOUTH AFRICA. M. A. G. Andreoli¹,², R. J. Hart², L. D. Ashwal³ and M. Tredoux⁴
¹ Atomic Energy Corp. of S. Africa (P.O. Box 582, Pretoria 0001, South Africa; aec@cis.co.za), ² Schönland Research Centre, Univ. Witwatersrand, P.O. Box 3, Wits 2050, South Africa; hart@schonland.src.wits.ac.za), ³ Dept. Geology, Rand Afrikaans Univ., P.O. Box 524, Auckland Park 2006, South Africa; LDA@rau3.rau.ac.za), ⁴ Dept. Geol. Sci., Univ. Cape Town, Rondebosch 7700, South Africa; MTD@geology.uct.ac.za)

The 145 ± 0.8 Ma Morokweng impact structure (diameter ~350 km) is among the largest on Earth [1,2,3]. Borehole data [3] show that the center of the structure is represented by a texturally complex, sheet-like igneous body (diam ~30 km; thickness ≥170 m), interpreted as an impact melt [1,3]. These igneous rocks consist of a variety of pyroxene-bearing lithologies, the most predominant of which is a homogeneous, medium-grained quartz norite. The melt sheet has a chilled basal contact with underlying basement granitoids, which are intensely affected by shock and thermal metamorphism. In places, veins and dykes of heterogeneous and/or finer-grained quartz norite, pyroxene-bearing granitoids or pegmatoids, and granophyres crosscut the impact melt sheet.

Constituent minerals in the impact melt rocks include plagioclase (An₂₂₋₅₁), orthopyroxene (En₅₅), minor subophitic augite (En₃₈₋₄₂, Wo₄₀₋₄₆) and granophyric quartz-K-feldspar intergrowths. The opaque minerals occur either as finely disseminated grains (mainly magnetite and ilmenite), or as occasional sulfide-rich blebs and tapering veinlets (up to 3 cm wide) in contact with pyroxenes and quartz. The mineralogy of these veins consists of Ni- and Cu-sulfides (Co-bearing millerite, bornite, chalcocite, chalcopyrite), Ni-rich oxides (bunsenite, Ni-rich ilmenite, trevorite), Ni-rich silicates (liebenbergite, willemseite) and traces of native platinum [3]. The quartz norites are marked by intermediate to acid bulk chemistry (SiO₂ = 59-66 wt%, MgO = 2.4-4.9 wt%). They show poorly fractionated REE and striking enrichments in siderophile elements (avg Ir = 3.8 ppb, Au = 9 ppb, Ni = 480 ppm, Cr = 360 ppm). These are equivalent to or above siderophile abundances in mantle-derived rocks from the Barberton greenstone belt (Fig. 1), possibly indicating an origin as impact-generated crustal melts with appreciable meteoritic contamination [3]. However, Morokweng differs from most other impacts, with the possible exception of Sudbury, as its impact melts show some degree of differentiation between earlier, medium-grained quartz norite and the cross-cutting, finer-grained varieties. There is also evidence of enrichment processes affecting the PGE and Au in the millerite-trevorite veins, which show non-chondritic PGE patterns (avg Os = 9.5 ppm, Ir = 7.8 ppm, Ru = 9.9 ppm, Pt = 2.7 ppm, Pd = 23 ppm, Au = 0.9 ppm; Fig. 1). The Ni-rich mineral assemblages are unique, although reminiscent of an enigmatic 3.5 Ga nickel deposit from the Barberton greenstone belt [4].


Fig. 1. Chondrite-normalized Ir concentrations of quartz norites (vertical bar) and PGE concentrations of millerite-trevorite veins (broken lines) from the Morokweng impact structure, compared to materials from the Barberton greenstone belt: trevorite-rich Ni ore (field A) and coarse-grained dunite and komatiite (field B). Data from refs [4] and [5].