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Sedimentology and source provenance analysis of diamondiferous gravels of the Middle Orange River, Northern Cape Province, South Africa

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Introduction

The Eureka diamond was the first diamond to be discovered in South Africa, in 1867, 30 km upstream from the confluence the Vaal and Orange River, at De Kalk in the Northern Cape (Norton *et al*. 2007). The Vaal River alluvial deposits were identified at Klipdrift (Barkley-West) in 1868, this discovery ignited the great South African diamond rush (Norton *et al*. 2007). Primary kimberlite and secondary diamondiferous gravel deposits have been mined for over 150 years in Northern Cape.

The Middle Orange River (MOR) is the river section between Hopetown, Douglas and Prieska (Figure 1). The MOR was relatively unexplored and unexploited compared to the Vaal, Riet and lower Orange River until 1985. Prospecting and mining methodologies adopted elsewhere were not suited for the MOR section, in particular between Douglas and Prieska. This was attributed to large areas of this MOR section being overlain by multiple generations of hard calcrete, requiring ripping or drill and blasting, to uncover diamondiferous basal gravels.

McCarthy (1983) noted that ~33 km downstream from the confluence, a previous major river system introduced banded-iron stone into the Orange River deposits. Metallurgical processing methods had to be adapted and magnetic scalping introduced to remove the high percentage of banded ironstone. The increased bedload and high specific gravity,created by the banded-iron stone, coupled with the low river gradient between Douglas and Prieska, allowed for ideal trap sites and the enhanced retention (ie. higher diamond grades) in this section of the river.

Alluvial diamond mining has shifted from ‘traditional areas’ in the Vaal, Riet and upper catchment of the MOR (Hopetown to Douglas section) through the application of modern treatment methods and equipment. Hence, there has been an increase in recovery of exceptional and distinctive MOR diamonds in the ‘sink’ immediately downstream of the confluence of three of South Africa’s major diamond-bearing rivers: the Riet, Vaal and Orange. The alluvial diamond population of this MOR ‘sink’ zone has primary sources in the diamondiferous kimberlites of Lesotho, Lichtenburg-Western Transvaal diamond fields, greater-Kimberley area, Botswana and the Postmasburg fields (Marshall, 2017). A high portion of Type II D flawless white and coloured diamonds (pink and yellow stones) having an average of US$ 1800/ct - $ 3500/ct, dominate this MOR diamond population (Figure 1). The ultra-low and low grades, 0.05 to 1 carat per hundred tons, of the MOR have become economic to mine due to the exceptional value of these spectacular stones, geological work and modelling, and improved processing and recovery. This indusrty is important in the rural areas of South Africa as is promotes job creation and skills development.

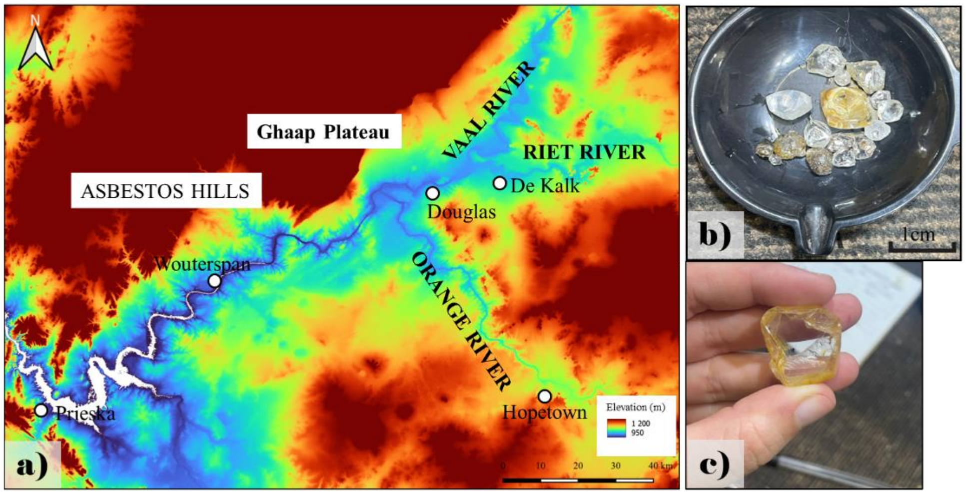

Figure 1: a) Digital elevation model of the Middle Orange River between Hopetown, Douglas and Prieska. b) Mixed diamond population recovered from Wouterspan Mine, 0.8-10.55 carats. c) Uncut 80.31 carat basal white (Type II) stone.

Diamondiferous palaeo-deposits of the Middle Orange River: Wouterspan Mine

Wouterspan, a historic mine on the right bank of the Middle Orange River (~50km downstream of the confluence), actively exploits two diamondiferous terraces at +20m and +40m. The diamondiferous gravel deposits occur as terrace remnants with ultra-low diamond grades in the range of 0.05- 0.15 carat per hundred tons. However, the high average value per stone of US$ 2500/ct to US$ 3500/ct makes this resource economics to mine. These deposits are estimated to be Miocene to Pliocene in age, and primary sources of diamonds are kimberlites outcropping within the drainage basins of the Orange, Vaal and Riet Rivers (Gresse, 2003).

Two diamantiferous units are targeted within the terraces: 1) “Primary basal gravels”, poorly sorted clast-supported conglomerates unconformably overlying diamictite of the Dwyka Group (+20m terrace); and 2) mobile, multi-cyclic deflation, and gravitational deposits, or “Rooikoppies”, characterized by iron-rich clast supported conglomerates and underlain by thick calcretes (+20m and +40 terrace). The combined successions of gravels and ‘Rooikoppies’ vary from 5-15 metres thick. The paleo-drainage system of Wouterspan mine has a complex internal morphology. The drainage system was structurally controlled by long-term reactivation of the south-west trending margin of the Ghaap Plateau Escarpment and associated graben-structure (Norton *et al.* 2007). The diamondiferous gravel deposits are correlated to the outwash deposits formed during the retreat of the ancient Ghaap Valley glacial system and the subsequent reworking and alluvial deposition by the Middle Orange River palaeo-drainage system (Norton *et al.* 2007). Alluvial diamond deposits develop where there is favourable interplay between: climatic conditions, basin dynamics, regional and local structures, and local geomorphic features. The nature of the deposits at Wouterspan Mine are complex and under-represented in the literature. A trans-disciplinary study is underway to deduce a robust sedimentological model of Wouterspan Mine, and related deposits of the MOR.

Ongoing sedimentological model of the diamondiferous gravel deposits of Wouterspan Mine

The sedimentology of 12 mined pits, on Wouterspan Mine, are being studied and represented by various litho-facies codes, the formation and architectural elements of facies successions and the development of a sedimentological facies model. This methodology is in line with Miall (2006) for describing the geology of fluvial deposits. Stratigraphic logs of each pit are correlated across several intersecting profiles, 1 to 5 km long, showing distinct sedimentary packages arranged into several depositional sequences that reveal important lateral facies variations and erosional hiatuses. Studies by Gresse (2003) described the +20 m terrace as a consequence of continuous channel migration within an alluvium-filled flood plain causing continued erosion and recycling of alluvium, whereas Marshall (2017) proposed that these deposits represented the preservation of fluvial-alluvial channels of an older braidplain subsequently incised by a younger, meandering channel. Preliminary detailed studies by this author have indicated several overlapping sedimentary architectural elements, including gravel bars, channel fills, migrating bars, scour channels and overbank fines.

Additional correlations are being constructed using borehole data and several bulk samples are being processed for heavy minerals at the Nelson Mandela University. The preliminary studies and interpretations point to both alluvial and fluvial depositional processes in a hybrid large meandering-braided river system. Extensive research is underway to construct a multi-faceted model that fully provides interpretation of the sedimentologic and concentration dynamics of the large and exceptional diamond population of unique MOR deposits. This work will be submitted in the form of a Masters Thesis at Nelson Mandela University, South Africa, in December 2024.

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